IEEE P802.11  
Wireless LANs

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| “(Annex G) Frame Exchange Sequence” | | | | |
| Date: 2021-08 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Graham SMITH | SR Technology | Sunrise, FL, USA. | 916 799 9563 | gsmith@srtrl.com |

Abstract

Based upon a concept that the Frame Exchange Sequence is defined along the lines of a sequence of packets separated by SIFS, ending with a back off, each reference in D0.0 is checked to see if any problems or anomolies arise.

Rev 1 Changes for and arising from ARC meeting 08/09/2021

Rev 2 Looked at results of the investigation and proposes a new definition.

Strawman definition

***frame exchange sequence***: A sequence of frames exchanged between two specific STAs and either solicits an immediate response from the other STA or is the response to a frame from the other STA that solicits an immediate reponse, *or a frame that is not an immediate response and that does not solicit an immediate response*.

The text in italics may be omitted.

Using D0.0 each reference is examined

In Draft D0.0

“frame exchange” 309 instances, of which “frame exchange sequence” 128,

“frame exchange sequences” 35

“valid response” 4 instances

“frame sequence” 23 instances

“see Annex G” 5 instances

“in Annex G” 9 instances

If we can remove “Annex G” from the definition, then it all gets easier. We could keep and modify Annex G, or remove it, but need to agree on a correct definition for “frame exchange sequence”.

The basic concept is that a frame exchange sequence is a ‘protected’ sequence.

What are the attributes of a frame exchange sequence?

**At Meeting on 08/09/2021**, each occurance of ‘frame exchange sequence” was looked at and the following points were made which may need further discussion with respect to agreeing what comprises a “frame exchange sequence” (FExS):

* Within a FExS, packets separated by SIFS
* Multiple FExSs allowed within a TXOP.
  + Limited to TXOP duration
  + Do multiple FExSs within a TXOP use a common Duration? (Think yes, a TXOP duration is defined)
  + FExSs within a polled TXOP, or HC TXOP, or EDCA TXOP separated by SIFS,
  + CMMG STA waits PIFS between FExSs.
* FIG.10-13 is this one FExS or three? Does it matter?
  + Maybe problem if FExS is restricted to 2 specific STAs?
* **End of FExS when RA or TA changes** (see 2183.22). (This may be OK for an MU case?)
* Assumed that Beam forming and Beam tracking uses FExSs.
* If not a frame exchange sequence, is “frame exchange” or “frame sequence” the better (assumed the former)
* ASEL is not FExS but “frame exchange”
* GAS frame exchanges are not FExSs

**DISCUSSION**

The exercise of looking at the occurances of “frame exchange sequence(s)” has provided the above list of “rules”.

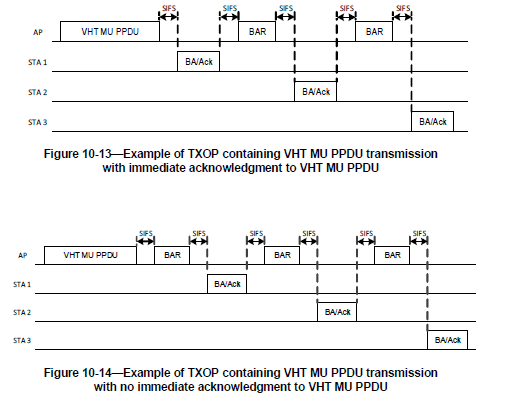
For me, a “frame exchange sequence” is a sequence of frames exchanged between STAs that the STAs do not want to be interrupted, i.e., a “frame exchange sequence” grabs the WM and keeps it. It does this by using SIFS between the frames.

Now, a TXOP also grabs the WM and can use it to send multiple “frame exchange sequences”. In this case, there is also a SIFS between the frame exchange sequences. So it is not just SIFS that defines a frame exchange sequence. The change of addresses, indicates the new frame exchange sequence (see 2183.22), or the medium goes idle (CS mechanism, or NAV is zero).

Hence, the definition is staring to form; a frame exchange sequence has the following characteristics:

* Frames separated by SIFS and protected by the NAV
* The TA and SA remain constant, from the perspective of each STA (exception of a CTS)

The remaining “problem” is the VHT MU case see FIGS. 10-13 and 10-14. They are termed “frame exchange sequences”. So, are they one or three frame exchange sequences”?



With SIFS between frames, the STA(s) obviously do not want this sequence to be interrupted.

Questions/points on VHT MU PPDU:

* The exchange is contained in a TXOP
  + AP gains control of channel and transmits MU frame to all receivers
  + AP follows up with explicit BA requests.
* Is the entire sequence protected by NAV? Yes, it is a TXOP but I can’t find an explicit statement for that
* As far as non-AP STAs are concerned, all packets have same TA.

Hence, the exchange looks like a “frame exchange sequence”. The question is, does this affect any definition the we come up with, i.e., do we need to cover MU PPDUs as a special case, or can we have a definition that encompasses it?

**What are the credentials of a “frame exchange sequence”?**

* Keeps the WM, using SIFS, (NAV)
* Ends when
  + a STA receives a frame with a TA that differs from the TA of the frame that started the frame exchange sequence
  + a STA receives a frame with an RA that differs from an RA included in the frame that started the frame exchange sequence
  + 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))

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**Strawman Definition for “frame exchange sequence”**

* ***frame exchange sequence***: a sequence of frames where each frame in the sequence is separated by a SIFS and ends when either a STA receives a frame with a TA that differs from the TA of the frame that started the frame exchange sequence, or a STA receives a frame with an RA that differs from an RA included in the frame that started the frame exchange sequence, or the medium is idle.

**“Frame Exchange Sequence” AND “Frame Exchange Sequences”**

(references appear in Contents ignored)

EXCEPT WHERE NOTED, THE “FRAME EXCHANGE SEQUENCE” REFERENCE IS THOUGHT TO BE CORRECT AND COMPLIES WITH THE “CONCEPT” OF “PROTECTED” SEQUENCE.

EDITS ARE SHOWN WHERE REQUIRED

166.50 **quality-of-service (QoS) facility:** The set of enhanced functions, channel access rules, frame formats, frame exchange sequences and managed objects used to provide parameterized and prioritized QoS.

**169.29 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)

183.24 **groupcast with retries (GCR) transmission opportunity (TXOP):** An interval of time during which anaccess point (AP) or a mesh station (STA) has the right to initiate frame exchange sequences onto thewireless medium (WM) for the purpose of transmitting multiple frames that are subject to the GCR service.

**184.30 hybrid coordinator (HC):** A type of coordinator, defined as part of the quality-of-service (QoS) facility, that implements the frame exchange sequences and medium access control (MAC) service data unit(MSDU) handling rules defined by the hybrid coordination function (HCF).

199.33 **transmission opportunity (TXOP) responder:** A station (STA) that transmits a frame in response to aframe received from a TXOP holder during a frame exchange sequence, but that does not acquire a TXOP in the process.

325.41 This request initiates the scan process when the current frame exchange sequence is completed

344.8 This primitive initiates a synchronization procedure once the current frame exchange sequence is complete

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401.8 This primitive initiates the BSS initialization procedure once the current frame exchange sequence is complete

781.31 The Power Management subfield is used to indicate the power management mode of a STA. The subfield is either reserved (as defined below) or remains constant in each frame from a particular STA within a frame exchange sequence ~~(see Annex G)~~.

The value indicates the mode of the STA after the successful completion of the frame exchange sequence.

794.47 The Mesh Power Save Level subfield indicates whether the mesh STA’s peer-specific mesh power

management mode will be deep sleep mode or light sleep mode after the successful completion of the frame exchange sequence.

813.35 *TSINGLE-MSDU* is the estimated time required for the transmission of the allowed frame

exchange sequence defined in 10.23.2.9 (TXOP limits) (for a TXOP limit of 0), including applicable IFSs.

815.22 If the frame is the sole or final frame in the TXOP, the actual remaining time needed for this frame exchange sequence

841.10 The Duration field calculation for the Data frame is based on the rules in 10.6 (Multirate support) that determine the data rate at which the Control frames in the frame exchange sequence are transmitted

846.7 The Duration field calculation for the Management frame is based on the rules in 10.6 (Multirate support) that determine the data rate at which the Control frames in the frame exchange sequence are transmitted.

1692.35 The CSMA/CA distributed algorithm mandates that a gap of a minimum specified duration exists between frame exchange sequences

1692.59 The HCF combines functions from the DCF with some enhanced, QoS-specific mechanisms and frame subtypes to allow a uniform set of frame exchange sequences to be used for QoS data transfers

1694.23 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.

1695.59 When the first frame in a frame exchange sequence intended to carry a QoS Data, QoS Null or Managementframe is an RTS or CTS frame.

1696.49 The HC is collocated with the AP of the BSS and uses the HC’s higher priority of access to the WM to initiate frame exchange sequences and to allocate TXOPs

1697.1 A STA may initiate multiple frame exchange sequences during a polled TXOP of sufficient duration to perform more than one such sequence

1724.19 Responses to A-MPDUs within a VHT MU PPDU that are not immediate responses to the VHT MU PPDU are transmitted in response to explicit BlockAckReq frames by the AP. Examples of VHT MU PPDU frame exchange sequences are shown in Figure 10-13 (Example of TXOP…

1737.54 Error recovery shall be attempted by retrying transmissions for frame exchange sequences that the initiating STA infers have failed. Retries shall continue, for each failing frame exchange sequence,

1811.52 the TXOP holder may commence transmission of that frame a SIFS (or RIFS, if the conditions defined in 10.3.2.3.2 (RIFS) are met, or PIFS, if the frame contains a bandwidth signaling TA) after the completion of the immediately preceding frame exchange sequence, subject to the TXOP limit restriction as described in 10.23.2.9 (TXOP limits).

1815.17 A TXOP holder that transmits a CF-End frame shall not initiate any further frame exchange sequences within the current TXOP

1815.20 An S1G STA that transmits an NDP CF-End frame shall set the frame’s Duration field to 0 and shall initiate no other frame exchange sequences in the current TXOP

1820.23 The HC grants a STA a polled TXOP with duration specified in a QoS (+)CF-Poll frame. A STA may transmit multiple frame exchange sequences within given polled TXOPs, subject to the limit on TXOP duration.

1820.53 The duration values used in QoS frame exchange sequences reserve the medium to permit completion of the current sequence

1821.24 After the last frame of all other nonfinal frame exchange sequences (e.g., sequences that convey individually addressed QoS Data or Management frames) during an HCCA TXOP

1822.18 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.

1824.37 A TXOP obtained by receiving a QoS (+)CF-Poll frame uses the specified TXOP limit consisting of one or more frame exchange sequences with the sole time-related restriction being that the final sequence shall end not later than the TXOP limit

1828.50 Frame exchange sequences that do not include any Data frames are excluded from the used\_time update. Any RD transmission granted by the AP is excluded from the used\_time update

1899.47 This subclause applies to frame exchange sequences that include PPDUs containing an HT variant HT Control field. The VHT variant HT Control field may be used by VHT STAs and S1G STAs

1997.23 Sequential operation allows the polled and contention based access methods to alternate, within intervals as short as the time to transmit a frame exchange sequence, under rules defined in 10.23 (HCF).

**1704.45 SIFS is the shortest of the IFSs between transmissions from different STAs. SIFS shall be used when STAs have seized the medium and need to keep it for the duration of the frame exchange sequence to be performed**. **Using the smallest gap between transmissions within the frame exchange sequence prevents other STAs, which are required to wait for the medium to be idle for a longer gap, from attempting to use the medium, thus giving priority to completion of the frame exchange sequence in progress**

1713.26 therefore no further RTS/CTS frames need to be generated after the RTS/CTS that began the frame exchange sequence

1716.8 The recognition of a valid CTS frame sent by the recipient of the RTS frame, corresponding to this PHY-RXEND.indication primitive, shall be interpreted as successful response, permitting the frame exchange sequence to continue ~~(see Annex G).~~

1737.46 Under DCF, error recovery is always the responsibility of the STA that initiates a frame exchange sequence ~~(described in Annex G)~~

1737.54 Error recovery shall be attempted by retrying transmissions for frame exchange sequences that the initiating STA infers have failed. Retries shall continue, for each failing frame exchange sequence, until the transmission is successful,

1738.27 A STA in PS mode, in an infrastructure BSS, initiates a frame exchange sequence by transmitting a PS-Poll

1738.34 error recovery shifts to the AP because the data are transferred in a subsequent frame exchange sequence,

1738.36 The AP shall attempt todeliver one buffered BU to the STA that transmitted the PS-Poll frame, using any frame exchange sequence valid for an individually addressed BU

1761.52 In a TXOP, a STA shall not set the TXVECTOR parameter CH\_BANDWIDTH to a value greater

than the RXVECTOR parameter CH\_BANDWIDTH for the next frame exchange sequence

1804.9 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 Ack frame

1804.30 An EDCA TXOP is granted to an EDCAF when the EDCAF determines that it shall initiate the transmission of a frame exchange sequence.

1805.15 each EDCAF shall make a determination to…..Initiate the transmission of a frame exchange sequence

1806.28 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,

**1811.55** after the completion of the immediately preceding frame exchange sequence, subject to the TXOP limit restriction as described in 10.23.2.9 (TXOP limits). **A STA shall not commence the transmission of an RTS with a bandwidth signaling**

**TA until at least a PIFS after the immediately preceding frame exchange sequence. A CMMG STA shall not commence the transmission of an RTS frame until at least PIFS time after the immediately preceding frame exchange sequence**.

1820.37 An HC may perform a backoff following an interruption of a frame exchange sequence due to lack of an expected response

1820.60 the HC shall transmit either a QoS (+)CF-Poll with the duration value set to cover the polled TXOP, or the first frame of any permitted frame exchange sequence with the duration value set to cover the HCCA TXOP.

**1821.25 After the last frame of all other nonfinal frame exchange sequences (e.g., sequences that convey individually addressed QoS Data or Management frames) during an HCCA TXOP, the holder of the current HCCA TXOP shall wait for one SIFS before transmitting the first frame of the next frame exchange sequence.**

**(Note: this maybe OK because the next Frame exchange sequence is between two other STAs (?), BUT needs checking what a “nonfinal” is)**

1824.28 A non-AP STA shall accept a polled TXOP by initiating a frame exchange sequence independent of its NAV.

1826.24In order to provide improved NAV protection, a STA may send an RTS frame as the first frame of any frame exchange sequence without regard for dot11RTSThreshold.

1828.43 The STA shall update the value of used\_time….After each successful or unsuccessful frame exchange sequence,

1828.47 The MPDUExchangeTime is the duration of the frame exchange sequence

1832.56 STA is allowed to cross its assigned RAW slot boundary to complete the ongoing frame exchange sequence.

1832.61 STA shall not transmit or cause to be transmitted a frame exchange sequence that would exceed boundary of its allocated RAW slot

1835.11 The duration of the trigger frame exchange sequence shall not exceed a RAW slot duration

1846.47 If the mesh STA does not receive all MCCAOP Advertisement elements of the sender of the MCCAOP advertisement before a frame exchange sequence on the wireless medium causes the mesh STA to set its NAV

1847.9 If the mesh STA does not receive this MCCAOP Advertisement element of the sender of the

MCCAOP Advertisement before a frame exchange sequence on the wireless medium causes the mesh STA

to set its NAV,

1873.34 The frames that propagate the NAV throughout the BSS include RTS/CTS/Ack frames, all Data frames with the More Fragments field equal to 1, all Data or Management frames sent in response to PS-Poll frame that are not proceeded in the frame exchange sequence by a Data frame with the More Fragments field equal to 1, and CFEnd frames.

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**BEAMFORMING**

**(???Check that the beamforming exchange are “protected”. These say that it is)**

**1908.50 STA A initiates the frame exchange sequence by sending an unsteered PPDU to STA B.**

**1909.13 STA A initiates the frame exchange sequence by sending an unsteered PPDU to STA B. The PPDU**

**includes a training request (TRQ= 1) in a +HTC MPDU**

**1911.5 A STA may initiate a calibration training frame exchange sequence with another STA if that STA supports calibration.**

**1916.44 as a response to a non-NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-26 (Rules for HT beamformee immediate feedback transmission responding to non-NDP sounding).**

**1916.50 TXOP as a response to a non-NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-26**

**1916.55in the HT beamformer’s TXOP as a response to a non-NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-26**

**1917.30** NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-27

1918.25 response to an NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-27

1918.32 response to an NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-27

1921.1 beamformer’s TXOP as a response to a non-NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-28

1921.36 for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-29

END OF BEAMFORMING \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1923.14 A STA shall not initiate an ASEL training frame exchange ~~sequence~~ with another STA unless that STA supports ASEL

1923.29 The frame exchange ~~sequence~~ for transmit ASEL is shown in Figure 10-51 (Transmit ASEL)

NOTE: Figure shows SIFS between packets)

1925.22 The frame exchange ~~sequence~~ for receive ASEL is shown in Figure 10-52

(NOTE: packets separated by SIFS)

1934.50 VHT beamformer shall not transmit a Beamforming Report Poll frame to a VHT SU-only beamformee unless the VHT beamformer has received at least one feedback segment of the VHT compressed beamforming feedback from the VHT beamformee in the current frame exchange sequence

1950.20 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.

1952.28 The source DMG STA shall initiate the frame exchange sequence that takes place during the SP at the start of the SP

1952.37 The source CMMG STA shall initiate the frame exchange sequence that takes place during the SP at the start of the SP,

1953.53 In no case shall the source or destination DMG STA extend a transmission frame exchange sequence that started during an SP beyond the end of that SP. A STA that initiates a sequence shall check that the frame exchange sequence, including any control frame responses, completes before the end of the SP

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BEAMTRACKING – Check uninterrupted sequences.

2033.36 Figure 10-89 (Example of beam tracking procedure with initiator requesting TRN-R) illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-R subfields, while Figure 10-90 (Example of beam tracking procedure with initiator requesting TRN-T) illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-T subfields

2033.38 Figure 10-90 (Example of beam tracking procedure with initiator requesting TRN-T) illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-T subfields.

(NOTE: Figures do not show SIFS or such. As beam tracking I assume uninterrupted sequence – needs checking)

2038.16 BRP frames transmitted during enhanced beam tracking may be aggregated within A-MPDUs.

Figure 10-93 (Example of an enhanced beam tracking procedure with the initiator requesting TRN-R)

illustrates a beam tracking frame exchange sequence when the beam tracking

2038.18 while Figure 10-94 (Example of an enhanced beam tracking procedure with the initiator requesting TRN-T) illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-T subfields.

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2048.6 For each frame received at the RDS during the SP, the RDS shall follow the same rules for frame exchange sequences as described in ~~Annex G and~~ 10.39 (DMG and CMMG channel access).

2069.45 Bidirectional TXOP (BDT) allows an S1G AP and an S1G non-AP STA to exchange a sequence of uplink and downlink PPDUs separated by SIFS. This operation combines both uplink and downlink channel access into a continuous frame exchange sequence between a pair of S1G STAs.

2082.44 Four types of frame exchange sequences, which can lead to the SO conditions by OBSS non-AP STAs or OBSS APs are described.

a) SO frame exchange sequence 1: As illustrated in Figure 10-106 (SO frame exchange sequence 1),

b) SO frame exchange sequence 2: As illustrated in Figure 10-107 (SO frame exchange sequence 2),

c) SO frame exchange sequence 3:

(NOTE: Figures show “NAV protected” sequences)

2084.6 first diagram in Figure 10-108 (SO frame exchange sequence 3),

2084.14Figure 10-108 (SO frame exchange sequence 3)

2085.1 d) SO frame exchange sequence 4:

(NOTE: Figure shows NAV protected)

2087.23 The frame exchange sequence for sector training is shown in Figure 10-111

(NOTE: Figure shows SIFS between packets)

2149.37 Power management mode shall not change during any single frame exchange sequence~~, as described in Annex G~~.

2183.6 the STA enables its multiple receive chains when it receives the start of a frame exchange sequence addressed to it. Such a frame exchange sequence shall start.

2183.14The STA switches to the multiple receive chain mode when it receives the frame addressed to it and switches back immediately when the frame exchange sequence ends.

**2183.22 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)).**

2363.1 considered inactive if the AP has not received a Data frame, PS-Poll frame, or Management frame (protected or unprotected as specified in this paragraph) of a frame exchange sequence initiated by the STA for a time period greater than or equal to the time specified by the Max Idle Period field

GAS FRAMES

I DOUBT IS THESE ARE FRAME EXCHANGE SEQUENCES and are simply FRAME SEQUENCES. The terms are intermixed. Assumed these are not protected by NAV and edited accordingly.

2381.49 Figure 11-38 (GAS frame sequence with dot11GASPauseForServerResponse equal to true) describes the GAS frame exchange ~~sequence~~

2381.54 Figure 11-39 (GAS frame sequence with GAS fragmentation and dot11GASPauseForServerResponse equal to true) describes the GAS frame exchange ~~sequence~~

2381.61 Figure 11-40 (GAS frame sequence with GAS fragmentation and dot11GASPauseForServerResponse equal to false) describes the GAS frame exchange ~~sequence~~

2382.1 Figure 11-41 (Group addressed GAS Query Request exchange frame ~~sequence~~) describes the GAS frame exchange ~~sequence~~ when a STA sends a Group Addressed GAS Request frame to a group of STAs.

2383.43 Figure 11-42 (Group addressed GAS Query Response exchange frame ~~sequence~~) describes a GAS frame exchange ~~sequence~~ when multiple STAs send a GAS Initial Request frame

2384.47 Figure 11-43 (Group addressed GAS Query Request for a specific fragment exchange ~~sequence~~) describes the GAS frame exchange ~~sequence~~

2385.1 Figure 11-44 (GAS frame exchange ~~sequence~~ using CAG Version) describes a GAS frame exchange ~~sequence~~

ALSO EDIT FIGURE 11-44 title

2392.34 Non-AP STAs receiving Beacon or Probe Response frames from different APs may choose to engage in GAS frame exchanges ~~sequences~~ with one or more of these APs

2392.38 Advertisement Server might or might not be dependent on the BSSID used in the GAS

frame exchange ~~sequence~~ and thus the STA from which the query was relayed

2392.50 not dependent on the BSSID value used in the GAS frame exchange ~~sequence~~ to post the quer

GDD I DON’T THINK THESE ARE PROTECTED> Need to check

2484.8 The frame exchange ~~sequence~~ between GDD enabling STA and GDD dependent STAs for enabling

their operation occurs in State 4 (see 11.3.1 (State variables)).

**PICS**

**3550.10 FS frame exchange sequence ANNEX B**

**(NOTE FS used as acronym)**

**3590.2, 5, 8, 12 These are all OK**

**3649.47** HCF frame exchange sequences

3665.43 A-MPDU frame exchange sequences

**4115.30** An RTS/CTS handshake is performed at the beginning of any frame exchange sequence where the PSDU contains an MPDU with the Type subfield equal to Data or Management and…

4129.53 This counter increments for each QoS (+)CF-Poll that has been received but could not be used due to the TXOP size being smaller than the time that is required for one frame exchange sequence."

Rest of the references are in Annex G