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Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Amendment 5: Enhancements for Higher Throughput

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

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Abstract: This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the IEEE 802.11 medium access control (MAC) sublayer so that modes of operation can be enabled that are capable of much higher throughputs, with a maximum throughput of at least 100 Mb/s, as measured at the MAC data service access point (SAP).
Keywords: high throughput, MAC, medium access control, MIMO, MIMO-OFDM, "multiple input, multiple output," PHY, physical layer, radio, wireless local area network, WLAN

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Introduction

This introduction is not part of IEEE Std 802.11n-2009, IEEE Standard for Information technology— Telecommunications and information exchange between systems—Local and metropolitan networks—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications— Amendment 5: Enhancements for Higher Throughput.

This amendment specifies enhancements to IEEE 802.11 physical layer (PHY) and medium access control (MAC) sublayer to provide modes of operation with useful data rates substantially higher than those previously available. Significantly higher IEEE 802.11 wireless local area network (WLAN) throughput is expected to improve user experiences for current applications and to enable new applications and market segments.

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IEEE Standard for
Information technology—
Telecommunications and information exchange between systems—
Local and metropolitan area networks—
Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Amendment 5: Enhancements for Higher Throughput

(This amendment is based on IEEE Std 802.11™-2007, as amended by IEEE Std 802.11k™-2008, IEEE Std 802.11r™-2008, IEEE Std 802.11y™-2008, and IEEE Std 802.11w™-2009.)

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NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.[1]

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Deletions and insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.

2. Normative references

Delete the following reference from Clause 2:

~~ISO/IEC 14977:1996, Information technology—Information technology. Syntactic Metalanguage. Extended BNF.~~

[1]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

3. Definitions

Insert the following definitions in alphabetical order into Clause 3, renumbering as necessary:

3.227 aggregate medium access control (MAC) protocol data unit (A-MPDU): A structure containing multiple MPDUs, transported as a single physical layer convergence procedure (PLCP) service data unit (PSDU) by the physical layer (PHY).

3.228 aggregate medium access control (MAC) service data unit (A-MSDU): A structure containing multiple MSDUs, transported within a single (unfragmented) data medium access control (MAC) protocol data unit (MPDU).

3.229 aggregate medium access control (MAC) service data unit (A-MSDU) subframe: A portion of an A-MSDU containing a header and associated MSDU.

3.230 antenna selection (ASEL) receiver: A station (STA) that performs receive ASEL.

3.231 antenna selection (ASEL) transmitter: A station (STA) that performs transmit ASEL.

3.232 beamformee: A station (STA) that receives a physical layer convergence procedure (PLCP) protocol data unit (PPDU) that was transmitted using a beamforming steering matrix.

3.233 beamformer: A station (STA) that transmits a physical layer convergence procedure (PLCP) protocol data unit (PPDU) using a beamforming steering matrix.

3.234 beamforming: A spatial filtering mechanism used at a transmitter to improve the received signal power or signal-to-noise ratio (SNR) at an intended receiver. *Syn:* beam steering.

3.235 calibration initiator: A station (STA) that initiates a calibration sequence.

3.236 calibration responder: A station (STA) that transmits during a calibration sequence in response to a transmission by a calibration initiator.

3.237 multiple input, multiple output (MIMO): A physical layer (PHY) configuration in which both transmitter and receiver use multiple antennas.

3.238 non-access-point (non-AP) station (STA): A STA that is not also an AP.

3.239 null data packet (NDP): A physical layer convergence procedure (PLCP) protocol data unit (PPDU) that carries no Data field.

3.240 operating channel width: The channel width in which the station (STA) is currently able to receive.

3.241 overlapping basic service set (OBSS): A basic service set (BSS) operating on the same channel as the station's (STA's) BSS and within (either partly or wholly) its basic service area (BSA).

3.242 primary channel: The common channel of operation for all stations (STAs) that are members of the basic service set (BSS).

3.243 quadrature binary phase shift keying (QBPSK): A binary phase shift keying modulation in which the binary data is mapped onto the imaginary (Q) axis.

3.244 receive chain: The physical entity that implements any necessary signal processing to provide the received signal to the digital baseband. Such signal processing includes filtering, amplification, down-conversion, and sampling.

3.245 sounding: The use of preamble training fields to measure the channel for purposes other than demodulation of the Data portion of the physical layer convergence procedure (PLCP) protocol data unit (PPDU) containing the training fields.

NOTE—These uses include calculation of transmit steering, calculation of recommended MCS, and calculation of calibration parameters.

3.246 space-time block coding/spatial multiplexing (STBC/SM): A combination of STBC and SM where one spatial stream is transmitted using STBC and one or two additional spatial streams are transmitted using SM.

3.247 space-time streams: Streams of modulation symbols created by applying a combination of spatial and temporal processing to one or more spatial streams of modulation symbols.

3.248 spatial multiplexing (SM): A transmission technique in which data streams are transmitted on multiple spatial channels that are provided through the use of multiple antennas at the transmitter and the receiver.

3.249 spatial stream: One of several streams of bits or modulation symbols that may be transmitted over multiple spatial dimensions that are created by the use of multiple antennas at both ends of a communications link.

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

Insert the following clause (Clause 3A) after Clause 3:

3A. Definitions specific to IEEE 802.11

The following terms and definitions are specific to this standard and are not appropriate for inclusion in the *IEEE Standards Dictionary: Glossary of Terms & Definitions*.[1]

3A.1 20 MHz basic service set (BSS): A BSS in which the Secondary Channel Offset field is set to SCN.

3A.2 20 MHz high-throughput (HT): A Clause 20 transmission using FORMAT=HT_MF or HT_GF and CH_BANDWIDTH=HT_CBW20.

3A.3 20 MHz mask physical layer convergence procedure (PLCP) protocol data unit (PPDU): A Clause 17 PPDU, a Clause 19 orthogonal frequency division multiplexing (OFDM) PPDU, or a Clause 20 20 MHz high-throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH set to HT_CBW20 and the CH_OFFSET parameter set to CH_OFF_20. The PPDU is transmitted using a 20 MHz transmit spectral mask defined in Clause 17, Clause 19, or Clause 20, respectively.

3A.4 20 MHz physical layer convergence procedure (PLCP) protocol data unit (PPDU): A Clause 15 PPDU, Clause 17 PPDU, Clause 18 PPDU, Clause 19 orthogonal frequency division multiplexing (OFDM) PPDU, or Clause 20 20 MHz high-throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH set to HT_CBW20.

[1]The *IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at http://shop.ieee.org/.

3A.5 20/40 MHz basic service set (BSS): A BSS in which the supported channel width of the access point (AP) or independent BSS (IBSS) dynamic frequency selection (DFS) owner (IDO) station (STA) is 20 MHz and 40 MHz (Channel Width field is set to 1) and the Secondary Channel Offset field is set to a value of SCA or SCB.

3A.6 40-MHz-capable (FC) high-throughput (HT) access point (AP): An HT AP that included a value of 1 in the Supported Channel Width Set subfield (indicating its capability to operate on a 40 MHz channel) of its most recent transmission of a frame containing an HT Capabilities element**.**

3A.7 40-MHz-capable (FC) high-throughput (HT) access point (AP) 2G4: An HT AP 2G4 that is also an FC HT AP.

3A.8 40-MHz-capable (FC) high-throughput (HT) access point (AP) 5G: An HT AP 5G that is also an FC HT AP.

3A.9 40-MHz-capable (FC) high-throughput (HT) station (STA): An HT STA that included a value of 1 in the Supported Channel Width Set subfield (indicating its capability to operate on a 40 MHz channel) of its most recent transmission of a frame containing an HT Capabilities element.

3A.10 40-MHz-capable (FC) high-throughput (HT) station (STA) 2G4: An HT STA 2G4 that is also an FC HT STA.

3A.11 40-MHz-capable (FC) high-throughput (HT) station (STA) 5G: An HT STA 5G that is also an FC HT STA.

3A.12 40 MHz high throughput (HT): A Clause 20 transmission using FORMAT=HT_MF or HT_GF and CH_BANDWIDTH=HT_CBW40.

3A.13 40 MHz mask physical layer convergence procedure (PLCP) protocol data unit (PPDU): One of the following PPDUs: 1) a 40 MHz high-throughput (HT) PPDU (TXVECTOR parameter CH_BANDWIDTH set to HT_CBW40); 2) a 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH set to NON_HT_CBW40); or 3) a Clause 20 20 MHz HT PPDU with the TXVECTOR parameter CH_BANDWIDTH set to HT_CBW20 and the CH_OFFSET parameter set to either CH_OFF_20U or CH_OFF_20L. The PPDU is transmitted using a 40 MHz transmit spectral mask defined in Clause 20.

3A.14 40 MHz physical layer convergence procedure (PLCP) protocol data unit (PPDU): A 40 MHz high-throughput (HT) PPDU (TXVECTOR parameter CH_BANDWIDTH set to HT_CBW40) or a 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH set to NON_HT_CBW40) as defined in Clause 20.

3A.15 basic space-time block coding (STBC) modulation and coding scheme (MCS): An MCS value and STBC encoder specification used in the transmission of STBC-encoded control frames and STBC-encoded group-addressed frames. The value is defined in 9.6.0c.

3A.16 BSSBasicMCSSet: The set of modulation and coding scheme (MCS) values that must be supported by all high-throughput (HT) stations (STAs) that are members of an HT basic service set (BSS).

3A.17 direct sequence spread spectrum/complementary code keying (DSSS/CCK): A Clause 15 or Clause 18 transmission.

3A.18 high-throughput (HT) basic service set (BSS): A BSS in which Beacon frames transmitted by an HT station (STA) include the HT Capabilities element.

3A.19 high-throughput-delayed (HT-delayed) block acknowledgment (Ack): A Delayed Block Ack mechanism that requires the use of the compressed BlockAck frame and the NoAck ack policy setting within both BlockAckReq and BlockAck frames. This Block Ack scheme is negotiated between two HT stations (STAs) that both support HT Delayed Block Ack.

3A.20 high-throughput-immediate (HT-immediate) block acknowledgment (Ack): An Immediate Block Ack mechanism that requires the use of the compressed BlockAck frame and an implicit Block Ack request and allows partial-state operation at the recipient. This Block Ack scheme is negotiated between two HT stations (STAs).

3A.21 high-throughput-greenfield (HT-greenfield) format: A physical layer convergence procedure (PLCP) protocol data unit (PPDU) format of the HT physical layer (PHY) using the HT-greenfield format preamble. This format is represented at the PHY data service access point (SAP) by the TXVECTOR/RXVECTOR FORMAT parameter being set to HT_GF.

3A.22 high-throughput-mixed (HT-mixed) format: A physical layer convergence procedure (PLCP) protocol data unit (PPDU) format of the HT physical layer (PHY) using the HT-mixed format preamble. This format is represented at the PHY data service access point (SAP) by the TXVECTOR/RXVECTOR FORMAT parameter being set to HT_MF.

3A.23 high-throughput (HT) physical layer convergence procedure (PLCP) protocol data unit (PPDU): A Clause 20 PPDU with the TXVECTOR FORMAT parameter set to HT_MF or HT_GF.

3A.24 high-throughput (HT) station (STA) 2G4: An HT STA that is also a STA 2G4.

3A.25 high-throughput (HT) station (STA) 5G: An HT STA that is also a STA 5G.

3A.26 independent basic service set (IBSS) dynamic frequency selection (DFS) owner (IDO) station (STA): A STA that is the DFS Owner of an IBSS that is operating on a channel within a regulatory class that has a value of 20 or 40 for the entry in the “Channel spacing” column and that has a value of 5 for the entry in the “Channel starting frequency” column of any of the tables found in Annex J.

3A.27 minimum downlink transmission time (DTT) to uplink transmission time (UTT) [DTT2UTT] spacing: The minimum time within a power save multi-poll (PSMP) sequence between the end of a station’s (STA’s) PSMP-DTT and the start of its PSMP-UTT.

3A.28 modulation and coding scheme (MCS): A specification of the high-throughput (HT) physical layer (PHY) parameters that consists of modulation order (e.g., BPSK, QPSK, 16-QAM, 64-QAM) and foward error correction (FEC) coding rate (e.g., 1/2, 2/3, 3/4, 5/6).

3A.29 modulation and coding scheme 32 (MCS 32) format: A physical layer convergence procedure (PLCP) protocol data unit (PPDU) format of the high-throughput (HT) physical layer (PHY) in which signals in two halves of the occupied channel width contain the same information. This HT PPDU format supports the lowest rate.

3A.30 modulation and coding scheme (MCS) feedback (MFB) requester: A station (STA) that transmits a physical layer convergence procedure (PLCP) protocol data unit (PPDU) containing an HT Control field with the MRQ subfield set to 1.

3A.31 modulation and coding scheme (MCS) feedback (MFB) responder: A station (STA) that transmits a physical layer convergence procedure (PLCP) protocol data unit (PPDU) containing an HT Control field with the MFB field containing an MCS index or the value 127 in response to a PPDU containing an HT Control field with the MRQ subfield is set to 1.

3A.32 non-40-MHz-capable (non-FC) high-throughput (HT) station (STA): A STA that is not an FC HT STA.

3A.33 nonaggregate medium access control (MAC) protocol data unit (non-A-MPDU) frame: A frame that is transmitted in a physical layer convergence procedure (PLCP) protocol data unit (PPDU) with the TXVECTOR AGGREGATION parameter either absent or set to NOT_AGGREGATED.

3A.34 non-high-throughput (non-HT) duplicate: A transmission format of the physical layer (PHY) that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels and allows a station (STA) in a non-HT basic service set (BSS) on either channel to receive the transmission.

3A.35 non-high-throughput (non-HT) duplicate frame: A frame transmitted in a non-HT duplicate physical layer convergence procedure (PLCP) protocol data unit (PPDU).

3A.36 non-high-throughput (non-HT) duplicate physical layer convergence procedure (PLCP) protocol data unit (PPDU): A PPDU transmitted by a Clause 20 physical layer (PHY) with the TXVECTOR FORMAT parameter set to NON_HT and the CH_BANDWIDTH parameter set to NON_HT_CBW40.

3A.37 non-high-throughput (non-HT) physical layer convergence procedure (PLCP) protocol data unit (PPDU): A Clause 20 physical layer (PHY) PPDU with the TXVECTOR FORMAT parameter set to NON_HT.

3A.38 Non-High-Throughput (non-HT) SIGNAL field (L-SIG) transmit opportunity (TXOP) protection: A protection mechanism in which protection is established by the non-HT SIG Length and Rate fields indicating a duration that is longer than the duration of the packet itself.

3A.39 non-phased-coexistence-operation-capable (non-PCO-capable) 20/40 station (STA): A high-throughput (HT) STA that included a value of 1 in the Supported Channel Width Set subfield (indicating its capability to operate on a 40 MHz channel) of its most recent transmission of a frame containing an HT Capabilities element and that sets the PCO field in the HT Extended Capabilities field to 0.

3A.40 non-space-time-block-coding (non-STBC) frame: A frame that is transmitted in a physical layer convergence procedure (PLCP) protocol data unit (PPDU) that has the TXVECTOR STBC parameter set to 0, or a frame that is received in a PPDU that has the RXVECTOR STBC parameter set to 0.

3A.41 null data packet (NDP) announcement: A physical layer convergence procedure (PLCP) protocol data unit (PPDU) that contains one or more +HTC frames (i.e., frames with an HT (high-throughput) Control field) that have the NDP Announcement subfield set to 1.

3A.42 payload protected (PP) aggregate medium access control (MAC) service data unit (A-MSDU): An A-MSDU that is protected with CTR with CBC-MAC Protocol (CCMP) but does not include the A-MSDU Present field (bit 7 of the QoS Control field) in the construction of the additional authentication data (AAD).

3A.43 phased coexistence operation (PCO): A basic service set (BSS) mode with alternating 20 MHz and 40 MHz phases controlled by an access point (AP).

3A.44 phased coexistence operation (PCO) active access point (AP): A high-throughput (HT) AP that is operating PCO.

3A.45 phased coexistence operation (PCO) active basic service set (BSS): A BSS in which a PCO active access point (AP) has the PCO Active field in the HT Operation element set to 1.

3A.46 phased coexistence operation (PCO) active non-access-point (non-AP) station (STA): A high-throughput (HT) non-AP STA that is associated with a PCO basic service set (BSS) and following PCO.

3A.47 phased coexistence operation (PCO) active station (STA): A STA that is either a PCO active access point (AP) or a PCO active non-AP STA.

3A.48 phased-coexistence-operation-capable (PCO-capable) access point (AP): A high-throughput (HT) AP that sets the PCO field in the HT Extended Capabilities field to 1.

3A.49 phased-coexistence-operation-capable (PCO-capable) non-access-point (non-AP) station (STA): A high-throughput (HT) non-AP STA that sets the PCO field in the HT Extended Capabilities field to 1.

3A.50 phased-coexistence-operation-capable (PCO-capable) station (STA): A STA that is either a PCO capable access point (AP) or a PCO capable non-AP STA.

3A.51 phased coexistence operation (PCO) inactive basic service set (BSS): A 20/40 MHz BSS in which an access point (AP) has the PCO Active field in the HT Operation element set to 0.

3A.52 power save multi-poll (PSMP): A mechanism that provides a time schedule that is used by an access point (AP) and its stations (STAs) to access the wireless medium. The mechanism is controlled using the PSMP Action frame.

3A.53 power save multi-poll (PSMP) burst: A series of one or more PSMP sequences, separated by short interframe space (SIFS).

3A.54 power save multi-poll downlink transmission time (PSMP-DTT): A period of time described by a PSMP frame during which the access point (AP) transmits.

3A.55 power save multi-poll (PSMP) sequence: A sequence of frames where the first frame is a PSMP frame that is followed by transmissions in zero or more power save multi-poll downlink transmission times (PSMP-DTTs) and then by transmissions in zero or more power save multi-poll uplink transmission times (PSMP-UTTs). The schedule of the PSMP-DTTs and PSMP-UTTs is defined in the PSMP frame.

3A.56 power save multi-poll (PSMP) session: The periodic generation of a PSMP burst aligned to its service period (SP).

3A.57 power save multi-poll uplink transmission time (PSMP-UTT): A period of time described by a PSMP frame during which a non-access-point (non-AP) station (STA) may transmit.

3A.58 power save multi-poll uplink transmission time (PSMP-UTT) spacing (PUS): The period of time between the end of one PSMP-UTT and the start of the following PSMP-UTT within the same PSMP sequence.

3A.59 reverse direction (RD) initiator: A station (STA) that is a transmit opportunity (TXOP) holder that transmits a medium access control (MAC) protocol data unit (MPDU) with the RDG/More PPDU subfield set to 1.

3A.60 reverse direction (RD) responder: A station (STA) that is not the RD initiator and whose medium access control (MAC) address matches the value of the Address 1 field of a received MAC protocol data unit (MPDU) that has the RDG/More PPDU subfield set to 1.

3A.61 secondary channel: A 20 MHz channel associated with a primary channel used by high-throughput (HT) stations (STAs) for the purpose of creating a 40 MHz channel.

3A.62 signaling and payload protected (SPP) aggregate medium access control (MAC) service data unit (A-MSDU): An A-MSDU that is protected with CTR with CBC-MAC Protocol (CCMP) and that includes the A-MSDU Present field (bit 7 of the QoS Control field) in the construction of the additional authentication data (AAD).

3A.63 sounding physical layer convergence procedure (PLCP) protocol data unit (PPDU): A PPDU that is intended by the transmitting station (STA) to enable the receiving STA to estimate the channel between the transmitting STA and the receiving STA. The Not Sounding field in the High-Throughput SIGNAL field (HT-SIG) is set to 0 in sounding PPDUs.

3A.64 space-time block coding (STBC) beacon: A beacon that is transmitted using the basic STBC modulation and coding scheme (MCS) to enable discovery of the basic service set (BSS) by high-throughput (HT) stations (STAs) that support the HT STBC feature in order to extend the range of the BSS.

3A.65 space-time block coding (STBC) delivery traffic indication map (DTIM): An STBC beacon transmission that is a DTIM beacon.

3A.66 space-time block coding (STBC) frame: A frame that is transmitted in a physical layer convergence procedure (PLCP) protocol data unit (PPDU) that has the TXVECTOR STBC parameter set to a nonzero value, or a frame that is received in a PPDU that has the RXVECTOR STBC parameter set to a nonzero value.

3A.67 staggered preamble: A physical layer convergence procedure (PLCP) preamble in a sounding PLCP protocol data unit (PPDU) that is not a null data packet (NDP) and that includes one or more Data Long Training fields (DLTFs) and one or more Extension Long Training fields (ELTFs).

3A.68 staggered sounding: The use of a sounding physical layer convergence procedure (PLCP) protocol data unit (PPDU) that is not a null data packet (NDP) and that includes one or more Data Long Training fields (DLTFs) and one or more Extension Long Training fields (ELTFs).

3A.69 station (STA) 2G4: A STA that is operating on a channel that belongs to any regulatory class that has a value of 25 or 40 for the entry in the “Channel spacing” column and that has a value of 2.407 or 2.414 for the entry in the “Channel starting frequency” column of any of the tables found in Annex J.

3A.70 station (STA) 5G: A STA that is operating on a channel that belongs to any regulatory class that has a value of 20 or 40 for the entry in the “Channel spacing” column and that has a value of 5 for the entry in the “Channel starting frequency” column of any of the tables found in Annex J.

4. Abbreviations and acronyms

Insert the following abbreviations and acronyms into Clause 4 in alphabetical order:

A-MPDU	aggregate MAC protocol data unit
A-MSDU	aggregate MAC service data unit
ASEL	antenna selection
CSD	cyclic shift diversity
CSI	channel state information
CTS1	clear to send 1
CTS2	clear to send 2
DFT	discrete Fourier transform

DLTF	Data Long Training field
ELTF	Extension Long Training field
FEC	forward error correction
HT	high throughput
HTC	high throughput control
HT-GF-STF	High-Throughput Greenfield Short Training field
HT-SIG	High-Throughput SIGNAL field
HT-STF	High-Throughput Short Training field
IDFT	inverse discrete Fourier transform
IDO	IBSS DFS owner
LDPC	low-density parity check
L-LTF	Non-HT Long Training field
L-SIG	Non-HT SIGNAL field
L-STF	Non-HT Short Training field
LTF	Long Training field
MCS	modulation and coding scheme
MFB	MCS feedback
MIMO	multiple input, multiple output
MRQ	MCS request
NDP	null data packet
OBSS	overlapping basic service set
PBAC	protected block ack agreement capable
PCO	phased coexistence operation
PP A-MSDU	payload protected aggregate MAC service data unit
PSMP	power save multi-poll
PSMP-DTT	power save multi-poll downlink transmission time
PSMP-UTT	power save multi-poll uplink transmission time
QBPSK	quadrature binary phase shift keying
RD	reverse direction
RDG	reverse direction grant
RIFS	reduced interframe space
RXASSI	receive antenna selection sounding indication
RXASSR	receive antenna selection sounding request
SM	spatial multiplexing
SNR	signal-to-noise ratio
SPP A-MSDU	signaling and payload protected aggregate MAC service data unit

STBC	space-time block coding
TXASSI	transmit antenna selection sounding indication
TXASSR	transmit antenna selection sounding request

5. General description

5.2 Components of the IEEE 802.11 architecture

Insert the following subclause (5.2.9) after 5.2.8.4:

5.2.9 High-throughput (HT) station (STA)

The IEEE 802.11 HT STA provides physical layer (PHY) and medium access control (MAC) features that can support a throughput of 100 Mb/s and greater, as measured at the MAC data service access point (SAP). An HT STA supports HT features as identified in Clause 9 and Clause 20. An HT STA operating in the 5 GHz band supports transmission and reception of frames that are compliant with mandatory PHY specifications as defined in Clause 17. An HT STA operating in the 2.4 GHz band supports transmission and reception of frames that are compliant with mandatory PHY specifications as defined in Clause 18 and Clause 19. An HT STA is also a quality of service (QoS) STA. The HT features are available to HT STAs associated with an HT access point (AP) in a basic service set (BSS). A subset of the HT features is available for use between two HT STAs that are members of the same independent basic service set (IBSS).

An HT STA has PHY features consisting of the modulation and coding scheme (MCS) set described in 20.3.5 and physical layer convergence procedure (PLCP) protocol data unit (PPDU) formats described in 20.1.4. Some PHY features that distinguish an HT STA from a non-HT STA are referred to as multiple input, multiple output (MIMO) operation; spatial multiplexing (SM); spatial mapping (including transmit beamforming); space-time block coding (STBC); low-density parity check (LDPC) encoding; and antenna selection (ASEL). The allowed PPDU formats are non-HT format, HT-mixed format, and HT-greenfield format. The PPDUs may be transmitted with 20 MHz or 40 MHz bandwidth.

An HT STA has MAC features that include frame aggregation, some Block Ack features, power save multi-poll (PSMP) operation, reverse direction (RD), and protection mechanisms supporting coexistence with non-HT STAs.

6. MAC service definition

6.1 Overview of MAC services

6.1.5 MAC data service architecture

Change the first two paragraphs of 6.1.5 as follows:

The MAC data plane architecture (i.e., processes that involve transport of all or part of a MAC service data unit (MSDU) is shown in Figure 6-1. During transmission, an MSDU goes through some or all of the following processes: <u>aggregate MSDU (A-MSDU) aggregation, </u>frame delivery deferral during power save mode, sequence number assignment, fragmentation, encryption, integrity protection, ~~and~~ frame formatting<u>, and aggregate MAC protocol data unit (A-MPDU) aggregation</u>. IEEE Std 802.1X-2004 may block the MSDU at the Controlled Port. At some point, the data frames that contain all or part of the MSDU are queued per access category/traffic stream (AC/TS).~~ This queuing may be at any of the three points indicated in Figure 6-1.~~

During reception, a received data frame goes through processes of possible A-MPDU deaggregation, MPDU header and cyclic redundancy code (CRC) validation, duplicate removal, possible reordering if the Block Ack mechanism is used, decryption, defragmentation, integrity checking, and replay detection. After replay detection (or defragmentation if security is used) and possible A-MSDU deaggregation, ~~the~~ one or more MSDUs ~~is~~ are delivered to the MAC_SAP or to the DS. The IEEE 802.1X Controlled/Uncontrolled Ports discard ~~the~~ any received MSDU if the Controlled Port is not enabled and if the MSDU does not represent an IEEE 802.1X frame. TKIP and CCMP MPDU frame order enforcement occurs after decryption, but prior to MSDU defragmentation; therefore, defragmentation will fail if MPDUs arrive out of order.

Replace Figure 6-1 with the following figure:

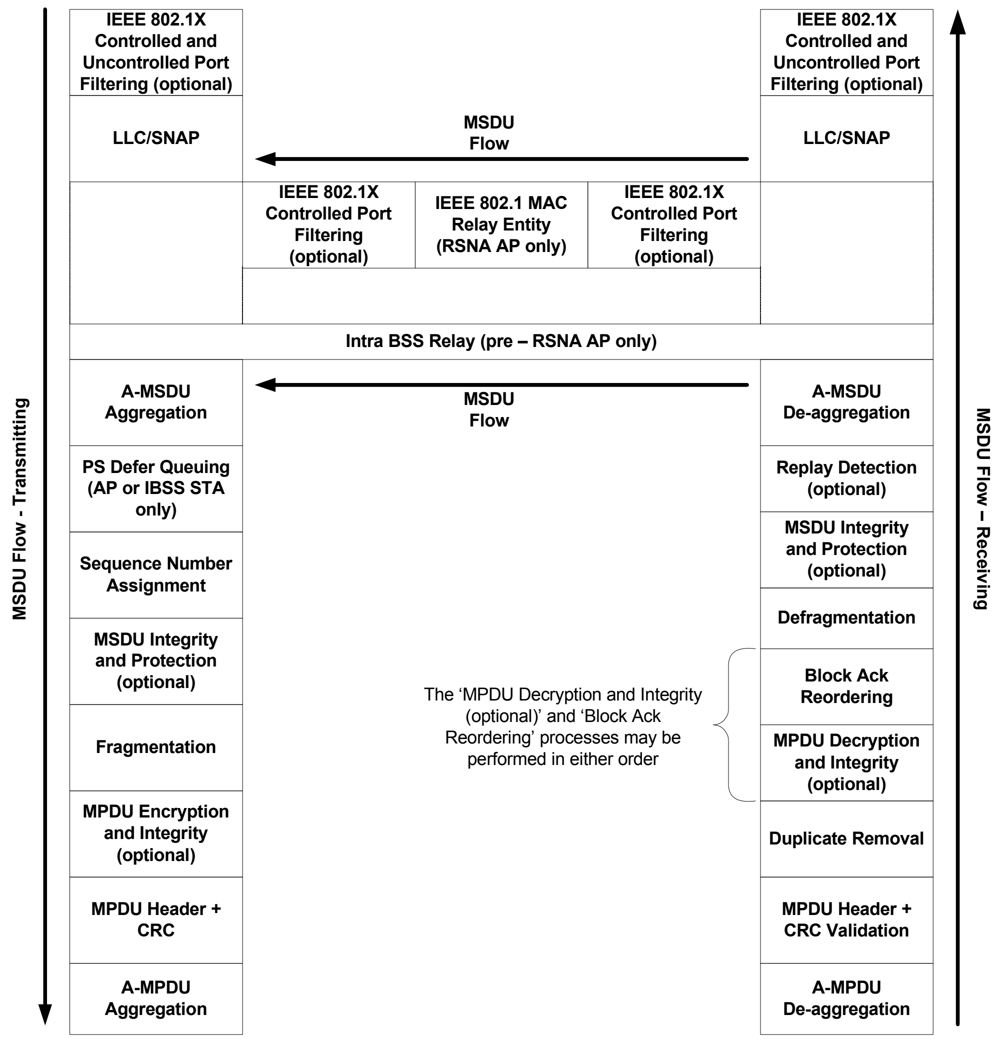


Figure 6-1—MAC data plane architecture

7. Frame formats

7.1 MAC frame formats

Change list item a) in 7.1 as follows:

a) A *MAC header*, which comprises frame control, duration, address, ~~and~~ optional sequence control information, ~~and, for QoS data frames~~ optional QoS ~~c~~Control ~~information~~ (QoS data frames only), and optional HT Control fields (+HTC frames only);

7.1.1 Conventions

Change the second paragraph of 7.1.1 as follows:

In figures, all bits within fields are numbered, from 0 to k, where the length of the field is $k + 1$ bits. Bits within numeric fields that are longer than a single bit are depicted in increasing order of significance, i.e., with the lowest numbered bit having the least significance. The octet boundaries within a field can be obtained by taking the bit numbers of the field modulo 8. Octets within numeric fields that are longer than a single octet are depicted in increasing order of significance, from lowest numbered bit to highest numbered bit. The octets in fields longer than a single octet are sent to the PLCP in order from the octet containing the lowest numbered bits to the octet containing the highest numbered bits.

Insert the following paragraph after the seventh paragraph in 7.1.1:

A frame that contains the HT Control field, including the Control Wrapper frame, is referred to as a *+HTC frame*.

7.1.2 General frame format

Change the first two paragraphs of 7.1.2 as follows:

The MAC frame format comprises a set of fields that occur in a fixed order in all frames. Figure 7-1 depicts the general MAC frame format. The first three fields (Frame Control, Duration/ID, and Address 1) and the last field (FCS) in Figure 7-1 constitute the minimal frame format and are present in all frames, including reserved types and subtypes. The fields Address 2, Address 3, Sequence Control, Address 4, QoS Control, HT Control, and Frame Body are present only in certain frame types and subtypes. Each field is defined in 7.1.3. The format of each of the individual subtypes of each frame types is defined in 7.2. The components of management frame bodies are defined in 7.3. The formats of management frames of subtype Action are defined in 7.4.

The Frame Body field is of variable size. The maximum frame body size is determined by the maximum MSDU size (2304 octets) or the maximum A-MSDU size (3839 or 7935 octets, depending upon the STA's capability), plus any overhead from security encapsulation.

Replace Figure 7-1 with the following figure:.

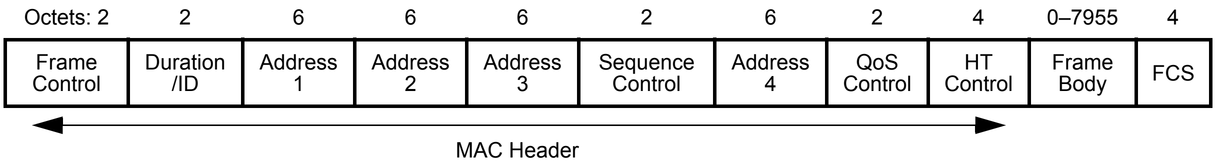


Figure 7-1—MAC frame format

7.1.3 Frame fields

7.1.3.1 Frame Control field

7.1.3.1.2 Type and Subtype fields

Insert management subtype 1110, change the management reserved subtypes row, change the control reserved subtypes row, and insert the control subtype 0111 in Table 7-1 as follows (note that the entire table is not shown here):

Table 7-1—Valid type and subtype combinations

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
00	Management	1110	Action No Ack
00	Management	~~1110–~~1111	Reserved
01	Control	0000–011~~1~~0	Reserved
01	Control	0111	Control Wrapper

7.1.3.1.6 Power Management field

Change the first paragraph of 7.1.3.1.6 as follows:

The Power Management field is 1 bit in length and is used to indicate the power management mode of a STA. The value of this field remains constant in each frame from a particular STA within a frame exchange sequence (see Annex S)~~defined in 9.12~~. The value indicates the mode in which the STA will be after the successful completion of the frame exchange sequence.

7.1.3.1.7 More Data field

Change the first paragraph of 7.1.3.1.7 as follows:

The More Data field is 1 bit in length and is used to indicate to a STA in PS mode that more MSDUs, A-MSDUs, or MMPDUs are buffered for that STA at the AP. The More Data field is valid in directed data or management type frames transmitted by an AP to a STA in PS mode. A value of 1 indicates that at least one additional buffered MSDU, A-MSDU, or MMPDU is present for the same STA.

7.1.3.1.9 Order field

Change 7.1.3.1.9 as follows :

The Order field is 1 bit in length. ~~and is set to 1 in any non-QoS data frame that contains an MSDU, or fragment thereof, which is being transferred using the StrictlyOrdered service class. This field is set to 0 in all other frames. All QoS STAs set this subfield to 0.~~ It is used for two purposes:

- When set to 1 in a non-QoS data frame transmitted by a non-QoS STA, it indicates that the frame contains an MSDU, or fragment thereof, which is being transferred using the StrictlyOrdered service class.
- When set to 1 in a QoS data or management frame transmitted with a value of HT_GF or HT_MF for the FORMAT parameter of the TXVECTOR, it indicates that the frame contains an HT Control field.

Otherwise, the Order field is set to 0.

7.1.3.2 Duration/ID field

Insert the following paragraph and note at the end of 7.1.3.2:

The Duration/ID fields in the MAC headers of MPDUs in an A-MPDU all carry the same value.

NOTE—The reference point for the Duration/ID field is the end of the PPDU carrying the MPDU. Setting the Duration/ID field to the same value in the case of A-MPDU aggregation means that each MPDU consistently specifies the same NAV setting.

7.1.3.3 Address fields

7.1.3.3.3 BSSID (BSS identification) field

Change the third paragraph of 7.1.3.3.3 as follows:

The value of all 1s is used to indicate the wildcard BSSID. A wildcard BSSID shall not be used in the BSSID field except for management frames of subtype probe request and of subtype Action with Category Public.

7.1.3.3.4 DA (destination address) field

Change 7.1.3.3.4 as follows:

The DA field contains an IEEE MAC individual or group address that identifies the MAC entity or entities intended as the final recipient(s) of the MSDU (or fragment thereof) or A-MSDU, as defined in 7.2.2.1, contained in the frame body field.

7.1.3.3.5 SA (source address) field

Change 7.1.3.3.5 as follows:

The SA field contains an IEEE MAC individual address that identifies the MAC entity from which the transfer of the MSDU (or fragment thereof) or A-MSDU, as defined in 7.2.2.1, contained in the frame body field was initiated. The individual/group bit is always transmitted as a zero in the source address.

7.1.3.4 Sequence Control field

7.1.3.4.1 Sequence Number field

Change 7.1.3.4.1 as follows:

The Sequence Number field is a 12-bit field indicating the sequence number of an MSDU, A-MSDU, or MMPDU. Each MSDU, A-MSDU, or MMPDU transmitted by a STA is assigned a sequence number. Sequence numbers are not assigned to control frames, as the Sequence Control field is not present.

Non-QoS STAs, as well as QoS STAs operating as non-QoS STAs because they are in a non-QoS BSS or non-QoS IBSS, assign sequence ~~numbers,~~ numbers to management frames and data frames (QoS subfield of the Subtype field is set to 0), from a single modulo-4096 counter, starting at 0 and incrementing by 1 for each MSDU or MMPDU.

QoS STAs associated in a QoS BSS maintain one modulo-4096 counter, per traffic identifer (TID), per unique receiver (specified by the Address 1 field of the MAC header). Sequence numbers for QoS data frames are assigned using the counter identified by the TID subfield of the QoS Control field of the frame, and that counter is incremented by 1 for each MSDU or A-MSDU belonging to that TID. Sequence numbers for management frames, QoS data frames with a ~~broadcast/multicast~~ group address in the Address 1 field, and all non-QoS data frames sent by QoS STAs are assigned using an additional single modulo-4096 counter, starting at 0 and incrementing by 1 for each MSDU, A-MSDU, or MMPDU. Sequence numbers for QoS (+)Null frames may be set to any value.

Each fragment of an MSDU or MMPDU contains a copy of the sequence number assigned to that MSDU or MMPDU. The sequence number remains constant in all retransmissions of an MSDU, MMPDU, or fragment thereof.

7.1.3.4.2 Fragment Number field

Change 7.1.3.4.2 as follows:

The Fragment Number field is a 4-bit field indicating the number of each fragment of an MSDU or MMPDU. The fragment number is set to 0 in the first or only fragment of an MSDU or MMPDU and is incremented by one for each successive fragment of that MSDU or MMPDU. The fragment number is set to 0 in the only fragment of an A-MSDU. The fragment number remains constant in all retransmissions of the fragment.

7.1.3.5 QoS Control field

Change the first paragraph of 7.1.3.5 as follows:

The QoS Control field is a 16-bit field that identifies the traffic category (TC) or traffic stream (TS) to which the frame belongs and various other QoS-related information about the frame that varies by frame type and subtype. The QoS Control field is present in all data frames in which the QoS subfield of the Subtype field is set to 1 (see 7.1.3.1.2). Each QoS Control field comprises five subfields, as defined for the particular sender (HC or non-AP STA) and frame type and subtype. The usage of these subfields and the various possible layouts of the QoS Control field are described 7.1.3.5.1 through ~~7.1.3.5.7~~ 7.1.3.5.8 and illustrated in Table 7-4.

Change Table 7-4 as follows:

Table 7-4—QoS Control field

Applicable frame (sub) types	**Bits 0–3**	**Bit 4**	**Bit 5–6**	**Bit 7**	**Bits 8–15**
QoS CF-Poll and QoS CF-Ack+CF-Poll frames sent by HC ~~QoS (+)CF-Poll frames sent by HC~~	TID	EOSP	Ack Policy	Reserved	TXOP Limit
QoS Data+CF-Poll and QoS Data+CF-Ack+CF-Poll frames sent by HC	TID	EOSP	Ack Policy	A-MSDU Present	TXOP Limit
QoS Data and QoS Data+CF-Ack frames sent by HC	TID	EOSP	Ack Policy	A-MSDU Present	AP PS Buffer State
QoS Null frames sent by HC ~~QoS Data, QoS Null, and QoS Data+CF-Ack frames sent by HC~~	TID	EOSP	Ack Policy	Reserved	AP PS Buffer State
QoS Data and QoS Data+CF-Ack frames sent by non-AP STAs	TID	0	Ack Policy	A-MSDU Present	TXOP Duration Requested
	TID	1	Ack Policy	A-MSDU Present	Queue Size
QoS Null frames sent by non-AP STAs ~~QoS data frames sent by non-AP STAs~~	TID	0	Ack Policy	Reserved	TXOP Duration Requested
	TID	1	Ack Policy	Reserved	Queue Size

7.1.3.5.1 TID subfield

Change the first paragraph of 7.1.3.5.1 as follows:

The TID subfield identifies the TC or TS to which the corresponding ~~MSDU, or fragment thereof,~~ MSDU (or fragment thereof) or A-MSDU in the Frame Body field belongs. The TID subfield also identifies the TC or TS of traffic for which a TXOP is being requested, through the setting of TXOP duration requested or queue size. The encoding of the TID subfield depends on the access policy (see 7.3.2.30) and is shown in Table 7-5. Additional information on the interpretation of the contents of this field appears in 6.1.1.2.

7.1.3.5.3 Ack Policy subfield

Change the first three rows of Table 7-6 as follows (note that the entire table is not shown here):

Table 7-6—Ack Policy subfield in QoS Control field of QoS data frames

Bits in QoS Control field		Meaning
Bit 5	**Bit 6**	
0	0	Normal Ack or Implicit Block Ack Request. In a frame that is a non-A-MPDU frame: The addressed recipient returns an ACK or QoS +CF-Ack frame after a short interframe space (SIFS) period, according to the procedures defined in 9.2.8~~, 9.3.3~~ and 9.9.2.3. ~~The Ack Policy subfield is set to this value in all directed frames in which the sender requires acknowledgment.~~ For QoS Null (no data) frames, this is the only permissible value for the Ack Policy subfield. In a frame that is part of an A-MPDU: The addressed recipient returns a BlockAck MPDU, either individually or as part of an A-MPDU starting a SIFS after the PPDU carrying the frame, according to the procedures defined in 9.2.8a, 9.10.7.5, 9.10.8.3, 9.15.3, 9.15.4 and 9.19.3.
1	0	No Ack The addressed recipient takes no action upon receipt of the frame. More details are provided in 9.11. The Ack Policy subfield is set to this value in all directed frames in which the sender does not require acknowledgment. This combination is also used for ~~broadcast and multicast~~ group-addressed frames that use the QoS frame format. This combination is not used for QoS data frames with a TID for which a Block Ack agreement exists.
0	1	No Explicit Acknowledgment or PSMP Ack. When bit 6 of the Frame Control field (see 7.1.3.1.2) is set to 1: There may be a response frame to the frame that is received, but it is neither the ACK nor any data frame of subtype +CF-Ack. For QoS CF-Poll and QoS CF-Ack+CF-Poll data frames, this is the only permissible value for the Ack Policy subfield. When bit 6 of the Frame Control field (see 7.1.3.1.2) is set to 0: The acknowledgment for a frame indicating PSMP Ack when it appears in a PSMP downlink transmission time (PSMP-DTT) is to be received in a later PSMP uplink transmission time (PSMP-UTT). The acknowledgment for a frame indicating PSMP Ack when it appears in a PSMP-UTT is to be received in a later PSMP-DTT. NOTE—Bit 6 of the Frame Control field (see 7.1.3.1.2) indicates the absence of a data payload. When set to 1, the QoS data frame contains no payload, and any response is generated in response to a QoS CF-Poll or QoS CF-Ack+CF-Poll frame, but does not signify an acknowledgment of data. When set to 0, the QoS data frame contains a payload, which is acknowledged as described in 9.16.1.7.

7.1.3.5.5 Queue Size subfield

Change the second paragraph of 7.1.3.5.5 as follows:

The queue size value is the total size, rounded up to the nearest multiple of 256 octets and expressed in units of 256 octets, of all MSDUs and A-MSDUs buffered at the STA (excluding the MSDU or A-MSDU of the present QoS data frame) in the delivery queue used for MSDUs and A-MSDUs with TID values equal to the value in the TID subfield of this QoS Control field. A queue size value of 0 is used solely to indicate the absence of any buffered traffic in the queue used for the specified TID. A queue size value of 254 is used for all sizes greater than 64 768 octets. A queue size value of 255 is used to indicate an unspecified or unknown size. If a QoS data frame is fragmented, the queue size value may remain constant in all fragments even if the amount of queued traffic changes as successive fragments are transmitted.

7.1.3.5.6 TXOP Duration Requested subfield

Change the second paragraph of 7.1.3.5.6 as follows:

TXOP Duration Requested subfield values are not cumulative. A TXOP duration requested for a particular TID supersedes any prior TXOP duration requested for that TID. A value of 0 in the TXOP Duration Requested subfield may be used to cancel a pending unsatisfied TXOP request when its MSDU or A-MSDU is no longer queued for transmission. The TXOP duration requested is inclusive of the PHY and IFS overhead, and a STA should account for this when attempting to determine whether a given transmission fits within a specified TXOP duration.

7.1.3.5.7 AP PS Buffer State subfield

Change the third and fourth paragraphs of 7.1.3.5.7 as follows:

The Highest-Priority Buffered AC subfield is 2 bits in length and is used to indicate the AC of the highest priority traffic remaining that is buffered at the AP, excluding the MSDU or A-MSDU of the present frame.

The AP Buffered Load subfield is 4 bits in length and is used to indicate the total buffer size, rounded up to the nearest multiple of 4096 octets and expressed in units of 4096 octets, of all MSDUs and A-MSDUs buffered at the QoS AP (excluding the MSDU or A-MSDU of the present QoS data frame). An AP Buffered Load field value of 15 indicates that the buffer size is greater than 57 344 octets. An AP Buffered Load subfield value of 0 is used solely to indicate the absence of any buffered traffic for the indicated highest priority buffered AC when the Buffer State Indicated bit is 1.

Insert the following subclause (7.1.3.5.8) after 7.1.3.5.7:

7.1.3.5.8 A-MSDU Present subfield

The A-MSDU Present subfield is 1 bit in length and indicates the presence of an A-MSDU. When the A-MSDU Present subfield is set to 1, the Frame Body field contains an entire A-MSDU as defined in 7.2.2.2. When the A-MSDU Present subfield is set to 0, the Frame Body field contains an MSDU or fragment thereof as defined in 7.2.2.1.

Insert the following subclause (7.1.3.5a) after 7.1.3.5.8:

7.1.3.5a HT Control field

The HT Control field is always present in a Control Wrapper frame and is present in QoS Data and management frames as determined by the Order bit of the Frame Control field as defined in 7.1.3.1.9.

NOTE—The only Control frame subtype for which HT Control field is present is the Control Wrapper frame. A control frame that is described as +HTC (e.g., RTS+HTC, CTS+HTC, BlockAck+HTC or BlockAckReq+HTC) implies the use of the Control Wrapper frame to carry that control frame.

The format of the 4-octet HT Control field is shown in Figure 7-4a.

	B0 B15	B16 B17	B18 B19	B20 B21	B22 B23	B24	B25 B29	B30	B31
	Link Adaptation Control	Calibration Position	Calibration Sequence	Reserved	CSI/ Steering	NDP Announce-ment	Reserved	AC Constraint	RDG/ More PPDU
Bits:	16	2	2	2	2	1	5	1	1

Figure 7-4a—HT Control field

The format of the Link Adaptation Control subfield of the HT Control field is defined in Figure 7-4b.

	B0	B1	B2 B5	B6 B8	B9 B15
	Reserved	TRQ	MAI	MFSI	MFB/ASELC
Bits:	1	1	4	3	7

Figure 7-4b—Link Adaptation Control subfield

The subfields of the Link Adaptation Control subfield are defined in Table 7-6a.

Table 7-6a—Subfields of Link Adaptation Control subfield

Subfield	Meaning	Definition
TRQ	Training request	Set to 1 to request the responder to transmit a sounding PPDU. When set to 0, the responder is not requested to transmit a sounding PPDU. See 9.19.2 and 9.21.2.
MAI	MCS request (MRQ) or ASEL indication	When set to 14 (indicating ASELI), the MFB/ASELC subfield is interpreted as ASELC. Otherwise, the MAI subfield is interpreted as shown in Figure 7-4c, and the MFB/ASELC subfield is interpreted as MCS feedback (MFB).
MFSI	MCS feedback sequence identifier	Set to the received value of MSI contained in the frame to which the MFB information refers. Set to 7 for unsolicited MFB.
MFB/ASELC	MCS feedback and antenna selection command/data	When the MAI subfield is set to the value ASELI, this subfield is interpreted as defined in Figure 7-4d and Table 7-6c. Otherwise, this subfield contains recommended MFB. A value of 127 indicates that no feedback is present.

The structure of the MAI subfield of the Link Adaptation Control subfield is defined in Figure 7-4c. The subfields of the MAI subfield are defined in Table 7-6b.

	B0	B1 B3
	MRQ	MSI
Bits:	1	3

Figure 7-4c—MAI subfield

Table 7-6b—Subfields of the MAI subfield

Subfield	Meaning	Definition
MRQ	MCS request	When the MRQ subfield is set to 1, MFB is requested. When set to 0, no MFB is requested.
MSI	MRQ sequence identifier	When the MRQ subfield is set to 1, the MSI subfield contains a sequence number in the range 0 to 6 that identifies the specific request.When the MRQ subfield is set to 0, the MSI subfield is reserved.

The ASELC subfield of the Link Adaptation Control subfield contains the ASEL Command and ASEL Data subfields, as shown in Figure 7-4d. The encoding of these subfields is shown in Table 7-6c.

	B0 B2	B3 B6
	ASEL Command	ASEL Data
Bits:	3	4

Figure 7-4d—ASELC subfield

Table 7-6c—ASEL Command and ASEL Data subfields

ASEL Command	Interpretation of ASEL Command	ASEL Data
0	Transmit Antenna Selection Sounding Indication (TXASSI)	Number of remaining sounding PPDUs to be transmitted 0 to 15 See NOTE
1	Transmit Antenna Selection Sounding Request (TXASSR) or Transmit ASEL Sounding Resumption	0 when the command is Transmit ASEL Sounding Request A number in the range of values of 1 through 15, the number being the number of the first sounding PPDU to be transmitted when the command is Transmit ASEL Sounding Resumption, where 0 corresponds to the first sounding PPDU in the original ASEL training sequence

Table 7-6c—ASEL Command and ASEL Data subfields *(continued)*

ASEL Command	Interpretation of ASEL Command	ASEL Data
2	Receive Antenna Selection Sounding Indication (RXASSI)	Number of remaining sounding PPDUs to be received 0 to 15 See NOTE
3	Receive Antenna Selection Sounding Request (RXASSR)	Number of sounding PPDUs required 0 to 15
4	Sounding Label	Sequence number of the sounding PPDU corresponding to a channel state information (CSI) frame in ASEL feedback 0 to 15
5	No Feedback Due to ASEL Training Failure or Stale Feedback	A number in the range of values of 0 through 15, the number being the number of the first sounding PPDU that was not received properly, where 0 corresponds to the first sounding PPDU in the ASEL training sequence, or 0 if no sounding PPDUs were received properly, or 0 if this is a request for a full retraining sequence
6	Transmit Antenna Selection Sounding Indication requesting feedback of explicit CSI (TXASSI-CSI)	Number of remaining sounding PPDUs to be transmitted 0 to 15 See NOTE
7	Reserved	Reserved
NOTE—If the HT Control field is carried in a sounding PPDU, then the value of the ASEL Data field contains the remaining number of sounding frames following the current one. If null data packet (NDP) sounding frame is used, then the value in the ASEL Data field contains the number of NDPs following a non-NDP+HTC. The NDP Announcement subfield in the HT Control field is set to 1 to indicate NDP sounding.		

The Calibration Position and Calibration Sequence subfields of the HT Control field are defined in Table 7-6d.

The Calibration Sequence subfield identifies an instance of the calibration procedure. The subfield is included in each frame within a calibration procedure, and its value is unchanged for frames within the same calibration procedure.

Table 7-6d—Calibration control subfields

Subfield	Meaning	Definition
Calibration Position	Position in calibration sounding exchange sequence	Set to 0 indicates this is not a calibration frame. Set to 1 indicates calibration start. Set to 2 indicates sounding response. Set to 3 indicates sounding complete.
Calibration Sequence	Calibration sequence identifier	The field is included in each frame within the calibration procedure and its value is unchanged for the frame exchanges during one calibration procedure. See 9.19.2.4.3.

The CSI/Steering subfield of the HT Control field indicates the type of feedback, as shown in Table 7-6e.

Table 7-6e—CSI/Steering subfield values

Value	Definition
0	No feedback required
1	CSI
2	Noncompressed beamforming
3	Compressed beamforming

The NDP Announcement subfield of the HT Control field indicates that an NDP will be transmitted after the frame (according to the rules described in 9.21). It is set to 1 to indicate that an NDP will follow; otherwise, it is set to 0.

The AC Constraint subfield of the HT Control field indicates whether the mapped AC of an RD data frame is constrained to a single AC, as defined in Table 7-6f.

Table 7-6f—AC Constraint subfield values

Value	Description
0	The response to a reverse direction grant (RDG) may contain data frames from any TID
1	The response to an RDG may contain data frames only from the same AC as the last data frame received from the RD initiator

The RDG/More PPDU subfield of the HT Control field is interpreted differently depending on whether it is transmitted by an RD initiator or an RD responder, as defined in Table 7-6g.

Table 7-6g—RDG/More PPDU subfield values

Value	Role of transmitting STA	Interpretation of value
0	RD initiator	No reverse grant
	RD responder	The PPDU carrying the frame is the last transmission by the RD responder
1	RD initiator	An RDG is present, as defined by the Duration/ID field
	RD responder	The PPDU carrying the frame is followed by another PPDU

7.1.3.6 Frame Body field

Change 7.1.3.6 as follows:

The Frame Body is a variable length field that contains information specific to individual frame types and subtypes. The minimum length of the frame body is 0 octets. The maximum length of the frame body is defined by the maximum length MSDU or A-MSDU plus any overhead for encryption as defined in Clause 8.~~(MSDU + ICV + IV), where integrity check value (ICV) and initialization vector (IV) are the WEP fields defined in 8.2.1~~.

Change the heading of 7.1.4 as follows:

7.1.4 Duration/ID field (QoS STA)~~in data and management frames~~

Delete the text of 7.1.4 (starting "Within all data frames..." and ending "...final frame in the TXOP."), and insert the following subclauses (7.1.4.1 through 7.1.4.8) after the heading for 7.1.4:

7.1.4.1 General

The value in the Duration/ID field in a frame transmitted by a QoS STA is defined in 7.1.4.2 through 7.1.4.8.

All times are calculated in microseconds. If a calculated duration includes a fractional microsecond, that value inserted in the Duration/ID field is rounded up to the next higher integer.

7.1.4.2 Setting for single and multiple protection under enhanced distributed channel access (EDCA)

Within a frame (excluding data frames containing QoS CF-Poll, PSMP frames, and frames that have the RDG/More PPDU subfield set to 1) transmitted under EDCA by a STA that initiates a TXOP, there are two classes of duration settings: single protection and multiple protection. In single protection, the value of the Duration/ID field of the frame can set a NAV value at receiving STAs that protects up to the end of any following data, management, or response frame plus any additional overhead frames as described below. In multiple protection, the value of the Duration/ID field of the frame can set a NAV that protects up to the estimated end of a sequence of multiple frames. Frames that have the RDG/More PPDU subfield set to 1 always use multiple protection. PSMP frames always use multiple protection. The STA selects between single and multiple protection when it transmits the first frame of a TXOP. All subsequent frames transmitted by the STA in the same TXOP use the same class of duration settings.

a) Single protection settings.
   1) For an RTS that is not part of a dual clear-to-send (CTS) exchange, the Duration/ID field is set to the estimated time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus one ACK or BlockAck frame if required, plus any NDPs required, plus explicit feedback if required, plus applicable IFS durations.
   2) For all CTS frames sent by STAs as the first frame in the exchange under EDCA and with the receiver address (RA) matching the MAC address of the transmitting STA, the Duration/ID field is set to one of the following:
      i) If there is a response frame, the estimated time required to transmit the pending frame, plus one SIFS interval, plus the response frame (ACK or BlockAck), plus an additional SIFS interval
      ii) If there is no response frame, the time required to transmit the pending frame, plus one SIFS interval
   3) For a BlockAckReq frame, the Duration/ID field is set to the estimated time required to transmit one ACK or BlockAck frame, as applicable, plus one SIFS interval.

4) For a BlockAck frame that is not sent in response to a BlockAckReq or an implicit Block Ack request, the Duration/ID field is set to the estimated time required to transmit an ACK frame plus a SIFS interval.

5) For management frames, non-QoS data frames (i.e., with bit 7 of the Frame Control field set to 0), and individually addressed data frames with the Ack Policy subfield set to Normal Ack only, the Duration/ID field is set to one of the following:

i) If the frame is the final fragment of the TXOP, the estimated time required for the transmission of one ACK frame (including appropriate IFS values)

ii) Otherwise, the estimated time required for the transmission of one ACK frame, plus the time required for the transmission of the following MPDU and its response if required, plus applicable IFS durations.

6) For individually addressed QoS data frames with the Ack Policy subfield set to No Ack or Block Ack, for management frames of subtype Action No Ack, and for group-addressed frames, the Duration/ID field is set to one of the following:

i) If the frame is the final fragment of the TXOP, 0

ii) Otherwise, the estimated time required for the transmission of the following frame and its response frame, if required (including appropriate IFS values)

b) Multiple protection settings. The Duration/ID field is set to a value D as follows:

1) If $T_{TXOP} = 0$ and $T_{END\_NAV} = 0$, then D = $T_{SINGLE\text{-}MSDU} - T_{PPDU}$

2) Else if $T_{TXOP} = 0$ and $T_{END\_NAV} > 0$, then D = $T_{END\text{-}NAV} - T_{PPDU}$

3) Else if $T_{END\text{-}NAV} = 0$, then $\min(T_{PENDING}, T_{TXOP} - T_{PPDU}) \le D \le T_{TXOP} - T_{PPDU}$

4) Else $T_{END-NAV} - T_{PPDU} \le D \le T_{TXOP-REMAINING} - T_{PPDU}$

where

$T_{SINGLE\text{-}MSDU}$ is the estimated time required for the transmission of the allowed frame exchange sequence defined in 7.3.2.29 (for a TXOP limit value of 0), including applicable IFS durations

$T_{PENDING}$ is the estimated time required for the transmission of

— Pending MPDUs of the same AC
— Any associated immediate response frames
— Any NDP transmissions and explicit feedback response frames
— Applicable IFS durations
— Any RDG

T_{TXOP} is the value of the MIB attribute dot11EDCATableTXOPLimit (dot11EDCAQAPTableTXOPLimit for the AP) for that AC

$T_{TXOP\_REMAINING}$ is T_{TXOP} less the time already used time within the TXOP

$T_{END\text{-}NAV}$ is the remaining duration of any NAV set by the TXOP holder, or 0 if no NAV has been established

T_{PPDU} is the time required for transmission of the current PPDU

7.1.4.3 Setting for QoS CF-Poll frames

Within a data frame containing QoS CF-Poll, the Duration/ID field value is set to one of the following:

a) One SIFS duration plus the TXOP limit, if the TXOP limit is nonzero, or

b) The time required for the transmission of one MPDU of nominal MSDU size and the associated ACK frame plus two SIFS intervals, if the TXOP limit is zero.

7.1.4.4 Setting for frames sent by a TXOP holder under HCCA

Within a frame sent by a TXOP holder under hybrid coordination function (HCF) controlled channel access (HCCA), to ensure NAV protection for the entire CAP, the Duration/ID field is set to one of the following values:

a) For an RTS frame
   1) If the pending frame is the final frame, the time required to transmit the pending frame, plus one CTS frame, plus one ACK frame if required, plus three SIFS intervals
   2) If the pending frame is not the final frame in the TXOP, the remaining duration of the TXOP
b) For a CTS frame
   1) If the pending frame is the sole frame in the TXOP, one of the following:
      i) If there is a response frame, the time required to transmit the pending frame, plus one SIFS interval, plus the response frame (ACK or BlockAck), plus an additional SIFS interval
      ii) If there is no response frame, the time required to transmit the pending frame, plus one SIFS interval
   2) If the pending frame is not the final frame in the TXOP, the remaining duration of the TXOP
c) Otherwise
   1) If the frame is a nonfinal frame in a TXOP with multiple frame exchanges, the remaining duration of the TXOP
   2) If the frame is the sole or final frame in the TXOP, the actual remaining time needed for this frame exchange sequence

7.1.4.5 Settings within a PSMP sequence

Within a PSMP frame, the Duration/ID field is set to a value that is no less than the time required to complete all PSMP-DTT and PSMP-UTT periods described in the frame.

Within the PSMP-DTT and PSMP-UTT of a PSMP sequence, the Duration/ID field is set to the Duration/ID value of the preceding PSMP frame minus the time between the end of the PSMP frame and the end of the PPDU carrying the frame.

NOTE—In other words, all frames transmitted within a PSMP sequence locate the same NAV endpoint.

7.1.4.6 Settings within a dual CTS sequence

Within a frame (“Frame1”) (excluding a second CTS (CTS2) transmission, as defined in 9.2.5.5a) sent by a QoS STA that is not a TXOP holder in a PPDU that contains an immediate response or that is sent by an RD responder, the Duration/ID field is set to the Duration/ID value from the frame(s) (“Frames2”) that elicited the response or that carried the RDG minus the time interval between the end of the PPDU that carried Frame1 and the end of the PPDU that carries Frames2.

Within a frame (“Frame1”) (excluding a CTS2 transmission, as defined in 9.2.5.5a) sent by a QoS STA that is a TXOP holder, the Duration/ID field is set according to the rules in the following subclauses:

— 7.1.4.2 rule b) for multiple protection if Frame1 is not a QoS+CF-Poll frame and the TXOP holder is not operating under HCCA or PSMP
— 7.1.4.3 if Frame1 is a QoS+CF-Poll frame and the TXOP holder is not operating under HCCA or PSMP
— 7.1.4.4 if the TXOP holder is operating under HCCA
— 7.1.4.5. if the TXOP holder is operating under PSMP

Within the CTS2 of a dual CTS exchange, defined in 9.2.5.5a, the Duration/ID field is set to the value of the Duration/ID field of the RTS that initiated the exchange minus the time required to transmit the first clear-to-sent (CTS1), CTS2, and the applicable IFS intervals.

7.1.4.7 Setting for control response frames

This subclause describes how to set the Duration/ID field for CTS, ACK, and BlockAck control response frames transmitted by a QoS STA.

For a CTS frame that is not part of a dual CTS sequence transmitted in response to an RTS frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the RTS frame that elicited the response minus the time, in microseconds, between the end of the PPDU carrying the RTS frame and the end of the PPDU carrying the CTS frame.

For an ACK frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the ACK frame.

For a BlockAck frame transmitted in response to a BlockAckReq frame or transmitted in response to a frame containing an implicit Block Ack request, the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the BlockAck frame.

7.1.4.8 Setting for other response frames

For any frame transmitted by a STA that is not the TXOP holder and is not specified by 7.1.4.1 through 7.1.4.7, the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds, between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the frame.

7.2 Format of individual frame types

7.2.1 Control frames

7.2.1.1 RTS frame format

Change the fourth and fifth paragraphs of 7.2.1.1 as follows:

For all RTS frames sent by non-QoS STAs, the duration value is the time, in microseconds, required to transmit the pending data or management frame, plus one CTS frame, plus one ACK frame, plus three SIFS intervals. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. <u>For RTS frames sent by QoS STAs, see 7.1.4.</u> ~~For all RTS frames sent by STAs under EDCA, following a contention access of the channel, the duration value is set in the following manner:~~

— ~~If the NAV protection is desired for only the first or sole frame in the TXOP, the duration value is set to the time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus one ACK frame if required, plus three SIFS intervals.~~

— ~~Otherwise, the duration value is set to the remaining duration of the TXOP.~~

~~For all RTS frames sent under HCCA, the duration value is set to one of the following values:~~

— ~~If the pending frame is the final frame, the duration value is set to the time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus one ACK frame if required, plus three SIFS intervals.~~

— ~~If the pending frame is not the final frame in the TXOP, the duration value is set to the remaining duration of the TXOP.~~

7.2.1.2 CTS frame format

Change the third paragraph of 7.2.1.2 as follows:

For all CTS frames <u>transmitted by a non-QoS STA</u> ~~sent~~ in response to RTS frames, the duration value is the value obtained from the Duration field of the immediately previous RTS frame, minus the time, in microseconds, required to transmit the CTS frame and its SIFS interval. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer.

Delete the fifth paragraph (starting with "For all CTS frames...") of 7.2.1.2.

Delete the sixth paragraph (starting with "For CTS frames sent under HCCA...") of 7.2.1.2.

Insert the following paragraph at the end of 7.2.1.2:

For other CTS transmissions by a QoS STA, the duration value is set as defined in 7.1.4.

7.2.1.3 ACK frame format

Change the third paragraph of 7.2.1.3 as follows:

For ACK frames sent by non-QoS STAs, if the More Fragments bit was set to 0 in the Frame Control field of the immediately previous directed data or management frame, the duration value is set to 0. In ~~all~~ other ACK frames<u> sent by non-QoS STAs</u>, the duration value is the value obtained from the Duration/ID field of the immediately previous data, management, PS-Poll, BlockAckReq, or BlockAck frame minus the time, in microseconds, required to transmit the ACK frame and its SIFS interval. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer.

Insert the following new paragraph at the end of 7.2.1.3:

In all other ACK frames, the duration value is specified by 7.1.4.

Change the heading of 7.2.1.7 as follows:

7.2.1.7 ~~Block Ack Request (~~BlockAckReq~~)~~ frame format

Insert the following heading (7.2.1.7.1) immediately after the heading for 7.2.1.7:

7.2.1.7.1 Overview

Replace Figure 7-12 with the following figure:

Octets: 2	2	6	6	2	Variable	4
Frame Control	Duration/ID	RA	TA	BAR Control	BAR Information	FCS

← MAC Header → (Frame Control through TA)

Figure 7-12—BlockAckReq frame

Change the second paragraph (inclusing the deletion of footnote 16) of the new 7.2.1.7.1 as follows:

The Duration/ID field value is set as defined in 7.1.4. ~~greater than or equal to the time~~[16]~~, in microseconds, required to transmit one ACK or BlockAck frame, as applicable, plus one SIFS interval. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer.~~

[16]~~To allow the possibility of time remaining in the TXOP, which the sender may use to schedule other transmissions.~~

Replace Figure 7-13 with the following figure:

B0	B1	B2	B3 B11	B12 B15
BAR Ack Policy	Multi-TID	Compressed Bitmap	Reserved	TID_INFO
Bits: 1	1	1	9	4

Figure 7-13—BAR Control field

Delete the sixth paragraph (starting "The TID subfield…") of the new 7.2.1.7.1.

Delete the seventh paragraph (starting "The Block Ack Starting Sequence Control…") of the new 7.2.1.7.1.

Insert the following text, tables (Table 7-6h and Table 7-6i), and subclause (7.2.1.7.2) after Figure 7-13 in the new 7.2.1.7.1 and before Figure 7-14, which is now in the new 7.2.1.7.2:

The BAR Ack Policy subfield of the BAR Control field has the meaning shown in Table 7-6h.

Table 7-6h—BAR Ack Policy subfield

Value	Meaning
0	Normal Acknowledgment. The BAR Ack Policy subfield is set to this value when the sender requires immediate acknowledgment. The addressee returns an ACK. See 9.16.1.7.
1	No Acknowledgment. The addressee sends no immediate response upon receipt of the frame. The BAR Ack Policy subfield is set to this value when the sender does not require immediate acknowledgment. The value 1 is not used in a Basic BlockAckReq frame outside a PSMP sequence. The value 1 is not used in an Multi-TID BlockAckReq frame.

The values of the Multi-TID and Compressed Bitmap subfields determine which of three possible BlockAckReq frame variants is represented, as indicated in Table 7-6i.

Table 7-6i—BlockAckReq frame variant encoding

Multi-TID subfield value	Compressed Bitmap subfield value	BlockAckReq frame variant
0	0	Basic BlockAckReq
0	1	Compressed BlockAckReq
1	0	Reserved
1	1	Multi-TID BlockAckReq

The meaning of the TID_INFO subfield of the BAR Control field depends on the BlockAckReq frame variant type. The meaning of this subfield is explained within the subclause for each of the BlockAckReq frame variants.

The meaning of the BAR Information field of the BlockAckReq frame depends on the BlockAckReq frame variant type. The meaning of this field is explained within the subclause for each of the BlockAckReq frame variants.

NOTE—Reference to “a BlockAckReq” frame without any other qualification from other subclauses applies to any of the variants, unless specific exclusions are called out.

7.2.1.7.2 Basic BlockAckReq variant

The TID_INFO subfield of the BAR Control field of the Basic BlockAckReq frame contains the TID for which a Basic BlockAck frame is requested.

The BAR Information field of the Basic BlockAckReq frame contains the Block Ack Starting Sequence Control subfield, as shown in Figure 7-14. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU for which this Basic BlockAckReq frame is sent. The Fragment Number subfield is set to 0.

Insert the following subclauses (7.2.1.7.3 and 7.2.1.7.4) after 7.2.1.7.2:

7.2.1.7.3 Compressed BlockAckReq variant

The TID_INFO subfield of the BAR Control field of the Compressed BlockAckReq frame contains the TID for which a BlockAck frame is requested.

The BAR Information field of the Compressed BlockAckReq frame contains the Block Ack Starting Sequence Control subfield, as shown in Figure 7-14. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAckReq frame is sent. The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.

7.2.1.7.4 Multi-TID BlockAckReq variant

The TID_INFO subfield of the BAR Control field of the Multi-TID BlockAckReq frame determines the number of TIDs present in the Multi-TID BlockAckReq frame as given by TID_INFO + 1, e.g., a value of 2 in the TID_INFO subfield means that three TID values are present in the Multi-TID BlockAckReq frame's BAR Information field.

The BAR Information field of the Multi-TID BlockAckReq frame comprises multiple sets of Per TID Info subfields and Block Ack Starting Sequence Control subfields, as shown in Figure 7-14a. The Per TID Info subfield is shown in Figure 7-4b. The Block Ack Starting Sequence Control subfield is shown in Figure 7-14. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAckReq frame is sent. The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.

Octets:	2	2
	Per TID Info	Block Ack Starting Sequence Control

Repeat for each TID

Figure 7-14a—BAR Information field (Multi-TID BlockAckReq)

	B0 B11	B12 B15
	Reserved	TID Value
Bits:	12	4

Figure 7-14b—Per TID Info subfield

Change the heading of 7.2.1.8 as follows:

7.2.1.8 ~~Block Ack (~~BlockAck~~)~~ frame format

Insert the following heading (7.2.1.8.1) immediately after the heading for 7.2.1.8:

7.2.1.8.1 Overview

Replace Figure 7-15 with the following figure:

Octets: 2	2	6	6	2	variable	4
Frame Control	Duration/ID	RA	TA	BA Control	BA Information	FCS

MAC Header

Figure 7-15—BlockAck frame

Change the second paragraph (including the deletion of footnote 17) of the new 7.2.1.8.1 as follows:

~~If the BlockAck frame is sent in response to the BlockAckReq frame, the~~ The Duration/ID field value is set as defined in 7.1.4. ~~the value obtained from the Duration/ID field of the immediate BlockAckReq frame, minus the time, in microseconds, required to transmit the BlockAck frame and its SIFS interval. If the BlockAck frame is not sent in response to the BlockAckReq, the Duration/ID field value is greater than (subject to the TXOP limit) or equal to the time[17] for transmission of an ACK frame plus a SIFS interval. If the calculated duration includes a fractional microsecond, that value is rounded to the next higher integer.~~

~~[17]The default values for TXOP limit are expressed in milliseconds and are multiples of 32 µs.~~

Replace Figure 7-16 with the following figure:

	B0	B1	B2	B3 B11	B12 B15
	BA Ack Policy	Multi-TID	Compressed Bitmap	Reserved	TID_INFO
Bits:	1	1	1	9	4

Figure 7-16—BA Control field

Delete the sixth paragraph (starting "The Block Ack Starting Sequence field…") of the new 7.2.1.8.1.

Delete the seventh paragraph (starting "The Block Ack Bitmap field…") of the new 7.2.1.8.1.

Insert the following text and tables (Table 7-6j and Table 7-6k) at the end of the new 7.2.1.8.1:

The BA Ack Policy subfield of the BAR Control field has the meaning shown in Table 7-6j.

Table 7-6j—BA Ack Policy subfield

Value	Meaning
0	Normal Acknowledgment. The BA Ack Policy subfield is set to this value when the sender requires immediate acknowledgment. The addressee returns an ACK. The value 0 is not used for data sent under HT-delayed BlockAck during a PSMP sequence.
1	No Acknowledgment. The addressee sends no immediate response upon receipt of the frame. The BA Ack Policy is set to this value when the sender does not require immediate acknowledgment. The value 1 is not used in a Basic BlockAck frame outside a PSMP sequence. The value 1 is not used in an Multi-TID BlockAck frame.

The values of the Multi-TID and Compressed Bitmap subfields of the BAR Control field determine which of three possible BlockAck frame variants is represented, as indicated in the Table 7-6k.

Table 7-6k—BlockAck frame variant encoding

Multi-TID subfield value	Compressed Bitmap subfield value	BlockAck frame variant
0	0	Basic BlockAck
0	1	Compressed BlockAck
1	0	Reserved
1	1	Multi-TID BlockAck

NOTE—Reference to “a BlockAck” frame without any other qualification from other subclauses applies to any of the variants, unless specific exclusions are called out.

The meaning of the TID_INFO subfield of the BA Control field depends on the BlockAck frame variant type. The meaning of this subfield is explained within the subclause for each of the BlockAck frame variants.

The meaning of the BA Information field depends on the BlockAck frame variant type. The meaning of this field is explained within the subclause for each of the BlockAck frame variants.

Insert the following subclauses (7.2.1.8.2 through 7.2.1.8.4 and then 7.2.1.9) and figures (Figure 7-16a through Figure 7-16d) after 7.2.1.8.1:

7.2.1.8.2 Basic BlockAck variant

The TID_INFO subfield of the BA Control field of the Basic BlockAck frame contains the TID for which a BlockAck frame is requested.

The BA Information field of the Basic BlockAck frame comprises the Block Ack Starting Sequence Control subfield and the Block Ack Bitmap subfield, as shown in Figure 7-16a. The format of the Block Ack Starting Sequence Control subfield is shown in Figure 7-14. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU for which this Basic BlockAck frame is sent and is set to the same value as in the immediately previously received Basic BlockAckReq frame.

Octets:	2	128
	Block Ack Starting Sequence Control	Block Ack Bitmap

Figure 7-16a—BA Information field (BlockAck)

The Block Ack Bitmap subfield is 128 octets in length and is used to indicate the received status of up to 64 MSDUs. Bit position n of the Block Ack bitmap, if set to 1, acknowledges receipt of an MPDU with an MPDU sequence control value equal to (Block Ack Starting Sequence Control + n). Bit position n of the Block Ack bitmap, if set to 0, indicates that an MPDU with MPDU sequence control value equal to (Block Ack Starting Sequence Control + n) has not been received. Each of the MPDU Sequence Control field and

Block Ack Starting Sequence Control subfield values are treated as a 16-bit unsigned integer. For unused fragment numbers of an MSDU, the corresponding bits in the bitmap are set to 0.

7.2.1.8.3 Compressed BlockAck variant

The TID_INFO subfield of the BA Control field of the Compressed BlockAck frame contains the TID for which a BlockAck frame is requested.

The BA Information field of the Compressed BlockAck frame comprises the Block Ack Starting Sequence Control subfield and the Block Ack Bitmap subfield, as shown in Figure 7-16b. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAck frame is sent. The value of this subfield is defined in 9.10.7.5. The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.

Octets:	2	8
	Block Ack Starting Sequence Control	Block Ack Bitmap

Figure 7-16b—BA Information field (Compressed BlockAck)

The Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is 8 octets in length and is used to indicate the received status of up to 64 MSDUs and A-MSDUs. Each bit that is set to 1 in the compressed Block Ack bitmap acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number, with the first bit of the Block Ack bitmap corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

7.2.1.8.4 Multi-TID BlockAck variant

The TID_INFO subfield of the BA Control field of the Multi-TID BlockAck frame contains the number of TIDs, less one, for which information is reported in the BA Information field. For example, a value of 2 in the TID_INFO subfield means that information for three TIDs is present.

The BA Information field of the Multi-TID BlockAck frame comprises 1 or more instances of the Per TID Info, Block Ack Starting Sequence Control, and the Block Ack Bitmap subfields, as shown in Figure 7-16c. The Per TID Info subfield is shown in Figure 7-14b, and the Block Ack Starting Sequence Control subfield is shown in Figure 7-14.

The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield is the sequence number of the first MSDU or A-MSDU for which this BlockAck frame is sent. The value of this subfield is defined in 9.10.7.5. The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0. The first instance of the Per TID Info, Block Ack Starting Sequence Control, and Block Ack Bitmap subfields that is transmitted corresponds to the lowest TID value, with subsequent instances ordered by increasing values of the Per TID Info subfield.

Octets:	2	2	8
	Per TID Info	Block Ack Starting Sequence Control	Block Ack Bitmap

Repeat for each TID

Figure 7-16c—BA Information field (Multi-TID BlockAck)

The Block Ack Bitmap subfield of the BA Information field of the Multi-TID BlockAck frame contains an 8-octet Block Ack bitmap. Each bit that is set to 1 in the Block Ack bitmap acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number with the first bit of the Block Ack bitmap corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

7.2.1.9 Control Wrapper frame

The format of the Control Wrapper frame is shown in Figure 7-16d.

Octets: 2	2	6	2	4	variable	4
Frame Control	Duration/ID	Address 1	Carried Frame Control	HT Control	Carried Frame	FCS

Figure 7-16d—Control Wrapper frame

The Control Wrapper frame is used to carry any other control frame (i.e., excluding the Control Wrapper frame) together with a HT Control field.

The Frame Control field is defined in 7.2.1. The value for the subtype field is the value from Table 7-1 of 7.1.3.1.2 that corresponds to Control Wrapper frame.

The value for the Duration/ID field of the Control Wrapper frame is generated by following the rules for the Duration/ID field of the control frame that is being carried.

The value for the Address 1 field of the Control Wrapper frame is generated by following the rules for the Address 1 field of the control frame that is being carried.

The Carried Frame Control field contains the value of the Frame Control field of the carried control frame.

The HT Control field is defined in 7.1.3.5a.

The Carried Frame field contains the fields that follow the Address 1 field of the control frame that is being carried, excluding the FCS field.

The FCS field is defined in 7.1.3.7.

7.2.2 Data frames

Insert the following heading (7.2.2.1) immediately after the heading for 7.2.2:

7.2.2.1 Data frame format

Replace Figure 7-17 with the following figure:

Octets: 2	2	6	6	6	2	6	2	4	0–7955	4
Frame Control	Duration/ ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	QoS Control	HT Control	Frame Body	FCS

MAC Header

Figure 7-17—Data frame

Change the fourth paragraph of the new 7.2.2.1 as follows:

The content of the address fields of data frames are dependent upon the values of the To DS and From DS fields in the Frame Control field and whether the Frame Body field contains either an MSDU (or fragment thereof) or an entire A-MSDU, as determined by the A-MSDU Present subfield of the QoS Control field (see 7.1.3.5.8). The content of the address fields is defined in Table 7-7. Where the content of a field is shown as not applicable (N/A), the field is omitted. Note that Address 1 always holds the receiver address of the intended receiver (or, in the case of ~~multicast~~ group-addressed frames, receivers) and that Address 2 always holds the address of the STA that is transmitting the frame.

Change Table 7-7 as follows:

Table 7-7—Address field contents

To DS	From DS	Address 1	Address 2	Address 3		Address 4	
				MSDU case	**A-MSDU case**	**MSDU case**	**A-MSDU case**
0	0	RA = DA	TA = SA	BSSID	BSSID	N/A	N/A
0	1	RA = DA	TA = BSSID	SA	BSSID	N/A	N/A
1	0	RA = BSSID	TA = SA	DA	BSSID	N/A	N/A
1	1	RA	TA	DA	BSSID	SA	BSSID

Change the seventh and eighth paragraphs of the new 7.2.2.1 as follows:

The DA field contains ~~is~~ the destination of the MSDU (or fragment thereof) or A-MSDU in the Frame Body field.

The SA field contains ~~is~~ the address of the MAC entity that initiated the MSDU (or fragment thereof) or A-MSDU in the Frame Body field.

Insert the following two new paragraphs and note after the eigth paragraph of the new 7.2.2.1:

When a data frame carries an MSDU (or fragment thereof), the DA and SA values related to that MSDU are carried in the Address 1, Address 2, Address 3, and Address 4 fields (according to the setting of the To DS and From DS fields) as defined in Table 7-7.

When a data frame carries an A-MSDU, the DA and SA values related to each MSDU carried by the A-MSDU are carried within the A-MSDU. One or both of these fields may also be present in the Address 1 and Address 2 fields as indicated in Table 7-7.

NOTE—If a DA or SA value also appears in any of these address fields, the value is necessarily the same for all MSDUs within the A-MSDU because this is guaranteed by the To DS and From DS field settings.

Insert the following paragraph in the new 7.2.2.1 after the paragraph stating "The QoS Control field is defined in 7.1.3.5." (formerly paragraph 13 in the old 7.2.2):

The HT Control field is defined in 7.1.3.5a. The presence of the HT Control field is determined by the Order subfield of the Frame Control field, as specified in 7.1.3.1.9.

Change the following paragraphs (formerly paragraphs 14 through 16 in the old 7.2.2) in the new 7.2.2.1:

The frame body consists of the ~~MSDU, or a fragment thereof,~~ <u>MSDU (or a fragment thereof) or A-MSDU</u> and a security header and trailer (if and only if the Protected Frame subfield in the Frame Control field is set to 1). ~~The frame body is null (0 octets in length) in data frames of subtype Null (no data), CF-Ack (no data), CF-Poll (no data), and CF-Ack+CF-Poll (no data), regardless of the encoding of the QoS subfield in the Frame Control field.~~ <u>The presence of an A-MSDU in the frame body is indicated by setting the A-MSDU Present subfield of the QoS Control field to 1, as shown in Table 7-4.</u>

For data frames of subtype Null (no data), CF-Ack (no data), CF-Poll (no data), and CF-Ack+CF-Poll (no data) and for the corresponding QoS data frame subtypes, the Frame Body field is <u>null (i.e., has a length of 0 octets)</u> ~~omitted~~; these subtypes are used for MAC control purposes. For data frames of subtypes Data, Data+CF-Ack, Data+CF-Poll, and ~~Data+CF-Ack+CF+Poll~~ <u>Data+CF-Ack+CF-Poll,</u> ~~and for the corresponding four QoS data frame subtypes,~~ the Frame Body field contains all of, or a fragment of, an MSDU after any encapsulation for security. <u>For data frames of subtypes QoS Data, QoS Data+CF-Ack, QoS Data+CF-Poll, and QoS Data+CF-Ack+CF-Poll, the Frame Body field contains an MSDU (or fragment thereof) or A-MSDU after any encapsulation for security.</u>

The maximum length of the Frame Body field can be determined from the maximum MSDU <u>or A-MSDU</u> length plus any overhead from encapsulation for encryption (i.e., it is always possible to send a maximum length MSDU, with any encapsulations provided by the MAC layer within a single data MPDU). <u>When the frame body carries an A-MSDU, the size of the frame body field may be limited by</u>

- <u>The PHY's maximum PLCP service data unit (PSDU) length</u>
- <u>If A-MPDU aggregation is used, a maximum MPDU length of 4095 octets (see 7.4a)</u>

Insert the following subclause (7.2.2.2) after 7.2.2.1:

7.2.2.2 A-MSDU format

An A-MSDU is a sequence of A-MSDU subframes as shown in Figure 7-17a. Each A-MSDU subframe consists of an A-MSDU subframe header followed by an MSDU and 0 to 3 octets of padding as shown in Figure 7-17b. Each A-MSDU subframe (except the last) is padded so that its length is a multiple of 4 octets. The last A-MSDU subframe has no padding.

The A-MSDU subframe header contains three fields: DA, SA, and Length. The order of these fields and the bits within these fields are the same as the IEEE 802.3 frame format. The DA and SA fields of the A-MSDU subframe header contain the values passed in the MA-UNITDATA.request and MA-UNITDATA.indication primitives. The Length field contains the length in octets of the MSDU.

A-MSDU subframe 1	A-MSDU subframe 2	…	A-MSDU subframe n

Figure 7-17a—A-MSDU structure

Octets: 6	6	2	0–2304	0–3
DA	SA	Length	MSDU	Padding

A-MSDU subframe header

Figure 7-17b—A-MSDU subframe structure

An A-MSDU contains only MSDUs whose DA and SA parameter values map to the same receiver address (RA) and transmitter address (TA) values, i.e., all the MSDUs are intended to be received by a single receiver, and necessarily they are all transmitted by the same transmitter. The rules for determining RA and TA are independent of whether the frame body carries an A-MSDU.

NOTE—It is possible to have different DA and SA parameter values in A-MSDU subframe headers of the same A-MSDU as long as they all map to the same Address 1 and Address 2 parameter values.

The MPDU containing the A-MSDU is carried in any of the following data frame subtypes: QoS Data, QoS Data + CF-Ack, QoS Data + CF-Poll, QoS Data + CF-Ack + CF-Poll. The A-MSDU structure is contained in the frame body of a single MPDU. If encrypted, the MPDU is encrypted as a single unit.

NOTE 1—The value of TID present in the QoS Control field of the MPDU carrying the A-MSDU indicates the TID for all MSDUs in the A-MSDU. Because this value of TID is common to all MSDUs in the A-MSDU, only MSDUs delivered to the MAC by an MA-UNITDATA.request with an integer priority parameter that maps to the same TID can be aggregated together using A-MSDU.

NOTE 2—The maximum MPDU length that can be transported using A-MPDU aggregation is 4095 octets. An A-MSDU cannot be fragmented. Therefore, an A-MSDU of a length that exceeds 4065 octets (4095 minus the QoS data MPDU overhead) cannot be transported in an A-MPDU.

7.2.3 Management frames

Replace Figure 7-18 with the following figure:

Octets: 2	2	6	6	6	2	4	0–2312	4
Frame Control	Duration	Address 1 (DA)	SA	BSSID	Sequence Control	HT Control	Frame Body	FCS

MAC Header

Figure 7-18—Management frame format

Change the second to the fourth paragraphs of 7.2.3 as follows:

A STA uses the contents of the Address 1 (DA) field to perform the address matching for receive decisions. In the case where the Address 1 (DA) field contains a group address and the frame subtype is other than Beacon, the BSSID also is validated to ensure that the broadcast or multicast originated from a STA in the BSS of which the receiving STA is a member. When the Address 1 (DA) field contains a group address and the frame subtype is either Probe Request or Action with Category Public, a wildcard BSSID value matches all receiving STA's BSSIDs. If the frame subtype is Beacon, other address matching rules apply, as specified in 11.1.2.3. Frames of subtype Probe Request with a group address in the Address 1 field are additionally processed as described in 11.1.3.2.1. If the frame subtype is Action, the Category is Public, and the Action is 20/40 BSS Coexistence Management, then additional address matching rules for receive decisions apply as specified in 11.14 and 11.16.

The address fields for management frames do not vary by frame subtype.

The BSSID of the management frame is determined as follows:

a) In management frames of subtype Probe Request, the BSSID is either a specific BSSID as described in item c) below or the wildcard BSSID as defined in the procedures specified in 11.1.3.

b) In management frames of subtype Action, Category Public, the BSSID value is set according to 11.18.

c) Otherwise:

  1)~~a)~~ If the STA is an AP or is associated with an AP, the BSSID is the address currently in use by the STA contained in the AP.

  2)~~b)~~ If the STA is a member of an IBSS, the BSSID is the BSSID of the IBSS.

~~c) In management frames of subtype Probe Request, the BSSID is either a specific BSSID, or the wildcard BSSID as defined in the procedures specified in 11.1.3.~~

Insert the following paragraph after the eighth paragraph (starting "The duration value...") of 7.2.3:

The HT Control field is defined in 7.1.3.5a. The presence of the HT Control field is determined by the Order subfield of the Frame Control field, as specified in 7.1.3.1.9.

7.2.3.1 Beacon frame format

Change order 7 and 8 information fields and insert order 37 through 41 information fields in Table 7-8 as follows (note that the entire table is not shown here):

Table 7-8—Beacon frame body

Order	Information	Notes
7	DS Parameter Set	The DS Parameter Set information element is present within Beacon frames generated by STAs using Clause 15, Clause 18, and Clause 19 PHYs. This element is also present if one of the rates defined in Clause 15 or Clause 18 is being used to transmit the beacon.
8	CF Parameter Set	The CF Parameter Set information element is present only within Beacon frames generated by APs supporting a point coordination function (PCF). This element shall not be present if dot11HighThroughputOption-Implemented is TRUE and the Dual CTS Protection field of the HT Operation element is set to 1.

Table 7-8—Beacon frame body *(continued)*

Order	Information	Notes
37	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented attribute is TRUE.
38	HT Operation	The HT Operation element is included by an AP when dot11HighThroughputOptionImplemented attribute is TRUE.
39	20/40 BSS Coexistence	The 20/40 BSS Coexistence element may be present when the dot112040BSSCoexistenceManagementSupport attribute is TRUE.
40	Overlapping BSS Scan Parameters	The Overlapping BSS Scan Parameters element may be present if the dot11FortyMHzOptionImplemented attribute is TRUE.
41	Extended Capabilities	The Extended Capabilities element may be present if any of the fields in this element are nonzero.

7.2.3.4 Association Request frame format

Insert order 13 through 15 information fields into Table 7-10 (note that the entire table is not shown here):

Table 7-10—Association Request frame body

Order	Information	Notes
13	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented attribute is TRUE.
14	20/40 BSS Coexistence	The 20/40 BSS Coexistence element may be present when the dot112040BSSCoexistenceManagementSupport attribute is TRUE.
15	Extended Capabilities	The Extended Capabilities element may be present if any of the fields in this element are nonzero.

7.2.3.5 Association Response frame format

Insert order 14 through 18 information fields into Table 7-11 (note that the entire table is not shown here):

Table 7-11—Association Response frame body

Order	Information	Notes
14	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented attribute is TRUE.
15	HT Operation	The HT Operation element is included by an AP when dot11HighThroughputOptionImplemented attribute is TRUE.
16	20/40 BSS Coexistence	The 20/40 BSS Coexistence element may be present when the dot112040BSSCoexistenceManagementSupport attribute is TRUE.
17	Overlapping BSS Scan Parameters	The Overlapping BSS Scan Parameters element may be present if the dot11FortyMHzOptionImplemented attribute is TRUE.
18	Extended Capabilities	The Extended Capabilities element may be present if any of the fields in this element are nonzero.

7.2.3.6 Reassociation Request frame format

Insert order 16 through 18 information fields into Table 7-12 (note that the entire table is not shown here):

Table 7-12—Reassociation Request frame format

Order	Information	Notes
16	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented attribute is TRUE.
17	20/40 BSS Coexistence	The 20/40 BSS Coexistence element may be present when the dot112040BSSCoexistenceManagementSupport attribute is TRUE.
18	Extended Capabilities	The Extended Capabilities element may be present if any of the fields in this element are nonzero.

7.2.3.7 Reassociation Response frame format

Insert order 16 through 20 information fields into Table 7-13 (note that the entire table is not shown here):

Table 7-13—Reassociation Response frame body

Order	Information	Notes
16	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented attribute is TRUE.
17	HT Operation	The HT Operation element is included by an AP when dot11HighThroughputOptionImplemented attribute is TRUE.
18	20/40 BSS Coexistence	The 20/40 BSS Coexistence element may be present when the dot112040BSSCoexistenceManagementSupport attribute is TRUE.
19	Overlapping BSS Scan Parameters	The Overlapping BSS Scan Parameters element may be present if the dot11FortyMHzOptionImplemented attribute is TRUE.
20	Extended Capabilities	The Extended Capabilities element may be present if any of the fields in this element are nonzero.

7.2.3.8 Probe Request frame format

Insert order 7 through 9 information fields into Table 7-14 (note that the entire table is not shown here):

Table 7-14—Probe Request frame body

Order	Information	Notes
7	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented attribute is TRUE.
8	20/40 BSS Coexistence	The 20/40 BSS Coexistence element may be present when the dot112040BSSCoexistenceManagementSupport attribute is TRUE.
9	Extended Capabilities	The Extended Capabilities element may be present if any of the fields in this element are nonzero.

7.2.3.9 Probe Response frame format

Insert order 35 through 39 information fields into Table 7-15 (note that the entire table is not shown here):

Table 7-15—Probe Response frame body

Order	Information	Notes
35	HT Capabilities	The HT Capabilities element is present when dot11HighThroughputOptionImplemented attribute is TRUE.
36	HT Operation	The HT Operation element is included by an AP when dot11HighThroughputOptionImplemented attribute is TRUE.
37	20/40 BSS Coexistence	The 20/40 BSS Coexistence element may be present when the dot112040BSSCoexistenceManagementSupport attribute is TRUE.
38	Overlapping BSS Scan Parameters	The Overlapping BSS Scan Parameters element may be present if the dot11FortyMHzOptionImplemented attribute is TRUE.
39	Extended Capabilities	The Extended Capabilities element may be present if any of the fields in this element are nonzero.

Insert the following subclause (7.2.3.13) after 7.2.3.12:

7.2.3.13 Action No Ack frame format

The frame body of a management frame of subtype Action No Ack contains the information shown in Table 7-19a.

Table 7-19a—Action No Ack frame body

Order	Information
1	Action
Last	One or more vendor-specific information elements may appear in this frame. This information element follows all other information elements.

NOTE—The selection of Action or Action No Ack is made per frame that uses these formats.

Unless specified as allowing the use of the Action No Ack management frame subtype, a frame described as an “Action frame” uses only the Action subtype.

7.3 Management frame body components

7.3.1 Fields that are not information elements

7.3.1.7 Reason Code field

Insert reason code 31 and change the Reserved reason code row in Table 7-22 as follows (note that the entire table is not shown here):

Table 7-22—Reason codes

Reason code	Meaning
25–30~~1~~	Reserved
31	TS deleted because QoS AP lacks sufficient bandwidth for this QoS STA due to a change in BSS service characteristics or operational mode (e.g., an HT BSS change from 40 MHz channel to 20 MHz channel)

7.3.1.9 Status Code field

Change status codes 27 and 29 in Table 7-23 as follows (note that the entire table is not shown here):

Table 7-23—Status codes

Status code	Meaning
27	~~Reserved~~ Association denied because the requesting STA does not support HT features
29	~~Reserved~~ Association denied because the requesting STA does not support the phased coexistence operation (PCO) transition time required by the AP

7.3.1.11 Action field

Insert category code 7 in Table 7-24 as follows (note that the entire table is not shown here):

Table 7-24—Category Values

Code	Meaning	See subclause	Robust
7	~~Reserved~~ HT	7.4.10	No

7.3.1.14 Block Ack Parameter Set field

Replace Figure 7-32 with the following figure:

	B0	B1	B2 B5	B6 B15
	A-MSDU Supported	Block Ack Policy	TID	Buffer Size
Octets:	2			

Figure 7-32—Block Ack Parameter Set fixed field

Insert the following paragraph after the first paragraph of 7.3.1.14:

The A-MSDU Supported subfield determines whether an A-MSDU may be carried in a QoS data MPDU sent under this Block Ack agreement. When set to 1, use of A-MSDU is permitted. When set to 0, use of A-MSDU is not permitted.

Change the now third through fifth paragraphs of 7.3.1.14 as follows:

The Block Ack Policy subfield is set to 1 for immediate Block Ack and 0 for delayed Block Ack. ~~The Block Ack Policy subfield value assigned by the originator of the QoS data frames is advisory.~~

The TID subfield contains the value of the TC or TS for which the ~~Block Ack~~ BlockAck is being requested.

The Buffer Size subfield indicates the number of buffers ~~of size 2304 octets available~~ for this particular TID.[18] When the A-MSDU Supported field is set to 0 as indicated by the STA transmitting the Block Ack Parameter Set field, each buffer is capable of holding a number of octets equal to the maximum size of an MSDU. When the A-MSDU Supported field is set to 1 as indicated by the STA, each buffer is capable of holding a number of octets equal to the maximum size of an A-MSDU that is supported by the STA.

Change footnote 18 in 7.3.1.14 as follows:

[18]For buffer size, the recipient of data advertises a scalar number that is the number of ~~maximum-size~~ fragment buffers of the maximum MSDU or A-MSDU size (indicated by the A-MSDU Supported field) available for the Block Ack agreement that is being negotiated. Every buffered MPDU that is associated with this Block Ack agreement will consume one of these buffers regardless of whether the frame contains a whole MSDU (or a fragment ~~of an MSDU~~thereof) or an A-MSDU. ~~In other words~~For example, ten maximum-size unfragmented MSDUs will consume the same amount of buffer space at the recipient as ~~10~~ten smaller fragments of a single MSDU of maximum size.

7.3.1.17 QoS Info field

Change paragraph 10 of 7.3.1.17 as follows:

The Max SP Length subfield is 2 bits in length and indicates the maximum number of total buffered MSDUs, A-MSDUs, and MMPDUs the AP may deliver to a non-AP STA during any service period (SP) triggered by the non-AP STA. This subfield is reserved when the APSD subfield in the Capability Information field is set to 0. This subfield is also reserved when all four U-APSD flags are set to 0. If the APSD subfield in the Capability Information field is set to 1 and at least one of the four U-APSD flags is set to 1, the settings of the values in the Max SP Length subfield are defined in Table 7-25.

Change Table 7-25 as follows:

Table 7-25—Settings of the Max SP Length subfield

Bit 5	Bit 6	Usage
0	0	AP may deliver all buffered MSDUs, A-MSDUs, and MMPDUs.
1	0	AP may deliver a maximum of two MSDUs, A-MSDUs, and MMPDUs per SP.
0	1	AP may deliver a maximum of four MSDUs, A-MSDUs, and MMPDUs per SP.
1	1	AP may deliver a maximum of six MSDUs, A-MSDUs, and MMPDUs per SP.

Insert the following subclauses (7.3.1.21 to 7.3.1.30) after 7.3.1.20:

7.3.1.21 Channel Width field

The Channel Width field is used in a Notify Channel Width frame (see 7.4.10.2) to indicate the channel width on which the sending STA is able to receive. The length of the field is 1 octet. The Channel Width field is illustrated in Figure 7-36d.

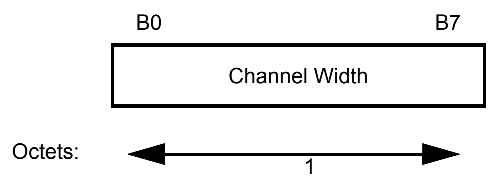


Figure 7-36d—Channel Width fixed field

If a STA transmitting or receiving this field is operating in a regulatory class that includes a value of 13 or 14 in the behavior limits as specified in Annex J, then the values of the Channel Width field are defined in Table 7-25a. If a STA transmitting or receiving this field is operating in a regulatory class that does not include a value of 13 or 14 in the behavior limits as specified in Annex J, then this field is reserved.

Table 7-25a—Settings of the Channel Width field

Value	Meaning
0	20 MHz channel width
1	Any channel width in the STA's Supported Channel Width Set subfield
2–255	Reserved

7.3.1.22 SM Power Control field

The SM Power Control field is used in an SM Power Save frame (see 7.4.10.3) by a STA to communicate changes in its SM power-saving state. The field is 1 octet in length and is illustrated in Figure 7-36e.

Figure 7-36e—SM Power Control fixed field

The SM Power Save Enabled subfield indicates whether SM power saving is enabled at the STA. A value of 1 indicates enabled, and a value of 0 indicates disabled.

The SM Mode subfield indicates the mode of operation. A value of 1 indicates dynamic SM power save mode, a value of 0 indicates static SM power save mode. The modes are described in 11.2.3.

7.3.1.23 PCO Phase Control field

The PCO Phase Control field is used in a Set PCO Phase frame (see 7.4.10.5) to indicate the phase of PCO operation (see 11.15). The length of the field is 1 octet. The PCO Phase Control field is illustrated in Figure 7-36f.

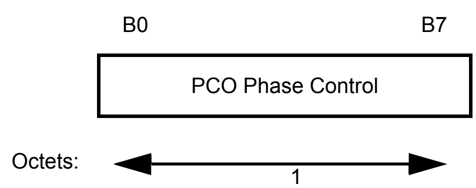


Figure 7-36f—PCO Phase Control fixed field

The PCO Phase Control field indicates the current PCO phase. The values of the PCO Phase Control field are defined in Table 7-25b.

Table 7-25b—Settings of the PCO Phase Control field

Value	Meaning
0	20 MHz phase
1	40 MHz phase
2–255	Reserved

7.3.1.24 PSMP Parameter Set field

The PSMP Parameter Set field is used in a PSMP frame (see 7.4.10.4) to define the number of PSMP STA Info fields held in the PSMP frame, to indicate whether the PSMP sequence is to be followed by another PSMP sequence, and to indicate the duration of the PSMP sequence.

The PSMP Parameter Set field is 2 octets in length. The structure of the PSMP Parameter Set field is defined in Figure 7-36g.

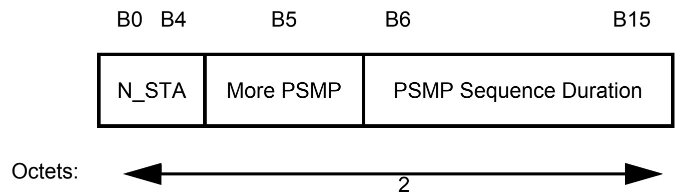


Figure 7-36g—PSMP Parameter Set fixed field

The N_STA subfield indicates the number of STA Info fields present in the PSMP frame that contains the PSMP Parameter Set field.

The More PSMP subfield, when set to 1, indicates that the current PSMP sequence will be followed by another PSMP sequence. A value of 0 indicates that there will be no PSMP sequence following the current PSMP sequence.

The PSMP Sequence Duration subfield indicates the duration of the current PSMP sequence that is described by the PSMP frame, in units of 8 µs, relative to the end of the PSMP frame. Therefore, this field can describe a PSMP sequence with a duration of up to 8.184 ms. The next PSMP sequence within the current PSMP burst starts a SIFS interval after the indicated duration.

7.3.1.25 PSMP STA Info field

The PSMP STA Info field is used by the PSMP frame (see 7.4.10.4). The PSMP STA Info field defines the allocation of time to the downlink (PSMP-DTT) and/or uplink (PSMP-UTT) associated with a single RA. There are two variants of the structure for the individually addressed and group-addressed cases. The length of the PSMP STA Info field is 8 octets.

The structure of the STA Info field is defined in Figure 7-36h and Figure 7-36i.

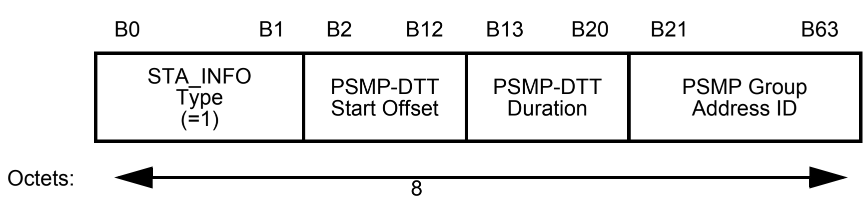


Figure 7-36h—PSMP STA Info fixed field (group-addressed)

	B0 B1	B2 B12	B13 B20	B21 B36	B37 B47	B48 B57	B58 B63
	STA_INFO Type (=2)	PSMP-DTT Start Offset	PSMP-DTT Duration	STA_ID	PSMP-UTT Start Offset	PSMP-UTT Duration	Reserved
Octets:	8						

Figure 7-36i—PSMP STA Info fixed field (individually addressed)

The STA_INFO Type subfield indicates the format of the remainder of the structure. When the STA_INFO Type subfield is set to 1, the PSMP STA Info field is structured as defined in Figure 7-36h and supports the transmission of group-addressed data by the AP. When the STA_INFO Type subfield is set to 2, the PSMP STA Info field is structured as defined in Figure 7-36i and supports the exchange of data with a single STA. STA_INFO Type subfield values 0 and 3 are reserved.

The PSMP-DTT Start Offset subfield indicates the start of the PSMP-DTT for the destination identified by the PSMP STA Info field, relative to the end of the PSMP frame, in units of 4 µs. This subfield locates the start of the first PPDU containing downlink data for this destination.

The PSMP-DTT Duration subfield indicates the duration of the PSMP-DTT for the destination identified by the PSMP STA Info field, in units of 16 µs. This subfield locates the end of the last PPDU containing downlink data for this destination relative to the PDMP-DTT start offset.

If no PSMP-DTT is scheduled for a STA, but a PSMP-UTT is scheduled for that STA, the PSMP-DTT Duration subfield is set to 0, and the PSMP-DTT Start Offset subfield is reserved.

The PSMP Group Address ID (B21 to B63) subfield contains the 43 least significant bits (LSBs) of a 48 bit MAC address. Use of this subfield is described in 9.16.1.8. B63 contains the LSB of the group address (considering the Individual/Group bit to be the most significant bit (MSB)).

The STA_ID subfield contains the AID of the STA to which the PSMP STA Info field is directed.

The PSMP-UTT Start Offset subfield indicates the start of the PSMP-UTT. The offset is specified relative to the end of the PSMP frame. It is specified in units of 4 µs. The first PSMP-UTT is scheduled to begin after a SIFS interval from the end of the last PSMP-DTT described in the PSMP.

The PSMP-UTT Duration subfield indicates the maximum length of a PSMP-UTT for a STA. PSMP-UTT duration is specified in units of 4 µs. All transmissions by the STA within the current PSMP sequence lie within the indicated PSMP-UTT.

If no PSMP-UTT is scheduled for a STA, but a PSMP-DTT is scheduled for that STA, the PSMP-UTT Start Offset and PSMP-UTT Duration subfields are both set to 0.

7.3.1.26 MIMO Control field

The MIMO Control field is used to manage the exchange of MIMO channel state or transmit beamforming feedback information. It is used in the CSI (see 7.4.10.6), Noncompressed Beamforming (see 7.4.10.7), and Compressed Beamforming (see 7.4.10.8) frames.

The MIMO Control field is 6 octets in length and is defined in Figure 7-36j.

B0 B1	B2 B3	B4	B5 B6	B7 B8	B9 B10	B11 B13	B14 B15	
Nc Index	Nr Index	MIMO Control Channel Width	Grouping (*Ng*)	Coefficient Size	Codebook Information	Remainin g Matrix Segment	Reserved	Sounding Timestamp
Octets: 2								4

Figure 7-36j—MIMO Control field

The subfields of the MIMO Control field are defined in Table 7-25c.

Table 7-25c—Subfields of the MIMO Control field

Subfield	Description
Nc Index	Indicates the number of columns in a matrix minus one: Set to 0 for $Nc = 1$ Set to 1 for $Nc = 2$ Set to 2 for $Nc = 3$ Set to 3 for $Nc = 4$
Nr Index	Indicates the number of rows in a matrix minus one: Set to 0 for $Nr = 1$ Set to 1 for $Nr = 2$ Set to 2 for $Nr = 3$ Set to 3 for $Nr = 4$
MIMO Control Channel Width	Indicates the width of the channel in which a measurement was made: Set to 0 for 20 MHz Set to 1 for 40 MHz
Grouping (*Ng*)	Number of carriers grouped into one: Set to 0 for $Ng = 1$ (No grouping) Set to 1 for $Ng = 2$ Set to 2 for $Ng = 4$ The value 3 is reserved
Coefficient Size	Indicates the number of bits in the representation of the real and imaginary parts of each element in the matrix. For CSI feedback: Set to 0 for $Nb = 4$ Set to 1 for $Nb = 5$ Set to 2 for $Nb = 6$ Set to 3 for $Nb = 8$ For noncompressed beamforming feedback: Set 0 for $Nb = 4$ Set 1 for $Nb = 2$ Set 2 for $Nb = 6$ Set 3 for $Nb = 8$

Table 7-25c—Subfields of the MIMO Control field *(continued)*

Subfield	Description
Codebook Information	Indicates the size of codebook entries: Set to 0 for 1 bit for ψ, 3 bits for φ Set to 1 for 2 bits for ψ, 4 bits for φ Set to 2 for 3 bits for ψ, 5 bits for φ Set to 3 for 4 bits for ψ, 6 bits for φ
Remaining Matrix Segment	Contains the remaining segment number for the associated measurement report. Valid range: 0 to 7. Set to 0 for the last segment of a segmented report or the only segment of an unsegmented report.
Sounding Timestamp	Contains the lower 4 octets of the TSF timer value sampled at the instant that the MAC received the PHY-CCA.indication(IDLE) signal that corresponds to the end of the reception of the sounding packet that was used to generate feedback information contained in the frame.

7.3.1.27 CSI Report field

The CSI Report field is used by the CSI frame (see 7.4.10.6) to carry explicit channel state information to a transmit beamformer, as described in 9.19.3.

The CSI Matrix subfields in the CSI Report field shown in Table 7-25d and Table 7-25e are matrices whose elements are taken from the CHAN_MAT parameter of RXVECTOR (see Table 20-1).

The structure of the field depends on the the value of the MIMO Control Channel Width subfield. The CSI Report field for 20 MHz has the structure defined in Table 7-25d where

Nb is the number of bits determined by the Coefficients Size field of the MIMO Control field

Nc is the number of columns in a CSI matrix determined by the Nc Index field of the MIMO Control field

Nr is the number of rows in a CSI matrix determined by the Nr Index field of the MIMO Control field

Table 7-25d—CSI Report field (20 MHz)

Field	Size (bits)	Meaning
SNR in receive chain 1	8	Signal-to-noise ratio in the first receive chain of the STA sending the report.
...		
SNR in receive chain *Nr*	8	Signal-to-noise ratio in the *Nr*'th receive chain of the STA sending the report.
CSI Matrix for carrier –28	$3+2\times Nb\times Nc\times Nr$	CSI matrix (see Figure 7-36k)
...		
CSI Matrix for carrier –1	$3+2\times Nb\times Nc\times Nr$	CSI matrix
CSI Matrix for carrier 1	$3+2\times Nb\times Nc\times Nr$	CSI matrix
...		
CSI Matrix for carrier 28	$3+2\times Nb\times Nc\times Nr$	CSI matrix

The CSI Report field for 40 MHz has the structure defined in Table 7-25e.

Table 7-25e—CSI Report field (40 MHz)

Field	Size (bits)	Meaning
SNR in receive chain 1	8	Signal-to-noise ratio in the first receive chain of the STA sending the report.
...		
SNR in receive chain *Nr*	8	Signal-to-noise ratio in the *Nr*'th receive chain of the STA sending the report.
CSI Matrix for carrier –58	3+2× *Nb*×*Nc*×*Nr*	CSI matrix (see Figure 7-36k)
...		
CSI Matrix for carrier –2	3+2× *Nb*×*Nc*×*Nr*	CSI matrix
CSI Matrix for carrier 2	3+2× *Nb*×*Nc*×*Nr*	CSI matrix
...		
CSI Matrix for carrier 58	3+2× *Nb*×*Nc*×*Nr*	CSI matrix

The signal-to-noise ratio (SNR) values in Table 7-25d and Table 7-25e are encoded as an 8-bit twos complement value of 4 × (SNR_average – 22), where SNR_average is the decibel representation of linearly averaged values over the tones represented. This encoding covers the SNR range from –10 dB to 53.75 dB in 0.25 dB steps.

Grouping is a method that reduces the size of the CSI Report field by reporting a single value for each group of *Ng* adjacent subcarriers. With grouping, the size of the CSI Report field is *Nr*×8+*Ns*×(3+2×*Nb*×*Nc*×*Nr)* bits, where the number of subcarriers sent, *Ns*, is a function of *Ng* and whether matrices for 40 MHz or 20 MHz are sent. The value of *Ns* and the specific carriers for which matrices are sent are shown in Table 7-25f. If the size of the CSI Report field is not an integral multiple of 8 bits, up to 7 zeros are appended to the end of the report to make its size an integral multiple of 8 bits.

Table 7-25f—Number of matrices and carrier grouping

BW	Grouping *Ng*	*Ns*	Carriers for which matrices are sent
20 MHz	1	56	All data and pilot carriers: –28, –27,…–2, –1, 1, 2,…27, 28
	2	30	–28,–26,–24,–22,–20,–18,–16,–14,–12,–10,–8,–6,–4,–2,–1, 1,3,5,7,9,11,13,15,17,19,21,23,25,27,28
	4	16	–28,–24,–20,–16,–12,–8,–4,–1,1,5,9,13,17,21,25,28
40 MHz	1	114	All data and pilot carriers: –58, –57, …, –3, –2, 2, 3,…, 57, 58
	2	58	–58,–56,–54,–52,–50,–48,–46,–44,–42,–40,–38,–36,–34,–32,–30, –28,–26,–24,–22,–20,–18,–16,–14,–12,–10,–8,–6,–4,–2, 2,4,6,8,10,12,14,16,18,20,22,24,26,28, 30,32,34,36,38,40,42,44,46,48,50,52,54,56,58
	4	30	–58,–54,–50,–46,–42,–38,–34,–30,–26,–22,–18,–14,–10,–6, –2, 2,6,10,14,18,22,26,30,34,38,42,46,50,54,58

The CSI matrix H_{eff} for a single carrier has the structure defined in Figure 7-36k. The encoding rules for the elements of the H_{eff} matrix are given in 20.3.12.2.1.

```
For each subcarrier include
{
    Carrier Matrix Amplitude of 3 bits
    For each of Nr rows in each CSI matrix in order: (1, …, Nr)
    {
        Include Nc complex coefficients of CSI matrix Heff in order: (1, …, Nc );
        each element of Heff includes the real part of the element (Nb bits) and
        imaginary part of the element (Nb bits) in that order
    }

}
```

Figure 7-36k—CSI matrix coding

7.3.1.28 Noncompressed Beamforming Report field

The Noncompressed Beamforming Report field is used by the Noncompressed Beamforming frame to carry explicit feedback in the form of noncompressed beamforming feedback matrices *V* for use by a transmit beamformer to determine steering matrices Q, as described in 9.19.3 and 20.3.12.2.

The structure of the field is dependent on the value of the MIMO Control Channel Width subfield. The Noncompressed Beamforming Report field for 20 MHz has the structure defined in Table 7-25g where

Nb is the number of bits determined by the Coefficients Size field of the MIMO Control field

Nc is the number of columns in a beamforming feedback matrix determined by the Nc Index field of the MIMO Control field

Nr is the number of rows in a beamforming feedback matrix determined by the Nr Index field of the MIMO Control field

Table 7-25g—Noncompressed Beamforming Report field (20 MHz)

Field	Size (bits)	Meaning
SNR for space-time stream 1	8	Average signal-to-noise ratio in the STA sending the report for space-time stream 1.
...		
SNR for space-time stream *Nc*	8	Average signal-to-noise ratio in the STA sending the report for space-time stream *Nc*.
Beamforming Feedback Matrix for carrier –28	$2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V* (see Figure 7-36l)
...		
Beamforming Feedback Matrix for carrier –1	$2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V*
Beamforming Feedback Matrix for carrier 1	$2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V*
...		
Beamforming Feedback Matrix for carrier 28	$2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V*

The Noncompressed Beamforming Report field for 40 MHz has the structure defined in Table 7-25h.

Table 7-25h—Noncompressed Beamforming Report field (40 MHz)

Field	Size (bits)	Meaning
SNR for space-time stream 1	8	Average signal-to-noise ratio in the STA sending the report for space-time stream 1.
...		
SNR for space-time stream *Nc*	8	Average signal-to-noise ratio in the STA sending the report for space-time stream *Nc*.
Beamforming Feedback Matrix for carrier –58	$2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V* (see Figure 7-36l)
...		
Beamforming Feedback Matrix for carrier –2	$2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V*
Beamforming Feedback Matrix for carrier 2	$2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V*
...		
Beamforming Feedback Matrix for carrier 58	$+2\times Nb\times Nc\times Nr$	Beamforming feedback matrix *V*

The SNR values in Table 7-25g and Table 7-25h are encoded as an 8-bit twos complement value of 4 × (SNR_average – 22), where SNR_average is the sum of the values of SNR per tone (in decibels) divided by the number of tones represented. This encoding covers the SNR range from –10 dB to 53.75 dB in 0.25 dB steps. The SNR in space-time stream *i* corresponds to the SNR associated with the column *i* of the beamforming feedback matrix *V*. Each SNR corresponds to the predicted SNR at beamformee when the beamformer applies the matrix *V*.

Grouping is a method that reduces the size of the Noncompressed Beamforming Report field by reporting a single value for each group of *Ng* adjacent subcarriers. With grouping, the size of the Noncompressed Beamforming Report field is $Nc\times 8+Ns\times(2\times Nb\times Nc\times Nr)$ bits. The number of subcarriers sent, *Ns*, is a function of *Ng* and whether matrices for 40 MHz or 20 MHz are sent. The value of *Ns* and the specific carriers for which matrices are sent is shown in Table 7-25f. If the size of the Noncompressed Beamforming Report field is not an integral multiple of 8 bits, up to 7 zeros are appended to the end of the report to make its size an integral multiple of 8 bits.

A beamforming feedback matrix *V* for a single carrier has the structure defined in Figure 7-36l.

```
For each subcarrier include
{
For each of Nr rows in the
        Noncompressed beamforming feedback matrix in order: (1, …, Nr)
    {
        Include Nc complex coefficients of the Noncompressed beamforming feedback
        matrix V in order: (1, …, Nc  );  each element of V includes the real
        part of the element (Nb bits) and imaginary part of the element (Nb bits)
        in that order
    }
}
```

Figure 7-36l—*V* matrix coding (noncompressed beamforming)

Encoding rules for elements of the *V* matrix are given in 20.3.12.2.4.

7.3.1.29 Compressed Beamforming Report field

The Compressed Beamforming Report field is used by the Compressed Beamforming frame (see 7.4.10.8) to carry explicit feedback information in the form of angles representing compressed beamforming feedback matrices *V* for use by a transmit beamformer to determine steering matrices Q, as described in 9.19.3 and 20.3.12.2.

The size of the Compressed Beamforming Report field depends on the values in the MIMO Control field.

The Compressed Beamforming Report field contains the channel matrix elements indexed, first, by matrix angles in the order shown in Table 7-25i and, second, by data subcarrier index from lowest frequency to highest frequency. The explanation on how these angles are generated from the beamforming feedback matrix *V* is given in 20.3.12.2.5.

Table 7-25i—Order of angles in the Compressed Beamforming Report field

Size of *V* (*Nr* × *Nc*)	Number of angles (*Na*)	The order of angles in the Quantized Beamforming Feedback Matrices Information field
2×1	2	ϕ11, ψ21
2×2	2	ϕ11, ψ21
3×1	4	ϕ11, ϕ21, ψ21, ψ31
3×2	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
3×3	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
4×1	6	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41
4×2	10	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42
4×3	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43
4×4	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43

The angles are quantized as defined in Table 7-25j. All angles are transmitted LSB to MSB.

Table 7-25j—Quantization of angles

Quantized ψ	Quantized ϕ
$\psi = \frac{k\pi}{2^{b_\psi+1}} + \frac{\pi}{2^{b_\psi+2}}$ radians where $k = 0,1,\ldots,2^{b_\psi} - 1$ b_ψ is the number of bits used to quantize ψ (defined by the Codebook Information field of the MIMO Control field; see 7.3.1.26);	$\phi = \frac{k\pi}{2^{b_\phi-1}} + \frac{\pi}{2^{b_\phi}}$ radians where $k = 0,1,\ldots,2^{b_\phi} - 1$ b_ϕ is the number of bits used to quantize ϕ (defined by the Codebook Information field of the MIMO Control field; see 7.3.1.26)

The Compressed Beamforming Report field for 20 MHz has the structure defined in Table 7-25k, where *Na* is the number of angles used for beamforming feedback matrix *V* (see Table 7-25i).

Table 7-25k—Compressed Beamforming Report field (20 MHz)

Field	Size (bits)	Meaning
SNR in space-time stream 1	8	Average signal-to-noise ratio in the STA sending the report for space-time stream 1
...		
SNR in space-time stream *Nc*	8	Average signal-to-noise ratio in the STA sending the report for space-time stream *Nc*
Beamforming Feedback Matrix *V* for carrier –28	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
...		
Beamforming Feedback Matrix *V* for carrier –1	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
Beamforming Feedback Matrix *V* for carrier 1	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
...		
Beamforming Feedback Matrix *V* for carrier 28	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*

The Compressed Beamforming Report field for 40 MHz has the structure defined in Table 7-25l, where *Na* is the number of angles used for beamforming feedback matrix *V* (see Table 7-25i).

Table 7-25l—Compressed Beamforming Report field (40 MHz)

Field	Size (bit)	Meaning
SNR in space-time stream 1	8	Average signal-to-noise ratio in the STA sending the report for space-time stream 1
...		
SNR in space-time stream *Nc*	8	Average signal-to-noise ratio in the STA sending the report for space-time stream *Nc*
Beamforming Feedback Matrix *V* for carrier –58	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
Beamforming Feedback Matrix *V* for carrier –58 + *Ng*	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
...		
Beamforming Feedback Matrix *V* for carrier –2	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
Beamforming Feedback Matrix *V* for carrier 2	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
Beamforming Feedback Matrix *V* for carrier 2 + *Ng*	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*
...		
Beamforming Feedback Matrix *V* for carrier 58	$Na \times (b_\psi + b_\phi)/2$	Beamforming feedback matrix *V*

The SNR values in Table 7-25k and Table 7-25l are encoded as an 8-bit twos complement value of 4 × (SNR_average – 22), where SNR_average is the sum of the values of SNR per tone (in decibels) divided by the number of tones represented. This encoding covers the SNR range from –10 dB to 53.75 dB in 0.25 dB steps. Each SNR value per tone in stream *i* (before being averaged) corresponds to the SNR associated with the column *i* of the beamforming feedback matrix *V* determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies the matrix *V*.

Grouping is a method that reduces the size of the Compressed Beamforming Report field by reporting a single value for each group of *Ng* adjacent subcarriers. With grouping, the size of the Compressed Beamforming Report field is $Nc \times 8 + Ns \times (Na \times (b_\psi + b_\phi)/2)$ bits, where the number of subcarriers sent, *Ns*, is a function of *Ng* and whether matrices for 40 MHz or 20 MHz are sent. The value of *Ns* and the specific carriers for which matrices are sent is defined in Table 7-25f. If the size of the Compressed Beamforming Report field is not an integral multiple of 8 bits, up to 7 zeros are appended to the end of the report to make its size an integral multiple of 8 bits.

See Figure 7-36n and Figure 7-36m for examples of this encoding.

Bits	b1..b5	b6..b8	b9..b13	b14..b16	…	b441..b445	b446..b448
Data	$\phi_{11}(-28)$	$\psi_{21}(-28)$	$\phi_{11}(-27)$	$\psi_{21}(-27)$	…	$\phi_{11}(28)$	$\psi_{21}(28)$
Conditions: — 2 x 2 V — $b_\psi = 3$, $b_\phi = 5$ — No grouping — 20 MHz width — The matrix *V* is encoded using 8 bits per tone.							

Figure 7-36m—First example of Compressed Beamforming Report field encoding

Bits	b1..b4	b5..b8	…	b27..b28	b29..b30	b31..b34	…	b59..b60	…	b871..b874	…	b899..b900
Data	$\phi_{11}(-58)$	$\phi_{21}(-58)$	…	$\psi_{32}(-58)$	$\psi_{42}(-58)$	$\phi_{11}(-54)$	…	$\psi_{42}(-54)$	…	$\phi_{11}(58)$	…	$\psi_{42}(58)$
Conditions: — 4 x 2 V — $b_\psi = 2$, $b_\phi = 4$ — 4 tone grouping — 40 MHz width — The matrix *V* is encoded using 30 bits per tone.												

Figure 7-36n—Second example of Compressed Beamforming Report field encoding

7.3.1.30 Antenna Selection Indices field

The Antenna Selection Indices field is used within the Antenna Selection Indices Feedback frame to carry ASEL feedback, as described in 9.20.

The Antenna Selection Indices field is 1 octet in length and illustrated in Figure 7-36o.

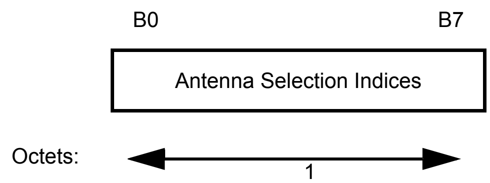


Figure 7-36o—Antenna Selection Indices fixed field

Bits 0 to 7 in the Antenna Selection Indices field correspond to antennas with indices 0 to 7, respectively. A value of 1 in a bit indicates the corresponding antenna is selected, and the value of 0 indicates the corresponding antenna is not selected.

7.3.2 Information elements

Insert element identifier (ID) 45, element IDs 61 and 62, and element IDs 72 through 74, and change element ID 127 and the Reserved element ID rows in Table 7-26 as follows (note that the entire table is not shown here):

Table 7-26—Element IDs

Information element	Element ID	Length (in octets)	Extensible
~~Reserved~~ HT Capabilities (see 7.3.2.56)	45	28	Yes
~~Reserved~~	~~61–62~~		
HT Operation (see 7.3.2.57)	61	24	Yes
Secondary Channel Offset (see 7.3.2.20a)	62	3	
~~Reserved~~	~~72–74~~		
20/40 BSS Coexistence (see 7.3.2.60)	72	3	Yes
20/40 BSS Intolerant Channel Report (see 7.3.2.58)	73	3–257	
Overlapping BSS Scan Parameters (see 7.3.2.59)	74	16	
Extended Capabilities	127	~~2 to 257~~ 3	Yes

7.3.2.2 Supported Rates element

Change the first paragraph of 7.3.2.2 as follows:

The Supported Rates element specifies up to eight rates in the OperationalRateSet ~~Operational Rate Set~~ parameter, as described in the MLME-JOIN.request and MLME-START.request primitives, and zero or more BSS membership selectors. The information field is encoded as 1 to 8 octets, where each octet describes a single supported rate or BSS membership selector. If the combined total of the number of rates in the ~~Operational Rate Set~~ OperationalRateSet parameter and the number of BSS membership selectors exceeds eight, then an Extended Supported Rate element ~~shall be~~is generated to specify the remaining supported rates and BSS membership selectors. The use of the Extended Supported Rates element is optional otherwise.

Insert the following paragraph after the second paragraph of 7.3.2.2:

Within Beacon, Probe Response, Association Response, and Reassociation Response management frames, each BSS membership selector contained in the BSSMembershipSelectorSet parameter is encoded as an octet with the MSB (bit 7) set to 1, and bits 6 through 0 are set to the encoded value for the selector as found in Table 7-26a (e.g., an HT PHY BSS membership selector contained in the BSSMembershipSelectorSet parameter is encoded as X'FF'). A BSS membership selector that has the MSB (bit 7) set to 1 in the Supported Rates element is defined to be basic. The MSB of each Supported Rate octet in other management frame types is ignored by receiving STAs.

Change the now fourth paragraph of 7.3.2.2 as follows:

The Supported Rate information in Beacon and Probe Response management frames is delivered to the management entity in a STA via the BSSBasicRateSet parameter in the MLME-SCAN.confirm primitive. <u>The BSS membership selector information in Beacon and Probe Response management frames is delivered to the management entity in a STA via the BSSMembershipSelectorSet parameter in the MLME-SCAN.confirm primitive. Together, these parameters are</u>~~It is~~ used by the management entity in a STA to avoid associating with a BSS if the STA cannot receive and transmit all the data rates in the BSSBasicRateSet parameter (see Figure 7-39)<u> or does not support all of the features represented in the BSSMembershipSelectorSet parameter.</u>

Insert the following note and paragraph after the now fourth paragraph of 7.3.2.2:

NOTE—A STA that was implemented before the existence of the BSSMembershipSelectorSet parameter will interpret each BSS membership selector in the Supported Rates element that is contained in the BSSMembershipSelectorSet parameter of the transmitting STA as though it were a rate from the BSSBasicRateSet parameter. The value of each BSS membership selector will not match a rate that is known to the STA and, therefore, the management entity in the STA will avoid associating with the BSS because it determines that the STA cannot receive or transmit at what appears to be a required rate.

A STA that is implemented after the existence of the BSSMembershipSelectorSet parameter includes each octet of the Supported Rates element that is encoded with the MSB (bit 7) set to 1 and that it does not recognize as a rate in its BSSMembershipSelectorSet parameter. The STA then determines if it can support all of the features represented in its BSSMembershipSelectorSet parameter before attempting to join the network. If some BSSMembershipSelectorSet parameter values are not recognized by the STA, the STA does not attempt to join the network.

Insert the following paragraph, note, and table (Table 7-26a) at the end of 7.3.2.2:

The valid values for BSS membership selectors and their associated features are shown in Table 7-26a.

NOTE—Because the BSS membership selector and supported rates are carried in the same field, the BSS membership selector value cannot match the value corresponding to any valid supported rate. This allows any value in the supported rates set to be determined as either a supported rate or a BSS membership selector.

Table 7-26a—BSS membership selector value encoding

Value	Feature	Interpretation
127	HT PHY	Support for the mandatory features of Clause 20 is required in order to join the BSS that was the source of the Supported Rates element or Extended Supported Rates element containing this value.

7.3.2.14 Extended Supported Rates element

Change the first paragraph of 7.3.2.14 as follows:

The Extended Supported Rates element specifies the rates in the OperationalRateSet parameter, as described in the MLME-JOIN.request and MLME-START.request primitives, and zero or more BSS membership selector values that are not carried in the Supported Rates element. The information field is encoded as 1 to 255 octets where each octet describes a single supported rate or BSS membership selector.

Insert the following paragraph after the second paragraph of 7.3.2.14:

Within Beacon, Probe Response, Association Response, and Reassociation Response management frames, each BSS membership selector contained in the BSSMembershipSelectorSet parameter is encoded as an octet with the MSB (bit 7) set to 1, and bits 6 through 0 are set to the encoded value for the selector as found in Table 7-26a (e.g., an HT PHY BSS membership selector contained in the BSSMembershipSelectorSet parameter is encoded as X'FF').

Change the now fourth and fifth paragraphs of 7.3.2.14 as follows:

Extended Supported Rate information in Beacon and Probe Response management frames is used by STAs in order to avoid associating with a BSS if they do not support all the data rates in the BSSBasicRateSet parameter or all of the BSS membership requirements in the BSSMembershipSelectorSet parameter.

For STAs supporting a combined total of eight or fewer data rates and BSS membership selectors, this element is optional for inclusion in all of the frame types that include the Supported Rates element. For STAs supporting more than a combined total of eight data rates and BSS membership selectors, this element ~~shall be~~is included in all of the frame types that include the Supported Rates element.

Insert the following subclause (7.3.2.20a) after 7.3.2.20:

7.3.2.20a Secondary Channel Offset element

The Secondary Channel Offset element is used by an AP in a BSS or a STA in an IBSS together with the Channel Switch Announcement element when changing to a new 40 MHz channel. The format of the Secondary Channel Offset element is shown in Figure 7-57a.

The Secondary Channel Offset element is included in Channel Switch Announcement frames, as described in 7.4.1.5.

	Element ID	Length (=1)	Secondary Channel Offset
Octets:	1	1	1

Figure 7-57a—Secondary Channel Offset element format

The Secondary Channel Offset field of the Secondary Channel Offset element represents the position of the secondary channel relative to the primary channel. The values of the Secondary Channel Offset field are defined in Table 7-27a.

Table 7-27a—Values of the Secondary Channel Offset field

Value	Name	Description
0	SCN - no secondary channel	Indicates that no secondary channel is present.
1	SCA - secondary channel above	Indicates that the secondary channel is above the primary channel.
2		Reserved.
3	SCB - secondary channel below	Indicates that the secondary channel is below the primary channel.
4–255		Reserved.

7.3.2.21 Measurement Request element

7.3.2.21.8 STA Statistics Request

Insert group identities 11 to 15 and change the reserved row in Table 7-29j as follows (note that the entire table is not shown here):

Table 7-29j—Group Identity for a STA Statistics Request

Statistics Group Name	Group Identity
STA Counters from dot11CountersGroup3 (A-MSDU)	11
STA Counters from dot11CountersGroup3 (A-MPDU)	12
STA Counters from dot11CountersGroup3 (BlockAckReq, Channel Width, PSMP)	13
STA Counters from dot11CountersGroup3 (RD, dual CTS, L-SIG TXOP protection)	14
STA Counters from dot11CountersGroup3 (beamforming and STBC)	15
Reserved	~~11~~16–255

7.3.2.22 Measurement Report element

7.3.2.22.6 Beacon Report

Change paragraph 17 of 7.3.2.22.6 as follows:

The Reported Frame Body subelement contains the requested fields and elements of the frame body of the reported Beacon, Measurement Pilot, or Probe Response frame. If the Reporting Detail subelement of the corresponding Beacon Request equals 0, the Reported Frame Body subelement is not included in the Beacon Report. If the Reporting Detail subelement equals 1, all fixed fields and any information elements whose Element IDs are present in the Request information element in the corresponding Beacon Request are included in the Reported Frame Body subelement, in the order that they appeared in the reported frame. If the Reporting Detail field equals 2, all fixed fields and information elements are included in the order they appeared in the reported frame. Reported TIM elements are truncated such that only the first 4 octets of the element are reported and the element length field is modified to indicate the truncated length of 4. Reported IBSS dynamic frequency selection (DFS) elements shall be truncated so that only the lowest and highest channel number map are reported and the element Length field is modified to indicate the truncated length of 13. Reported RSN elements shall be truncated so that only the first 4 octets of the element are reported and the element length field is modified to indicate the truncated length of 4. If the Reported Frame Body subelement would cause the Measurement Report element to exceed the maximum information element size, then the Reported Frame Body subelement is truncated so that the last information element in the Reported Frame Body subelement is a complete information element.

7.3.2.22.8 STA Statistics Report

Insert group identities 11 to 15 and change the reserved row in Table 7-31f as follows (note that the entire table is not shown here):

Table 7-31f—Group Identity for a STA Statistics Report

Group Identity Requested	Statistics Group Data field length (octets)	Statistics Returned
11	40	STA Counters from dot11CountersGroup3 (A-MSDU): dot11TransmittedAMSDUCount (Counter32), dot11FailedAMSDUCount (Counter32), dot11RetryAMSDUCount (Counter32), dot11MultipleRetryAMSDUCount (Counter32), dot11TransmittedOctetsInAMSDUCount (Counter64), dot11AMSDUAckFailureCount (Counter32), dot11ReceivedAMSDUCount (Counter32), dot11ReceivedOctetsInAMSDUCount (Counter64)
12	36	STA Counters from dot11CountersGroup3 (A-MPDU): dot11TransmittedAMPDUCount (Counter32), dot11TransmittedMPDUsInAMPDUCount (Counter32), dot11TransmittedOctetsInAMPDUCount (Counter64), dot11AMPDUReceivedCount (Counter32), dot11MPDUInReceivedAMPDUCount (Counter32), dot11ReceivedOctetsInAMPDUCount (Counter64), dot11AMPDUDelimiterCRCErrorCount (Counter32)
13	36	STA Counters from dot11CountersGroup3 (BlockAckReq, Channel Width, PSMP): dot11ImplicitBARFailureCount (Counter32), dot11ExplicitBARFailureCount (Counter32), dot11ChannelWidthSwitchCount (Counter32), dot11TwentyMHzFrameTransmittedCount (Counter32), dot11FortyMHzFrameTransmittedCount (Counter32), dot11TwentyMHzFrameReceivedCount (Counter32), dot11FortyMHzFrameReceivedCount (Counter32), dot11PSMPUTTGrantDuration (Counter32), dot11PSMPUTTUsedDuration (Counter32)

Table 7-31f—Group Identity for a STA Statistics Report *(continued)*

Group Identity Requested	Statistics Group Data field length (octets)	Statistics Returned
14	36	STA Counters from dot11CountersGroup3 (RD, dual CTS, L-SIG TXOP protection): dot11GrantedRDGUsedCount (Counter32), dot11GrantedRDGUnusedCount (Counter32), dot11TransmittedFramesInGrantedRDGCount (Counter32), dot11TransmittedOctetsInGrantedRDGCount (Counter64), dot11DualCTSSuccessCount (Counter32), dot11DualCTSFailureCount (Counter32), dot11RTSLSIGSuccessCount (Counter32), dot11RTSLSIGFailureCount (Counter32)
15	20	STA Counters from dot11CountersGroup3 (beamforming and STBC): dot11BeamformingFrameCount (Counter32), dot11STBCCTSSuccessCount (Counter32), dot11STBCCTSFailureCount (Counter32), dot11nonSTBCCTSSuccessCount (Counter32), dot11nonSTBCCTSFailureCount (Counter32)
1~~1~~6–255		Reserved

7.3.2.25 RSN information element

7.3.2.25.3 RSN capabilities

Replace Figure 7-74 with the following figure:

	B0	B1	B2 B3	B4 B5	B6	B7
	Pre-Auth	No Pairwise	PTKSA Replay Counter	GTKSA Replay Counter	Management Frame Protection Required (MFPR)	Management Frame Protection Capable (MFPC)
Bits:	1	1	2	2	1	1

	B8	B9	B10	B11	B12	B13 B15
	Reserved	Peerkey Enabled	SPP A-MSDU Capable	SPP A-MSDU Required	PBAC	Reserved
Bits:	1	1	1	1	1	3

Figure 7-74—RSN Capabilities field format

Insert the following items after the "Bits 9" item in the dashed list immediately after Figure 7-74 in 7.3.2.25.3:

— Bit 10: SPP A-MSDU Capable. A STA sets the SPP A-MSDU Capable subfield of the RSN Capabilities field to 1 to signal that it supports signaling and payload protected A-MSDUs (SPP A-MSDUs) (see 11.17). Otherwise, this subfield is set to 0.

— Bit 11: SPP A-MSDU Required. A STA sets the SPP A-MSDU Required subfield of the RSN Capabilities field to 1 when it allows only SPP A-MSDUs (i.e., will not send or receive payload protected A-MSDUs (PP A-MSDUs) (see 11.17). Otherwise, this subfield is set to 0.

— Bit 12: PBAC (protected block ack agreement capable). A STA sets the PBAC subfield of RSN Capabilities field to 1 to indicate it supports PBAC. Otherwise, this subfield is set to 0.

Change the last item in the dashed list immediately after Figure 7-74 in 7.3.2.25.3 as follows:

— Bits 8 and ~~10~~13–15: Reserved. The remaining subfields of the RSN Capabilities field are reserved.

7.3.2.27 Extended Capabilities information element

Insert the rows for Bit 0 and Bit 4 through Bit 6 and change the reserved rows in Table 7-35a as follows (note that the entire table is not shown here):

Table 7-35a—Capabilities field

Bit	Information	Notes
0	20/40 BSS Coexistence Management Support	The 20/40 BSS Coexistence Management Support field indicates support for the 20/40 BSS Coexistence Management frame and its use. The 20/40 BSS Coexistence Management Support field is set to 1 to indicate support for the communication of STA information through the transmission and reception of the 20/40 BSS Coexistence Management frame. The 20/40 BSS Coexistence Management Support field is set to 0 to indicate a lack of support for the communication of STA information through the transmission and reception of the 20/40 BSS Coexistence Management frame.
~~0,~~ 1	Reserved	
3~~-n~~	Reserved	
4	PSMP Capability	This bit in the Extended Capabilities information element is set to 1 if the STA supports PSMP operation described in 9.16. In Beacon and Probe Response frames transmitted by an AP: Set to 0 if the AP does not support PSMP operation Set to 1 if the AP supports PSMP operation In Beacon frames transmitted by a non-AP STA: Set to 0 Otherwise: Set to 0 if the STA does not support PSMP operation Set to 1 if the STA supports PSMP operation
5	Service Interval Granularity	Duration of the shortest service interval (SI). Used for scheduled PSMP only. This field is defined when the S-PSMP Support field is set to 1; otherwise, it is reserved. See 11.4.4b. Set to 0 for 5 ms Set to 1 for 10 ms Set to 2 for 15 ms Set to 3 for 20 ms Set to 4 for 25 ms Set to 5 for 30 ms Set to 6 for 35 ms Set to 7 for 40 ms

Table 7-35a—Capabilities field *(continued)*

Bit	Information	Notes
6	S-PSMP Support	Indicates support for scheduled PSMP. When PSMP Support is set to 0, S-PSMP support is set to 0. When PSMP Support is set to 1, the S-PSMP Support field is defined as follows: Set to 0 if STA does not support S-PSMP Set to 1 is STA supports S-PSMP
7–*n*	Reserved	

Add the following note at the end of 7.3.2.27:

NOTE—The fields of the Extended Capabilities element are not dynamic. They are determined by the parameters of the MLME-START.request or MLME-JOIN.request that caused the STA to start or join its current BSS, and they remain unchanged until the next MLME-START.request or MLME-JOIN.request.

7.3.2.28 BSS Load element

Change the third paragraph of 7.3.2.28 as shown:

The Channel Utilization field is defined as the percentage of time, linearly scaled with 255 representing 100%, that the AP sensed the medium was busy, as indicated by either the physical or virtual carrier sense (CS) mechanism. <u>When more than one channel is in use for the BSS, the Channel Utilization field value is calculated only for the primary channel.</u> This percentage is computed using the formula,

Channel Utilization = Integer((channel_busy_time/(dot11ChannelUtilization-BeaconIntervals × dot11BeaconPeriod × 1024)) × 255),

where

channel_busy_time is defined to be the number of microseconds during which the CS mechanism, as defined in 9.2.1, has indicated a channel busy indication

dot11ChannelUtilizationBeaconIntervals represents the number of consecutive beacon intervals during which the channel busy time is measured. The default value of dot11ChannelUtilization-BeaconIntervals is defined in Annex D.

7.3.2.29 EDCA Parameter Set element

Change paragraph 10 in 7.3.2.29 as follows:

The value of the TXOP Limit field is specified as an unsigned integer, with the least significant octet transmitted first, in units of 32 μs. A TXOP Limit field value of 0 indicates that ~~a single MSDU or MMPDU, in addition to a possible RTS/CTS exchange or CTS to itself, may be transmitted at any rate for each TXOP.~~ <u>the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:</u>

<u>a)</u> <u>A single MSDU, MMPDU, A-MSDU, or A-MPDU at any rate, subject to the rules in 9.6</u>

<u>b)</u> <u>Any required acknowledgments</u>

<u>c)</u> <u>Any frames required for protection, including one of the following:</u>

  <u>1)</u> <u>An RTS/CTS exchange</u>

  <u>2)</u> <u>CTS to itself</u>

3) Dual CTS as specified in 9.2.5.5a

d) Any frames required for beamforming as specified in 9.17

e) Any frames required for link adaptation as specified in 9.16.2

Change Table 7-37 as follows:

Table 7-37—Default EDCA Parameter Set element parameter values

AC	CWmin	CWmax	AIFSN	TXOP limit		
				For PHYs defined in Clause 15 and Clause 18	For PHYs defined in Clause 17, ~~and~~ Clause 19, and Clause 20	Other PHYs
AC_BK	aCWmin	aCWmax	7	0	0	0
AC_BE	aCWmin	aCWmax	3	0	0	0
AC_VI	(aCWmin+1)/2 – 1	aCWmin	2	6.016 ms	3.008 ms	0
AC_VO	(aCWmin+1)/4 – 1	(aCWmin+1)/2 – 1	2	3.264 ms	1.504 ms	0

7.3.2.30 TSPEC element

Change the first item in the dashed list immediately after Figure 7-83 in 7.3.2.30 as follows:

— The Traffic Type subfield is a single bit and is set to 1 for a periodic traffic pattern (e.g., isochronous TS of MSDUs or A-MSDUs, with constant or variable sizes, that are originated at fixed rate) or set to 0 for an aperiodic, or unspecified, traffic pattern (e.g., asynchronous TS of low-duty cycles).

Change Table 7-38 as follows:

Table 7-38—Direction subfield encoding

Bit 5	Bit 6	Usage
0	0	Uplink (MSDUs or A-MSDUs are sent from the non-AP STA to HC)
1	0	Downlink (MSDUs or A-MSDUs are sent from the HC to the non-AP STA)
0	1	Direct link (MSDUs or A-MSDUs are sent from the non-AP STA to another non-AP STA)
1	1	Bidirectional link (equivalent to a downlink request plus an uplink request, each direction having the same parameters). The fields in the TSPEC element specify resources for a single direction. Double the specified resources are required to support both streams.

Change items 7 and 8 in the dashed list immediately after Figure 7-83 in 7.3.2.30 as follows:

— The UP subfield is 3 bits and indicates the actual value of the UP to be used for the transport of MSDUs or A-MSDUs belonging to this TS in cases where relative prioritization is required. When the TCLAS element is present in the request, the UP subfield in TS Info field of the TSPEC element is reserved.

— The TS Info Ack Policy subfield is 2 bits in length and indicates whether MAC acknowledgments are required for MPDUs or A-MSDUs belonging to this TID and the desired form of those acknowledgments. The encoding of the TS Info Ack Policy subfield is shown in Table 7-40. If the TS Info Ack Policy subfield is set to Block Ack and the type of Block Ack policy is unknown to the HC, the HC shall assume, for TXOP scheduling, that the immediate Block Ack policy is being used (see 9.10).

Change Table 7-41 and delete the line immediately after the table as follows:

Table 7-41—Setting of Schedule subfield

APSD	Schedule	Usage
0	0	No Schedule
1	0	Unscheduled APSD
0	1	~~Reserved~~ Scheduled PSMP
1	1	Scheduled APSD

~~The configuration of APSD=0, Schedule=1 is reserved.~~

Change the fourth and fifth paragraphs of 7.3.2.30 as follows:

The Nominal MSDU Size field is 2 octets long, contains an unsigned integer that specifies the nominal size, in octets, of MSDUs or A-MSDUs belonging to the TS under this TSPEC, and is defined in Figure 7-84. If the Fixed subfield is set to 1, then the size of the MSDU or A-MSDU is fixed and is indicated by the Size subfield. If the Fixed subfield is set to 0, then the size of the MSDU or A-MSDU might not be fixed and the Size subfield indicates the nominal MSDU size. If both the Fixed and Size subfields are set to 0, then the nominal MSDU size is unspecified.

The Maximum MSDU Size field is 2 octets long and contains an unsigned integer that specifies the maximum size, in octets, of MSDUs or A-MSDUs belonging to the TS under this TSPEC.

Change paragraphs 11 to 17 of 7.3.2.30 as follows:

The Minimum Data Rate field is 4 octets long and contains an unsigned integer that specifies the lowest data rate specified at the MAC_SAP, in bits per second, for transport of MSDUs or A-MSDUs belonging to this TS within the bounds of this TSPEC. The minimum data rate does not include the MAC and PHY overheads incurred in transferring the MSDUs or A-MSDUs.

The Mean Data Rate[20] field is 4 octets long and contains an unsigned integer that specifies the average data rate specified at the MAC_SAP, in bits per second, for transport of MSDUs or A-MSDUs belonging to this TS within the bounds of this TSPEC. The mean data rate does not include the MAC and PHY overheads incurred in transferring the MSDUs or A-MSDUs.

The Peak Data Rate field is 4 octets long and contains an unsigned integer that specifies the maximum allowable data rate, in bits per second, for transfer of MSDUs or A-MSDUs belonging to this TS within the bounds of this TSPEC. If p is the peak rate in bits per second, then the maximum amount of data, belonging to this TS, arriving in any time interval $[t1,t2]$, where $t1 < t2$ and $t2 - t1 > 1$ TU, does not exceed $p \times (t2 - t1)$ bits.

The Burst Size field is 4 octets long and contains an unsigned integer that specifies the maximum burst, in octets, of the MSDUs or A-MSDUs belonging to this TS that arrive at the MAC_SAP at the peak data rate. A value of 0 indicates that there are no bursts.

The Delay Bound field is 4 octets long and contains an unsigned integer that specifies the maximum amount of time, in microseconds, allowed to transport an MSDU or A-MSDU belonging to the TS in this TSPEC, measured between the time marking the arrival of the MSDU, or the first MSDU of the MSDUs constituting an A-MSDU, at the local MAC sublayer from the local MAC_SAP and the time of completion of the successful transmission or retransmission of the MSDU or A-MSDU to the destination. The completion of the MSDU or A-MSDU transmission includes the relevant acknowledgment frame transmission time, if present.

The Minimum PHY Rate field is 4 octets long and contains an unsigned integer that specifies the desired minimum PHY rate to use for this TS, in bits per second, that is required for transport of the MSDUs or A-MSDUs belonging to the TS in this TSPEC.[21]

The Surplus Bandwidth Allowance field is 2 octets long and specifies the excess allocation of time (and bandwidth) over and above the stated application rates required to transport an MSDU or A-MSDU belonging to the TS in this TSPEC. This field is represented as an unsigned binary number and, when specified, is greater than 0. The 13 LSBs indicate the decimal part while the three MSBs indicate the integer part of the number. This field takes into account the retransmissions, as the rate information does not include retransmissions. It represents the ratio of over-the-air bandwidth (i.e., time that the scheduler allocates for the transmission of MSDUs or A-MSDUs at the required rates) to bandwidth of the transported MSDUs or A-MSDUs required for successful transmission (i.e., time that would be necessary at the minimum PHY rate if there were no errors on the channel) to meet throughput and delay bounds under this TSPEC, when specified. As such, it should be greater than unity. A value of 1 indicates that no additional allocation of time is requested.

7.3.2.37 Neighbor Report element

Replace Figure 7-95c with the following figure:

	B0 B1	B2	B3	B4 B9	B10	B11	B12 B31
	AP Reachability	Security	Key Scope	Capabilities	Mobility Domain	High Throughput	Reserved
Bits:	2	1	1	6	1	1	20

Figure 7-95c—BSSID Information field

Insert the following paragraph after the tenth paragraph (starting "The Mobility Domain bit...") in 7.3.2.37:

The High Throughput bit, when set to 1, indicates that the AP represented by this BSSID is an HT AP including the HT Capabilities element in its Beacons, and that the contents of that HT Capabilities element are identical to the HT Capabilities element advertised by the AP sending the report.

Change the following paragraph in 7.3.2.37 as follows:

Bits ~~11~~12–31 are reserved.

Insert subelement ID 45, 61, and 62 and change the reserved subelement ID rows in Table 7-43b as follows (note that the entire table is not shown here):

Table 7-43b—Optional Subelement IDs for Neighbor Report

Subelement ID	Name	Length field (octets)	Extensible
3–~~65~~44	Reserved		
45	HT Capabilities subelement	26	Yes
46–60	Reserved		
61	HT Operation subelement	22	Yes
62	Secondary Channel Offset subelement	1	
63–65	Reserved		

Insert the following paragraphs after now paragraph 23 (starting "The Measurement Pilot Transmission Information subelement...") in 7.3.2.37:

The HT Capabilities subelement is the same as the HT Capabilities element as defined in 7.3.2.56.

The HT Operation subelement is the same as the HT Operation element as defined in 7.3.2.57.

The Secondary Channel Offset subelement is the same as the Secondary Channel Offset element as defined in 7.3.2.20a.

Insert the following subclauses (7.3.2.56 to 7.3.2.60) after 7.3.2.55:

7.3.2.56 HT Capabilities element

7.3.2.56.1 HT Capabilities element structure

An HT STA declares that it is an HT STA by transmitting the HT Capabilities element.

The HT Capabilities element contains a number of fields that are used to advertise optional HT capabilities of an HT STA. The HT Capabilities element is present in Beacon, Association Request, Association Response, Reassociation Request, Reassociation Response, Probe Request, and Probe Response frames. The HT Capabilities element is defined in Figure 7-95o17.

	Element ID	Length	HT Capabilities Info	A-MPDU Parameters	Supported MCS Set	HT Extended Capabilities	Transmit Beamforming Capabilities	ASEL Capabilities
Octets:	1	1	2	1	16	2	4	1

Figure 7-95o17—HT Capabilities element format

The Element ID field is set to the value for HT Capabilities element defined in Table 7-26.

The Length field of the HT Capabilities element is set to 26.

7.3.2.56.2 HT Capabilities Info field

The HT Capabilities Info field of the HT Capabilities element is 2 octets in length, and contains capability information bits. The structure of this field is defined in Figure 7-95o18.

B0	B1	B2 B3	B4	B5	B6	B7	B8 B9
LDPC Coding Capability	Supported Channel Width Set	SM Power Save	HT-Greenfield	Short GI for 20 MHz	Short GI for 40 MHz	Tx STBC	Rx STBC

B10	B11	B12	B13	B14	B15
HT-Delayed Block Ack	Maximum A-MSDU Length	DSSS/CCK Mode in 40 MHz	Reserved	Forty MHz Intolerant	L-SIG TXOP Protection Support

Figure 7-95o18—HT Capabilities Info field

The subfields of the HT Capabilities Info field are defined in Table 7-43j.

Table 7-43j—Subfields of the HT Capabilities Info field

Subfield	Definition	Encoding
LDPC Coding Capability	Indicates support for receiving LDPC coded packets	Set to 0 if not supported Set to 1 if supported
Supported Channel Width Set	Indicates the channel widths supported by the STA. See 11.14.	Set to 0 if only 20 MHz operation is supported Set to 1 if both 20 MHz and 40 MHz operation is supported This field is reserved when the transmitting or receiving STA is operating in a regulatory class that does not include a value of 13 or 14 in the behavior limits as specified in Annex J.
SM Power Save	Indicates the spatial multiplexing power save mode. See 11.2.3.	Set to 0 for static SM power save mode Set to 1 for dynamic SM power save mode Set to 3 for SM Power Save disabled The value 2 is reserved
HT-Greenfield	Indicates support for the reception of PPDUs with HT-greenfield format. See 20.1.4.	Set to 0 if not supported Set to 1 if supported
Short GI for 20 MHz	Indicates short GI support for the reception of packets transmitted with TXVECTOR parameter CH_BANDWIDTH set to HT_CBW20	Set to 0 if not supported Set to 1 if supported

Table 7-43j—Subfields of the HT Capabilities Info field *(continued)*

Subfield	Definition	Encoding
Short GI for 40 MHz	Indicates short GI support for the reception of packets transmitted with TXVECTOR parameter CH_BANDWIDTH set to HT_CBW40	Set to 0 if not supported Set to 1 if supported
Tx STBC	Indicates support for the transmission of PPDUs using STBC	Set to 0 if not supported Set to 1 if supported
Rx STBC	Indicates support for the reception of PPDUs using STBC	Set to 0 for no support Set to 1 for support of one spatial stream Set to 2 for support of one and two spatial streams Set to 3 for support of one, two and three spatial streams
HT-Delayed Block Ack	Indicates support for HT-delayed Block Ack operation. See 9.10.8.	Set to 0 if not supported Set to 1 if supported Support indicates that the STA is able to accept an ADDBA request for HT-delayed Block Ack
Maximum A-MSDU Length	Indicates maximum A-MSDU length. See 9.7c.	Set to 0 for 3839 octets Set to 1 for 7935 octets
DSSS/CCK Mode in 40 MHz	Indicates use of DSSS/CCK mode in a 20/40 MHz BSS. See 11.14.	In Beacon and Probe Response frames: Set to 0 if the BSS does not allow use of DSSS/CCK in 40 MHz Set to 1 if the BSS does allow use of DSSS/CCK in 40 MHz Otherwise: Set to 0 if the STA does not use DSSS/CCK in 40 MHz Set to 1 if the STA uses DSSS/CCK in 40 MHz See 11.14.8 for operating rules
Forty MHz Intolerant	Indicates whether APs receiving this information or reports of this information are required to prohibit 40 MHz transmissions (see 11.14.12).	Set to 1 by an HT STA to prohibit a receiving AP from operating that AP's BSS as a 20/40 MHz BSS; otherwise, set to 0.
L-SIG TXOP Protection Support	Indicates support for the L-SIG TXOP protection mechanism (see 9.13.5)	Set to 0 if not supported Set to 1 if supported

7.3.2.56.3 A-MPDU Parameters field

The structure of the A-MPDU Parameters field of the HT Capabilities element is shown in Figure 7-95o19.

	B0 B1	B2 B4	B5 B7
	Maximum A-MPDU Length Exponent	Minimum MPDU Start Spacing	Reserved
Octets:	1		

Figure 7-95o19—A-MPDU Parameters field

The subfields of the A-MPDU Parameters field are defined in Table 7-43k.

Table 7-43k—Subfields of the A-MPDU Parameters field

Subfield	Definition	Encoding
Maximum A-MPDU Length Exponent	Indicates the maximum length of A-MPDU that the STA can receive.	This field is an integer in the range 0 to 3. The length defined by this field is equal to $2^{(13 + \text{Maximum A-MPDU Length Exponent})} - 1$ octets.
Minimum MPDU Start Spacing	Determines the minimum time between the start of adjacent MPDUs within an A-MPDU that the STA can receive, measured at the PHY-SAP. See 9.7d.3.	Set to 0 for no restriction Set to 1 for 1/4 µs Set to 2 for 1/2 µs Set to 3 for 1 µs Set to 4 for 2 µs Set to 5 for 4 µs Set to 6 for 8 µs Set to 7 for 16 µs

7.3.2.56.4 Supported MCS Set field

The Supported MCS Set field of the HT Capabilities element indicates which MCSs a STA supports.

An MCS is identified by an MCS index, which is represented by an integer in the range 0 to 76. The interpretation of the MCS index (i.e., the mapping from MCS to data rate) is PHY dependent. For the HT PHY, see 20.6.

The structure of the MCS Set field is defined in Figure 7-95o20.

	B0 B76	B77 B79	B80 B89	B90 B95
	Rx MCS Bitmask	Reserved	Rx Highest Supported Data Rate	Reserved
Bits:	77	3	10	6

	B96	B97	B98 B99	B100	B101 B127
	Tx MCS Set Defined	Tx Rx MCS Set Not Equal	Tx Maximum Number Spatial Streams Supported	Tx Unequal Modulation Supported	Reserved
Bits:	1	1	2	1	27

Figure 7-95o20—Supported MCS Set field

The Rx MCS Bitmask subfield of the Supported MCS Set field defines a set of MCS index values, where bit B0 corresponds to MCS 0 and bit B76 corresponds to MCS 76.

NOTE— An HT STA includes the mandatory MCS values defined in 20.1 in the Rx MCS Bitmask subfield.

The Rx Highest Supported Data Rate subfield of the Supported MCS Set field defines the highest data rate that the STA is able to receive, in units of 1 Mb/s, where 1 represents 1 Mb/s, and incrementing by 1 Mb/s steps to the value 1023, which represents 1023 Mb/s. The value 0 indicates that this subfield does not specify the highest data rate that the STA is able to receive, see 9.6.0e.5.3.

The Tx MCS Set Defined, Tx Rx MCS Set Not Equal, Tx Maximum Number Spatial Streams Supported, and Tx Unequal Modulation Supported subfields of the Supported MCS Set field indicate the transmit-supported MCS set, as defined in Table 7-43l.

Table 7-43l—Transmit MCS Set

Condition	Tx MCS Set Defined	Tx Rx MCS Set Not Equal	Tx Maximum Number Spatial Streams Supported	Tx Unequal Modulation Supported
No Tx MCS set is defined	0	0	0	0
The Tx MCS set is defined to be equal to the Rx MCS set	1	0	0	0
The Tx MCS set may differ from the Rx MCS set	1	1	Indicates the maximum number of spatial streams supported when transmitting: Set to 0 for 1 spatial stream Set to 1 for 2 spatial streams Set to 2 for 3 spatial streams Set to 3 for 4 spatial streams	Indicates whether transmit unequal modulation (UEQM) is supported: Set to 0 for UEQM not supported Set to 1 for UEQM supported

7.3.2.56.5 HT Extended Capabilities field

The structure of the HT Extended Capabilities field of the HT Capabilities element is defined in Figure 7-95o21.

	B0	B1 B2	B3 B7	B8 B9	B10	B11	B12 B15
	PCO	PCO Transition Time	Reserved	MCS Feedback	+HTC Support	RD Responder	Reserved
Bits:	1	2	5	2	1	1	4

Figure 7-95o21—HT Extended Capabilities field

The subfields of the HT Extended Capabilities field are defined in Table 7-43m.

Table 7-43m—Subfields of the HT Extended Capabilities field

Subfield	Definition	Encoding
PCO	Indicates support for PCO. When transmitted by an AP: indicates whether the AP can operate its BSS as a PCO BSS. When transmitted by a non-AP STA: indicates whether the STA can operate as a PCO active STA when the Transition Time subfield in its HT Extended Capabilities field meets the intended transition time of the PCO capable AP.	Set to 0 if not supported Set to 1 if supported
PCO Transition Time	When transmitted by a non-AP STA: indicates that the STA can switch between 20 MHz channel width and 40 MHz channel width within the specified time. When transmitted by an AP: indicates the PCO Transition Time to be used during PCO operation. The value contained in this field is dynamic when transmitted by an AP, i.e., the value of this field may change at any time during the lifetime of the association of a STA with the AP. See 11.15.3.	If the PCO subfield is set to 0, this field is reserved. Otherwise: Set to 1 for 400 µs Set to 2 for 1.5 ms Set to 3 for 5 ms Set to 0 for no transition. In this case, the PCO active STA does not change its operating channel width and is able to receive 40 MHz PPDUs during the 20 MHz phase (see 11.15).
MCS Feedback	Indicates whether the STA can provide MFB	Set to 0 (No Feedback) if the STA does not provide MFB Set to 2 (Unsolicited) if the STA provides only unsolicited MFB Set to 3 (Both) if the STA can provide MFB in response to MRQ (either Delayed or Immediate, see 9.18.1) as well as unsolicited MFB The value 1 is reserved
+HTC Support	Indicates support of the HT Control field. See 9.7a	Set to 0 if not supported Set to 1 if supported
RD Responder	Indicates support for acting as a reverse direction responder, i.e., the STA may use an offered RDG to transmit data to an RD initiator using the Reverse Direction Protocol described in 9.15.	Set to 0 if not supported Set to 1 if supported

7.3.2.56.6 Transmit Beamforming Capabilities

The structure of the Transmit Beamforming Capabilities field is defined in Figure 7-95o22.

B0	B1	B2	B3	B4	B5	B6 B7	B8
Implicit Transmit Beamforming Receiving Capable	Receive Staggered Sounding Capable	Transmit Staggered Sounding Capable	Receive NDP Capable	Transmit NDP Capable	Implicit Transmit Beamforming Capable	Calibration	Explicit CSI Transmit Beamforming Capable
Bits: 1	1	1	1	1	1	2	1

B9	B10	B11 B12	B13 B14	B15 B16	B17 B18	B19 B20
Explicit Noncompressed Steering Capable	Explicit Compressed Steering Capable	Explicit Transmit Beamforming CSI Feedback	Explicit Noncompressed Beamforming Feedback Capable	Explicit Compressed Beamforming Feedback Capable	Minimal Grouping	CSI Number of Beamformer Antennas Supported
1	1	2	2	2	2	2

B21 B22	B23 B24	B25 B26	B27 B28	B29 B31
Noncompressed Steering Number of Beamformer Antennas Supported	Compressed Steering Number of Beamformer Antennas Supported	CSI Max Number of Rows Beamformer Supported	Channel Estimation Capability	Reserved
2	2	2	2	3

Figure 7-95o22—Transmit Beamforming Capabilities field

The subfields of the Transmit Beamforming Capabilities field are defined in Table 7-43n.

Table 7-43n—Subfields of the Transmit Beamforming Capabilities field

Subfield	Definition	Encoding
Implicit Transmit Beamforming Receiving Capable	Indicates whether this STA can receive Transmit Beamforming steered frames using implicit feedback	Set to 0 if not supported Set to 1 if supported
Receive Staggered Sounding Capable	Indicates whether this STA can receive staggered sounding frames.	Set to 0 if not supported Set to 1 if supported
Transmit Staggered Sounding Capable	Indicates whether this STA can transmit staggered sounding frames.	Set to 0 if not supported Set to 1 if supported
Receive NDP Capable	Indicates whether this receiver can interpret null data packets as sounding frames.	Set to 0 if not supported Set to 1 if supported
Transmit NDP Capable	Indicates whether this STA can transmit null data packets as sounding frames.	Set to 0 if not supported Set to 1 if supported
Implicit Transmit Beamforming Capable	Indicates whether this STA can apply implicit transmit beamforming.	Set to 0 if not supported Set to 1 if supported

Table 7-43n—Subfields of the Transmit Beamforming Capabilities field *(continued)*

Subfield	Definition	Encoding
Calibration	Indicates whether the STA can participate in a calibration procedure initiated by another STA that is capable of generating an immediate response sounding PPDU and can provide a CSI report in response to the receipt of a sounding PPDU.	Set to 0 if not supported Set to 1 if the STA can respond to a calibration request using the CSI report, but cannot initiate calibration The value 2 is reserved Set to 3 if the STA can both initiate and respond to a calibration request
Explicit CSI Transmit Beamforming Capable	Indicates whether this STA can apply transmit beamforming using CSI explicit feedback in its transmission	Set to 0 if not supported Set to 1 if supported
Explicit Noncompressed Steering Capable	Indicates whether this STA can apply transmit beamforming using noncompressed beamforming feedback matrix explicit feedback in its transmission	Set to 0 if not supported Set to 1 if supported
Explicit Compressed Steering Capable	Indicates whether this STA can apply transmit beamforming using compressed beamforming feedback matrix explicit feedback in its transmission	Set to 0 if not supported Set to 1 if supported
Explicit Transmit Beamforming CSI Feedback	Indicates whether this receiver can return CSI explicit feedback.	Set to 0 if not supported Set to 1 for delayed feedback Set to 2 for immediate feedback Set to 3 for delayed and immediate feedback
Explicit Noncompressed Beamforming Feedback Capable	Indicates whether this receiver can return noncompressed beamforming feedback matrix explicit feedback.	Set to 0 if not supported Set to 1 for delayed feedback Set to 2 for immediate feedback Set to 3 for delayed and immediate feedback
Explicit Compressed Beamforming Feedback Capable	Indicates whether this receiver can return compressed beamforming feedback matrix explicit feedback.	Set to 0 if not supported Set to 1 for delayed feedback Set to 2 for immediate feedback Set to 3 for delayed and immediate feedback
Minimal Grouping	Indicates the minimal grouping used for explicit feedback reports	Set to 0 if the STA supports groups of 1 (no grouping) Set to 1 indicates groups of 1, 2 Set to 2 indicates groups of 1, 4 Set to 3 indicates groups of 1, 2, 4
CSI Number of Beamformer Antennas Supported	Indicates the maximum number of beamformer antennas the beamformee can support when CSI feedback is required	Set to 0 for single Tx antenna sounding Set to 1 for 2 Tx antenna sounding Set to 2 for 3 Tx antenna sounding Set to 3 for 4 Tx antenna sounding
Noncompressed Steering Number of Beamformer Antennas Supported	Indicates the maximum number of beamformer antennas the beamformee can support when noncompressed beamforming feedback matrix is required	Set to 0 for single Tx antenna sounding Set to 1 for 2 Tx antenna sounding Set to 2 for 3 Tx antenna sounding Set to 3 for 4 Tx antenna sounding

Table 7-43n—Subfields of the Transmit Beamforming Capabilities field *(continued)*

Subfield	Definition	Encoding
Compressed Steering Number of Beamformer Antennas Supported	Indicates the maximum number of beamformer antennas the beamformee can support when compressed beamforming feedback matrix is required	Set to 0 for single Tx antenna sounding Set to 1 for 2 Tx antenna sounding Set to 2 for 3 Tx antenna sounding Set to 3 for 4 Tx antenna sounding
CSI Max Number of Rows Beamformer Supported	Indicates the maximum number of rows of CSI explicit feedback from the beamformee or calibration responder or transmit ASEL responder that a beamformer or calibration initiator or transmit ASEL initiator can support when CSI feedback is required.	Set to 0 for a single row of CSI Set to 1 for 2 rows of CSI Set to 2 for 3 rows of CSI Set to 3 for 4 rows of CSI
Channel Estimation Capability	Indicates the maximum number of space-time streams (columns of the MIMO channel matrix) for which channel dimensions can be simultaneously estimated when receiving an NDP sounding PPDU or the extension portion of the HT Long Training fields (HT-LTFs) in a staggered sounding PPDU. See NOTE.	Set 0 for 1 space-time stream Set 1 for 2 space-time streams Set 2 for 3 space-time streams Set 3 for 4 space-time streams
NOTE—The maximum number of space-time streams for which channel coefficients can be simultaneously estimated using the HT-LTFs corresponding to the data portion of the packet is limited by the Rx MCS Bitmask subfield of the Supported MCS Set field and by the Rx STBC subfield of the HT Capabilities Info field. Both fields are part of the HT Capabilities element.		

7.3.2.56.7 ASEL Capability field

The structure of the ASEL Capability field of the HT Capabilities element is defined in Figure 7-95o23.

B0	B1	B2	B3	B4	B5	B6	B7
Antenna Selection Capable	Explicit CSI Feedback Based Transmit ASEL Capable	Antenna Indices Feedback Based Transmit ASEL Capable	Explicit CSI Feed-back Capable	Antenna Indices Feedback Capable	Receive ASEL Capable	Transmit Sounding PPDUs Capable	Reserved
Bits: 1	1	1	1	1	1	1	1

Figure 7-95o23—ASEL Capability field

The subfields of the ASEL Capability field are defined in Table 7-43o.

Table 7-43o—ASEL Capability field subfields

Subfield	Definition	Encoding
Antenna Selection Capable	Indicates whether this STA supports ASEL	Set to 0 if not supported Set to 1 if supported
Explicit CSI Feedback Based Transmit ASEL Capable	Indicates whether this STA supports transmit ASEL based on explicit CSI feedback	Set to 0 if not supported Set to 1 if supported
Antenna Indices Feedback Based Transmit ASEL Capable	Indicates whether this STA supports transmit ASEL based on antenna indices feedback	Set to 0 if not supported Set to 1 if supported
Explicit CSI Feedback Capable	Indicates whether this STA can compute CSI and provide CSI feedback in support of ASEL	Set to 0 if not supported Set to 1 if supported
Antenna Indices Feedback Capable	Indicates whether this STA can compute an antenna indices selection and return an antenna indices selection in support of ASEL	Set to 0 if not supported Set to 1 if supported
Receive ASEL Capable	Indicates whether this STA supports receive ASEL	Set to 0 if not supported Set to 1 if supported
Transmit Sounding PPDUs Capable	Indicates whether this STA can transmit sounding PPDUs for ASEL training on request	Set to 0 if not supported Set to 1 if supported

7.3.2.57 HT Operation element

The operation of HT STAs in the BSS is controlled by the HT Operation element. The structure of this element is defined in Figure 7-95o24.

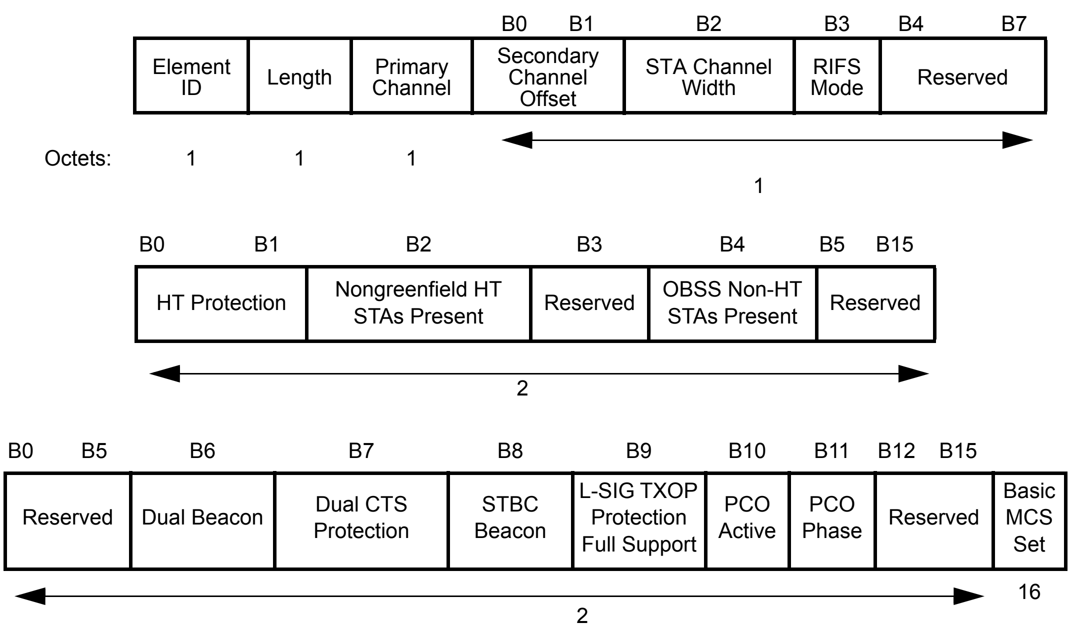


Figure 7-95o24—HT Operation element format

The Element ID field is set to the value for HT Operation element defined in Table 7-26.

The fields of the HT Operation element are defined in Table 7-43p. The "Reserved in IBSS?" column indicates whether each field is reserved (Y) or not reserved (N) when this element is present in a frame transmitted within an IBSS.

Table 7-43p—HT Operation element

Field	Definition	Encoding	Reserved in IBSS ?
Primary Channel	Indicates the channel number of the primary channel. See 11.14.2.	Channel number of the primary channel	N
Secondary Channel Offset	Indicates the offset of the secondary channel relative to the primary channel.	Set to 1 (SCA) if the secondary channel is above the primary channel Set to 3 (SCB) if the secondary channel is below the primary channel Set to 0 (SCN) if no secondary channel is present The value 2 is reserved	N
STA Channel Width	Defines the channel widths that may be used to transmit to the STA. See 11.14.12	Set to 0 for a 20 MHz channel width Set to 1 allows use of any channel width in the Supported channel width set This field is reserved when the transmitting or receiving STA is operating in a regulatory class that does not include a value of 13 or 14 in the behavior limits as specified in Annex J. See NOTE 1.	N
RIFS Mode	Indicates whether the use of reduced interframe space is permitted within the BSS. See 9.2.3.0b and 9.13.3.3	Set to 0 if use of RIFS is prohibited Set to 1 if use of RIFS is permitted	Y
HT Protection	Indicates protection requirements of HT transmissions. See 9.13.3.	Set to 0 for no protection mode Set to 1 for nonmember protection mode Set to 2 for 20 MHz protection mode Set to 3 for non-HT mixed mode	Y
Nongreenfield HT STAs Present	Indicates if any HT STAs that are not HT-greenfield capable have associated. Determines when a non-AP STA should use HT-greenfield protection. Present in Beacon and Probe response frames transmitted by an AP. Otherwise reserved. See 9.13.3.1.	Set to 0 if all HT STAs that are associated are HT-greenfield capable Set to 1 if one or more HT STAs that are not HT-greenfield capable are associated	Y

Table 7-43p—HT Operation element *(continued)*

Field	Definition	Encoding	Reserved in IBSS ?
OBSS Non-HT STAs Present	Indicates if the use of protection for non-HT STAs by overlapping BSSs is determined to be desirable. If the BSS is operating in a regulatory class for which the behavior limits set listed in Annex J includes the value 16, this field indicates if there exist any non-HT OBSSs and whether HT-greenfield transmissions are allowed. Present in Beacon and Probe response frames transmitted by an AP. Otherwise reserved. See 9.13.3.4 and 11.9.7.3.	If not operating in a regulatory class for which the behavior limits set listed in Annex J includes the value 16: Set to 1 if the use of protection for non-HT STAs by OBSSs is determined to be desirable. See NOTE 2. Set to 0 otherwise. If operating in a regulatory class for which the behavior limits set listed in Annex J includes the value 16: Set to 1 if there exists one or more non-HT OBSSs. Indicates that HT-greenfield transmissions are disallowed in the BSS. Set to 0 otherwise.	Y
Dual Beacon	Indicates whether the AP transmits an STBC beacon.	Set to 0 if no STBC beacon is transmitted Set to 1 if an STBC beacon is transmitted by the AP	Y
Dual CTS Protection	Dual CTS protection is used by the AP to set a NAV at STAs that do not support STBC and at STAs that can associate solely through the STBC beacon. See 9.2.5.5a.	Set to 0 if dual CTS protection is not required Set to 1 if dual CTS protection is required	Y
STBC Beacon	Indicates whether the beacon containing this element is a primary or an STBC beacon. The STBC beacon has half a beacon period shift relative to the primary beacon. Defined only in a Beacon transmitted by an AP. Otherwise reserved. See 11.1.2.1.	Set to 0 in a primary beacon Set to 1 in an STBC beacon	Y
L-SIG TXOP Protection Full Support	Indicates whether all HT STA in the BSS support L-SIG TXOP protection. See 9.13.5.	Set to 0 if one or more HT STA in the BSS do not support L-SIG TXOP protection Set to 1 if all HT STA in the BSS support L-SIG TXOP protection	Y
PCO Active	Indicates whether PCO is active in the BSS Present in Beacon/Probe Response frames transmitted by an AP. Otherwise reserved. Non-PCO STAs regard the BSS as a 20/40 MHz BSS and may associate with the BSS without regard to this field. See 11.15.	Set to 0 if PCO is not active in the BSS Set to 1 if PCO is active in the BSS	Y

Table 7-43p—HT Operation element *(continued)*

Field	Definition	Encoding	Reserved in IBSS ?
PCO Phase	Indicates the PCO phase of operation Defined only in a Beacon and Probe Response frames when PCO Active is 1. Otherwise reserved. See 11.15.	Set to 0 indicates switch to or continue 20 MHz phase Set to 1 indicates switch to or continue 40 MHz phase	Y
Basic MCS Set	Indicates the MCS values that are supported by all HT STAs in the BSS. Present in Beacon/Probe Response frames. Otherwise reserved.	The Basic MCS Set is a bitmap of size 128 bits. Bit 0 corresponds to MCS 0. A bit is set to 1 to indicate support for that MCS and 0 otherwise. MCS values are defined in 7.3.2.56.4.	N

NOTE 1—Any change of STA Channel Width field value does not impact the value of the HT Protection field.

NOTE 2—Examples of when this bit may be set to 1 include, but are not limited to, the following situations:
- One or more non-HT STAs are associated
- A non-HT BSS is overlapping (a non-HT BSS may be detected by the reception of a Beacon where the supported rates contain only Clause 15, Clause 17, Clause 18, or Clause 19 rates)
- A management frame (excluding a Probe Request) is received where the supported rate set includes only Clause 15, Clause 17, Clause 18, and Clause 19 rates

7.3.2.58 20/40 BSS Intolerant Channel Report element

The 20/40 BSS Intolerant Channel Report element contains a list of channels on which a STA has found conditions that disallow the use of a 20/40 MHz BSS. The format of the 20/40 BSS Intolerant Channel Report element is shown in Figure 7-95o25.

	Element ID	Length	Regulatory Class	Channel List
Octets:	1	1	1	Variable

Figure 7-95o25—20/40 BSS Intolerant Channel Report element format

The Element ID field is set to the value of 20/40 BSS Intolerant Channel Report element defined in Table 7-26.

The Length field of the 20/40 BSS Intolerant Channel Report element is variable and depends on the number of channels reported in the Channel List field. The minimum value of the Length field is 1 (based on a minimum length for the Channel List field of 0 octets).

Regulatory Class field of the 20/40 MHz BSS Intolerant Channel Report element contains an enumerated value from Annex J, encoded as an unsigned integer, specifying the regulatory class in which the channel list is valid. A 20/40 BSS Intolerant Channel Report only reports channels for a single regulatory class. Multiple 20/40 BSS Intolerant Channel Report elements are used to report channels in more than one regulatory class.

The Channel List field of the 20/40 MHz BSS Intolerant Channel Report element a variable number of octets, where each octet describes a single channel number. Channel numbering shall be dependent on regulatory class according to Annex J.

A 20/40 BSS Intolerant Channel Report element includes only channels that are valid for the regulatory domain in which the STA transmitting the element is operating and that are consistent with the Country element transmitted by the AP of the BSS of which it is a member.

7.3.2.59 Overlapping BSS Scan Parameters element

The Overlapping BSS Scan Parameters element is used by an AP in a BSS to indicate the values to be used by BSS members when performing OBSS scan operations. The format of the Overlapping BSS Scan Parameters element is shown in Figure 7-95o26.

	Element ID	Length	OBSS Scan Passive Dwell	OBSS Scan Active Dwell	BSS Channel Width Trigger Scan Interval	OBSS Scan Passive Total Per Channel	OBSS Scan Active Total Per Channel	BSS Width Channel Transition Delay Factor	OBSS Scan Activity Threshold
Octets:	1	1	2	2	2	2	2	2	2

Figure 7-95o26—Overlapping BSS Scan Parameters element format

The Element ID field value is equal to the Overlapping BSS Scan Parameters element value in Table 7-26.

The Length field is set to 14.

The OBSS Scan Passive Dwell field contains a value in TUs, encoded as an unsigned integer, that a receiving STA uses to set its dot11OBSSScanPassiveDwell MIB variable as described in 11.14.5.

The OBSS Scan Active Dwell field contains a value in TUs, encoded as an unsigned integer, that a receiving STA uses to set its dot11OBSSScanActiveDwell MIB variable as described in 11.14.5.

The BSS Channel Width Trigger Scan Interval field contains a value in seconds, encoded as an unsigned integer, that a receiving STA uses to set its dot11BSSWidthTriggerScanInterval MIB variable as described in 11.14.5.

The OBSS Scan Passive Total Per Channel field contains a value in TUs, encoded as an unsigned integer, that a receiving STA uses to set its dot11OBSSScanPassiveTotalPerChannel MIB variable as described in 11.14.5.

The OBSS Scan Active Total Per Channel field contains a value in TUs, encoded as an unsigned integer, that a receiving STA uses to set its dot11OBSSScanActiveTotalPerChannel MIB variable as described in 11.14.5.

The BSS Width Channel Transition Delay Factor field contains an integer value that a receiving STA uses to set its dot11BSSWidthChannelTransitionDelayFactor MIB variable as described in 11.14.5.

The OBSS Scan Activity Threshold field contains a value in hundredths of percent, encoded as an unsigned integer, that a receiving STA uses to set its dot11OBSSScanActivityThreshold MIB variable as described in 11.14.5.

The use of each of these parameters is described in 11.14.5.

7.3.2.60 20/40 BSS Coexistence element

The 20/40 BSS Coexistence element is used by STAs to exchange information that affects 20/40 BSS coexistence.

The 20/40 BSS Coexistence element is formatted as shown in Figure 7-95o27.

			B0	B1	B2	B3	B4	B5 B7
	Element ID	Length	Information Request	Forty MHz Intolerant	20 MHz BSS Width Request	OBSS Scanning Exemption Request	OBSS Scanning Exemption Grant	Reserved
Octets:	1	1	1					

Figure 7-95o27—20/40 BSS Coexistence element format

The Element ID field is set to the value for 20/40 BSS Coexistence element defined in Table 7-26.

The Information Request field is used to indicate that a transmitting STA is requesting the recipient to transmit a 20/40 BSS Coexistence Management frame with the transmitting STA as the recipient.

The Forty MHz Intolerant field, when set to 1, prohibits an AP that receives this information or reports of this information from operating a 20/40 MHz BSS. When set to 0, it does not prohibit a receiving AP from operating a 20/40 MHz BSS. This field is used for inter-BSS communication. The definition of this field is the same as the definition of the Forty MHz Intolerant field in the HT Capabilities element (see 7.3.2.56), and its operation is described in 11.14.11.

The 20 MHz BSS Width Request field, when set to 1, prohibits a receiving AP from operating its BSS as a 20/40 MHz BSS. Otherwise, it is set to 0. This field is used for intra-BSS communication. The operation of this field is described in 11.14.12.

The OBSS Scanning Exemption Request field is set to 1 to indicate that the transmitting non-AP STA is requesting the BSS to allow the STA to be exempt from OBSS scanning. Otherwise, it is set to 0. The OBSS Scanning Exemption Request field is reserved when transmitted by an AP. The OBSS Scanning Exemption Request field is reserved when a 20/40 BSS Coexistence element is included in a group-addressed frame.

The OBSS Scanning Exemption Grant field is set to 1 by an AP to indicate that the receiving STA is exempted from performing OBSS Scanning. Otherwise, it is set to 0. The OBSS Scanning Exemption Grant field is reserved when transmitted by a non-AP STA. The OBSS Scanning Exemption Grant field is reserved when a 20/40 BSS Coexistence element is included in a group-addressed frame.

7.4 Action frame format details

7.4.1 Spectrum management action details

7.4.1.5 Channel Switch Announcement frame format

Replace Figure 7-100 with the following figure:

	Category	Action Value	Channel Switch Announcement element	Secondary Channel Offset element
Octets:	1	1	5	3

Figure 7-100—Channel Switch Announcement frame body format

Insert the following paragraph at the end of 7.4.1.5:

The Secondary Channel Offset element is defined in 7.3.2.20a. This element is present when switching to a 40 MHz channel. It may be present when switching to a 20 MHz channel (in which case the secondary channel offset is set to SCN).

7.4.3 DLS Action frame details

7.4.3.1 DLS Request frame format

Change the first paragraph of 7.4.3.1 as follows:

The DLS Request frame is used to set up a direct link with a peer MAC. The frame body of the DLS Request frame contains the information shown in Table 7-51<u>, with some fields being optionally present as indicated in the “Notes” column of the table</u>.

Change Table 7-51 as shown, and insert the order 9 as follows (note that the entire table is not shown here):

Table 7-51—DLS Request frame body

Order	Information	<u>Notes</u>
9	HT Capabilities	The HT Capabilities element shall be present when the dot11HighThroughputOptionImplemented attribute is TRUE.

7.4.3.2 DLS Response frame format

Change the first paragraph of 7.4.3.2 as follows:

The DLS Response frame is sent in response to a DLS Request frame. The frame body of a DLS Response frame contains the information shown in Table 7-52<u>, with some fields being optionally present as indicated in the “Notes” column of the table</u>.

Change Table 7-52 as shown and insert order 9 as follows (note that the entire table is not shown here):

Table 7-52—DLS Response frame body

Order	Information	Notes
9	HT Capabilities	The HT Capabilities element shall be present when the dot11HighThroughputOptionImplemented attribute is TRUE.

7.4.4 Block Ack Action frame details

Change the first paragraph of 7.4.4 as follows:

The ADDBA frames are used to set up or, if PBAC is used, to modify Block Ack for a specific TC or TS. The Action field value associated with each frame format within the Block Ack category are defined in Table 7-54.

7.4.7 Public Action details

7.4.7.1 Public Action frames

Change the first paragraph of 7.4.7.1 as follows:

The Public Action frame is defined to allow inter-BSS and AP to unassociated-STA communications in addition to intra-BSS communication. The defined Public Action frames are listed in Table 7-57e.

Change the Action field value 0 in Table 7.57e as follows (note that the entire table is not shown here):

Table 7-57e—Public Action field values

Action field value	Description
0	~~Reserved~~ 20/40 BSS Coexistence Management (see 7.4.7.1a)

Insert the following subclause 7.4.7.1a after 7.4.7.1:

7.4.7.1a 20/40 BSS Coexistence Management frame format

The 20/40 BSS Coexistence Management frame is a Public Action frame. The format of its frame body is defined in Table 7-57e1.

The Category field is set to the value for Public, specified in Table 7-24.

The Action field is set to the value for 20/40 BSS Coexistence Management, specified in Table 7-57e.

Table 7-57e1—20/40 BSS Coexistence Management frame body

Order	Information	Notes
1	Category	
2	Action	
3	20/40 BSS Coexistence (see 7.3.2.60)	
4	20/40 BSS Intolerant Channel Report (see 7.3.2.58)	May appear zero or more times

Insert the following subclauses (7.4.10 to 7.4.10.9) after 7.4.9a.7:

7.4.10 HT Action frame details

7.4.10.1 HT Action field

Several Action frame formats are defined to support HT features. The Action field values associated with each frame format within the HT category are defined in Table 7-57n. The frame formats are defined in 7.4.10.2 through 7.4.10.9.

Table 7-57n—HT Action field values

Value	Meaning
0	Notify Channel Width
1	SM Power Save
2	PSMP
3	Set PCO Phase
4	CSI
5	Noncompressed Beamforming
6	Compressed Beamforming
7	ASEL Indices Feedback
8–255	Reserved

7.4.10.2 Notify Channel Width frame format

A STA sends the Notify Channel Width Action frame to another STA if it wants to change the channel width of frames that the other STA sends to it. See definition in 11.14.2.

The format of the Notify Channel Width Action frame body is defined in Table 7-57o.

This frame can be sent by both non-AP STA and AP. If an AP wishes to receive 20 MHz packets, it broadcasts this Action frame to all STAs in the BSS. In addition, the AP indicates its current STA channel width in the HT Operation element in the beacon.

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for Notify Channel Width, specified in Table 7-57n.

Table 7-57o—Notify Channel Width frame body

Order	Information
1	Category
2	Action
3	Channel Width (see 7.3.1.21)

7.4.10.3 SM Power Save frame format

The SM Power Save Action frame is of category HT. The SM Power Save frame is used to manage SM power-saving state transitions as defined in 11.2.3.

The frame body of the SM Power Save Action frame is defined in Table 7-57p.

Table 7-57p—SM Power Save frame body

Order	Information
1	Category
2	Action
3	SM Power Control (see 7.3.1.22)

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for SM Power Save, specified in Table 7-57n.

7.4.10.4 PSMP frame format

PSMP is an Action frame of category HT.

The DA field of this frame is a group address. (See 9.16.1.8.)

The PSMP Parameter Set field and PSMP STA Info fields define zero or more PSMP-DTT and PSMP-UTT time allocations that follow immediately after the PSMP frame.

The frame body of this frame is defined in Table 7-57q. The PSMP Parameter Set field is followed by zero or more PSMP STA Info fields.

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for PSMP, specified in Table 7-57n.

The PSMP STA Info fields within a PSMP frame are ordered by STA_INFO Type as follows: group-addressed (STA_INFO Type=1) and then individually addressed (STA_INFO Type=2).

Table 7-57q—PSMP frame body

Order	Information
1	Category
2	Action
3	PSMP Parameter Set (see 7.3.1.24)
4 to (N_STA+3)	PSMP STA Info (see 7.3.1.25) Repeated N_STA times (N_STA is a subfield of the PSMP Parameter Set field)

7.4.10.5 Set PCO Phase frame format

Set PCO Phase is an Action frame of category HT that announces the phase change between 20 MHz and 40 MHz. The format of its frame body is defined in Table 7-57r. The operation of the PCO feature is defined in 11.15.

Table 7-57r—Set PCO Phase frame body

Order	Information
1	Category
2	Action
3	PCO Phase Control (see 7.3.1.23)

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for Set PCO Phase, specified in Table 7-57n.

This frame is sent by a PCO active AP.

7.4.10.6 CSI frame format

The CSI frame is an Action or an Action No Ack frame of category HT. The format of its frame body is defined in Table 7-57s.

Table 7-57s—CSI frame body

Order	Information
1	Category
2	Action
3	MIMO Control (see 7.3.1.26)
4	CSI Report (see 7.3.1.27)

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for CSI, specified in Table 7-57n.

In a CSI frame, the fields of the MIMO Control field (see 7.3.1.26) are used as described in Table 7-25c. The Codebook Information subfield is reserved in this frame.

7.4.10.7 Noncompressed Beamforming frame format

The Noncompressed Beamforming frame is an Action or an Action No Ack frame of category HT. The format of the frame body is defined in Table 7-57t.

Table 7-57t—Noncompressed Beamforming frame body

Order	Information
1	Category
2	Action
3	MIMO Control (see 7.3.1.26)
4	Noncompressed Beamforming Report (see 7.3.1.28)

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for Noncompressed Beamforming, specified in Table 7-57n.

In a Noncompressed Beamforming frame, the fields of the MIMO Control field (see 7.3.1.26) are used as described in Table 7-25c. The Codebook Information subfield is reserved in this frame.

7.4.10.8 Compressed Beamforming frame format

The Compressed Beamforming frame is an Action or an Action No Ack frame of category HT. The format of its frame body is defined in Table 7-57u.

Table 7-57u—Compressed Beamforming frame body

Order	Information
1	Category
2	Action
3	MIMO Control (see 7.3.1.26)
4	Compressed Beamforming Report (see 7.3.1.29)

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for Compressed Beamforming, specified in Table 7-57n.

In a Compressed Beamforming frame, the fields of the MIMO Control field (see 7.3.1.26) are used as described in Table 7-25c. The Coefficient Size subfield is reserved in this frame.

7.4.10.9 Antenna Selection Indices Feedback frame format

The Antenna Selection Indices Feedback frame is an Action or Action No Ack frame of category HT. The format of its frame body is defined in Table 7-57v.

Table 7-57v—Antenna Selection Indices Feedback frame body

Order	Information
1	Category
2	Action
3	Antenna Selection Indices (see 7.3.1.30)

The Category field is set to the value for HT, specified in Table 7-24.

The Action field is set to the value for ASEL Indices Feedback, specified in Table 7-57n.

Insert the following subclauses (7.4a through 7.4a.3) after 7.4.10.9:

7.4a Aggregate MPDU (A-MPDU)

7.4a.1 A-MPDU format

An A-MPDU consists of a sequence of one or more A-MPDU subframes as shown in Figure 7-101o.

	A-MPDU subframe 1	A-MPDU subframe 2	…	A-MPDU subframe n
Octets:	variable	variable		variable

Figure 7-101o—A-MPDU format

Each A-MPDU subframe consists of an MPDU delimiter followed by an MPDU. Except when an A-MPDU subframe is the last one in an A-MPDU, padding octets are appended to make each A-MPDU subframe a multiple of 4 octets in length. The A-MPDU maximum length is 65 535 octets. The length of an A-MPDU addressed to a particular STA may be further constrained as described in 9.7d.2.

The MPDU delimiter is 4 octets in length. The structure of the MPDU delimiter is defined in Figure 7-101p.

Bits:	B0 B3	B4 B15	B16 B23	B24 B31		
	Reserved	MPDU length	CRC	Delimiter Signature	MPDU	Pad
	MPDU Delimiter					
Octets:	4				Variable	0–3

Figure 7-101p—A-MPDU subframe format

The fields of the MPDU delimiter are defined in Table 7-57w.

Table 7-57w— MPDU delimiter fields

Field	Size (bits)	Description
Reserved	4	
MPDU length	12	Length of the MPDU in octets
CRC	8	8-bit CRC of the preceding 16-bits.
Delimiter Signature	8	Pattern that may be used to detect an MPDU delimiter when scanning for a delimiter. The unique pattern is set to the value 0x4E. NOTE—As the Delimiter Signature field was created by the IEEE 802.11 Task Group n, it chose the ASCII value for the character 'N' as the unique pattern.

The purpose of the MPDU delimiter is to locate the MPDUs within the A-MPDU so that the structure of the A-MPDU can usually be recovered when one or more MPDU delimiters are received with errors. See T.2 for a description of a deaggregation algorithm.

A delimiter with MPDU length zero is valid. This value is used as defined in 9.7d.3 to meet the minimum MPDU start spacing requirement.

7.4a.2 MPDU delimiter CRC field

The MPDU delimiter CRC field is an 8-bit CRC value. It is used as a frame check sequence (FCS) to protect the Reserved and MPDU Length fields. The CRC field is the ones complement of the remainder generated by the modulo 2 division of the protected bits by the polynomial $x^8 + x^2 + x^1 + 1$, where the shift-register state is preset to all ones.

NOTE—The order of transmission of bits within the CRC field is defined in 7.1.1.

Figure 7-101q illustrates the CRC calculation for the MPDU delimiter.

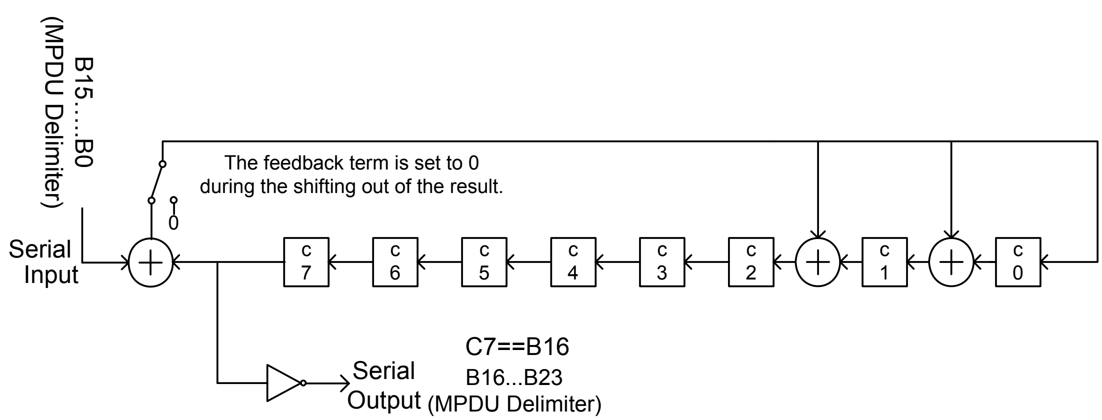


Figure 7-101q—MPDU delimiter CRC calculation

7.4a.3 A-MPDU contents

An A-MPDU is a sequence of MPDUs carried in a single PPDU with the TXVECTOR/RXVECTOR AGGREGATION parameter set to 1.

All the MPDUs within an A-MPDU are addressed to the same RA. All QoS data frames within an A-MPDU that have a TID for which an HT-immediate Block Ack agreement exists have the same value for the Ack Policy subfield of the QoS Control field.

The Duration/ID fields in the MAC headers of all MPDUs in an A-MPDU carry the same value.

An A-MPDU is transmitted in one of the contexts specified in Table 7-57x. Ordering of MPDUs within an A-MPDU is not constrained, except where noted in these tables. See 9.7d.1.

NOTE 1—The TIDs present in a data enabled A-MPDU context are also constrained by the channel access rules (for a TXOP holder, see 9.9.1 and 9.9.2) and the RD response rules (for an RD responder, see 9.15.4). This is not shown in these tables.

NOTE 2—MPDUs carried in an A-MPDU are limited to a maximum length of 4095 octets. If a STA supports A-MSDUs of 7935 octets (indicated by the Maximum A-MSDU Length field in the HT Capabilities element), A-MSDUs transmitted by that STA within an A-MPDU are constrained so that the length of the QoS data MPDU carrying the A-MSDU is no more than 4095 octets. The use of A-MSDU within A-MPDU can be further constrained as described in 7.3.1.14 through the operation of the A-MSDU Supported field.

Table 7-57x—A-MPDU Contexts

Name of Context	Definition of Context	Table defining permitted contents
Data Enabled Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder or an RD responder including potential immediate responses.	Table 7-57y
Data Enabled No Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder that does not include or solicit an immediate response. See NOTE.	Table 7-57z
PSMP	The A-MPDU is transmitted within a PSMP sequence.	Table 7-57aa
Control Response	The A-MPDU is transmitted by a STA that is neither a TXOP holder nor an RD responder that also needs to transmit one of the following immediate response frames: a) Ack b) BlockAck with a TID for which an HT-immediate Block Ack agreement exists	Table 7-57ab
NOTE—This context includes cases when no response is generated or when a response is generated later by the operation of the delayed Block Ack rules.		

Table 7-57y—A-MPDU contents in the data enabled immediate response context

<table>
<tr><th>MPDU Description</th><th colspan="2">Conditions</th></tr>
<tr><td>ACK MPDU</td><td>If the preceding PPDU contains an MPDU that requires an ACK response, a single ACK MPDU at the start of the A-MPDU.</td><td rowspan="2">At most one of these MPDUs is present.</td></tr>
<tr><td>HT-immediate BlockAck</td><td>If the preceding PPDU contains an implicit or explicit Block Ack request for a TID for which an HT-immediate Block Ack agreement exists,
at most one BlockAck for this TID, in which case it occurs at the start of the A-MPDU.</td></tr>
<tr><td>Delayed BlockAcks</td><td colspan="2">BlockAck frames with the BA Ack Policy subfield set to No Acknowledgment with a TID for which an HT-delayed Block Ack agreement exists.</td></tr>
<tr><td>Delayed Block Ack data</td><td colspan="2">QoS Data MPDUs with a TID that corresponds to a Delayed or HT-delayed Block Ack agreement.
These have the Ack Policy field set to Block Ack.</td></tr>
<tr><td>Action No Ack</td><td colspan="2">Management frames of subtype Action No Ack.</td></tr>
<tr><td>Delayed BlockAckReqs</td><td colspan="2">BlockAckReq MPDUs with a TID that corresponds to an HT-delayed Block Ack agreement in which the BA Ack Policy subfield is set to No Acknowledgment.</td></tr>
<tr><td>Data MPDUs sent under an HT-immediate Block Ack agreement</td><td>QoS Data MPDUs with the same TID, which corresponds to an HT-immediate Block Ack agreement.

These MPDUs all have the Ack Policy field set to the same value, which is either Implicit Block Ack Request or Block Ack.</td><td rowspan="2">Of these, at most one of the following is present:
a) One or more QoS Data MPDUs with the Ack Policy field set to Implicit Block Ack Request
b) BlockAckReq</td></tr>
<tr><td>Immediate BlockAckReq</td><td>At most one BlockAckReq frame with a TID that corresponds to an HT-immediate Block Ack agreement.
This is the last MPDU in the A-MPDU.

It is not present if any QoS data frames for that TID are present.</td></tr>
</table>

Table 7-57z—A-MPDU contents in the data enabled no immediate response context

MPDU Description	Conditions
Delayed BlockAcks	BlockAck frames for a TID for which an HT-delayed Block Ack agreement exists with the BA Ack Policy subfield set to No Acknowledgment.
Delayed Block Ack data	QoS Data MPDUs with a TID that corresponds to a Delayed or HT-delayed Block Ack agreement. These have the Ack Policy field set to Block Ack.
Data without a Block Ack agreement	QoS Data MPDUs with a TID that does not correspond to a Block Ack agreement. These have the Ack Policy field set to No Ack and the A-MSDU Present subfield set to 0.
Action No Ack	Management frames of subtype Action No Ack.
Delayed BlockAckReqs	BlockAckReq MPDUs with the BA Ack Policy subfield set to No Acknowledgment and with a TID that corresponds to an HT-delayed Block Ack agreement.

Table 7-57aa—A-MPDU contents in the PSMP context

<table>
<tr><th>MPDU Description</th><th colspan="2">Conditions</th></tr>
<tr><td>Acknowledgment for PSMP data</td><td colspan="2">At most one Multi-TID BlockAck MPDU.

Acknowledgment in response to data received with the Ack Policy field set to PSMP Ack and/or a Multi-TID BlockAckReq MPDU in the previous PSMP-UTT or PSMP-DTT.</td></tr>
<tr><td>Delayed BlockAcks</td><td colspan="2">BlockAck frames with the BA Ack Policy subfield set to No Acknowledgment and with a TID for which an HT-delayed Block Ack agreement exists.</td></tr>
<tr><td>HT-immediate Data</td><td>QoS Data MPDUs in which the Ack Policy field is set to PSMP Ack or Block Ack and with a TID that corresponds to an HT-immediate Block Ack agreement.</td><td rowspan="3">An A-MPDU containing MPDUs with a Block Ack agreement cannot also contain MPDUs without a Block Ack agreement.</td></tr>
<tr><td>Delayed Block Ack data</td><td>QoS Data MPDUs with a TID that corresponds to a Delayed or HT-delayed Block Ack agreement.
These have the Ack Policy field set to Block Ack.</td></tr>
<tr><td>Data without a Block Ack agreement</td><td>QoS Data MPDUs with a TID that does not correspond to a Block Ack agreement.
These have the Ack Policy field set to No Ack and the A-MSDU Present subfield is set to 0.</td></tr>
<tr><td>Action No Ack</td><td colspan="2">Management frames of subtype Action No Ack.</td></tr>
<tr><td>Delayed BlockAckReqs</td><td colspan="2">BlockAckReq MPDUs with the BA Ack Policy subfield set to No Acknowledgment and with a TID that corresponds to an HT-delayed Block Ack.</td></tr>
<tr><td>Multi-TID BlockAckReq</td><td colspan="2">At most one Multi-TID BlockAckReq MPDU with the BA Ack Policy subfield set to No Ack.</td></tr>
</table>

Table 7-57ab—A-MPDU contents MPDUs in the control response context

MPDU	Conditions	
ACK	ACK transmitted in response to an MPDU that requires an ACK.	Only one of these is present at the start of the A-MPDU.
BlockAck	BlockAck with a TID that corresponds to an HT-immediate Block Ack agreement.	
Action No Ack	Management frames of subtype Action No Ack +HTC carrying a Management Action Body containing an explicit feedback response.	

Delete 7.5 in its entirety (including Table 7-58).

~~7.5 Frame usage~~

~~Table 7-58 shows ... functions.~~

~~Table 7-58—Frame subtype ... function~~

8. Security

8.1 Framework

8.1.5 RSNA assumptions and constraints

Insert the following paragraph at the end of 8.1.5:

An HT STA shall not use either of the pairwise cipher suite selectors: “Use group cipher suite” or TKIP to communicate with another HT STA.

8.3 RSNA data confidentiality protocols

8.3.3 CTR with CBC-MAC Protocol (CCMP)

8.3.3.3 CCMP cryptographic encapsulation

8.3.3.3.2 Construct AAD

Change the third paragraph of 8.3.3.3.2 as follows:

The AAD is constructed from the MPDU header. The AAD does not include the header Duration field, because the Duration field value can change due to normal IEEE 802.11 operation (e.g., a rate change during retransmission). The AAD includes neither the Duration/ID field nor the HT Control field because the contents of these fields can change during normal operation (e.g., due to a rate change preceding retransmission). The HT Control field can also be inserted or removed during normal operation (e.g., retransmission of an A-MPDU where the original A-MPDU included an MRQ that has already generated a response). For similar reasons, several subfields in the Frame Control field are masked to 0. AAD construction is performed as follows:

a) FC – MPDU Frame Control field, with
   1) Subtype bits (bits 4 5 6) in a Data MPDU masked to 0
   2) Retry bit (bit 11) masked to 0
   3) PwrMgt bit (bit 12) masked to 0
   4) MoreData bit (bit 13) masked to 0
   5) Protected Frame bit (bit 14) always set to 1
   6) Order bit (bit 15) as follows:
      i) Masked to 0 in all data MPDUs containing a QoS Control field
      ii) Unmasked otherwise
b) A1 – MPDU Address 1 field.
c) A2 – MPDU Address 2 field.
d) A3 – MPDU Address 3 field.
e) SC – MPDU Sequence Control field, with the Sequence Number subfield (bits 4–15 of the Sequence Control field) masked to 0. The Fragment Number subfield is not modified.
f) A4 – MPDU Address field, if present.
g) QC – QoS Control field, if present, a 2-octet field that includes the MSDU priority. The QC TID field is used in the construction of the AAD. When both the STA and its peer have their SPP A-MSDU Capable fields set to 1, bit 7 (the A-MSDU Present field) is used in the construction of the AAD. ~~, and t~~The remaining QC fields are masked ~~set~~ to 0 for the AAD calculation (bits 4 to 6, bits 8 to 15, and bit 7 when either the STA or its peer has the SPP A-MSDU Capable field ~~are~~ set to 0).

8.3.3.3.5 CCM originator processing

Change item c) of the second paragraph of 8.3.3.3.5 as follows:

c) *Frame body:* the frame body of the MPDU (1–7919~~2296~~ octets; 7919~~2296~~ = 7935~~2312~~ – 8 MIC octets – 8 CCMP header octets).

8.3.3.4 CCMP decapsulation

8.3.3.4.3 PN and replay detection

Change list items e), f), and g) of 8.3.3.4.3 as follows (note that list item e1) between e) and f) remains unchanged):

e) For each PTKSA, GTKSA, and STKSA, the recipient shall maintain a separate replay counter for each IEEE 802.11 MSDU or A-MSDU priority and shall use the PN recovered from a received frame to detect replayed frames, subject to the limitation of the number of supported replay counters indicated in the RSN Capabilities field (see 7.3.2.25). A replayed frame occurs when the PN extracted from a received frame is less than or equal to the current replay counter value for the frame's MSDU or A-MSDU priority and frame type. A transmitter shall not use IEEE 802.11 MSDU or A-MSDU priorities without ensuring that the receiver supports the required number of replay counters. The transmitter shall not reorder frames within a replay counter, but may reorder frames across replay counters. One possible reason for reordering frames is the IEEE 802.11 MSDU or A-MSDU priority.

f) The receiver shall discard MSDUs, A-MSDUs, and MMPDUs whose constituent MPDU PN values are not sequential. A receiver shall discard any MPDU that is received with its PN less than or equal to the replay counter. When discarding a frame, the receiver shall increment by 1 the value of dot11RSNAStatsCCMPReplays for data frames or dot11RSNAStatsRobustMgmtCCMPReplays for Robust Management frames.

g) For MSDUs or A-MSDUs sent using the Block Ack feature, reordering of received MSDUs or A-MSDUs according to the Block Ack receiver operation (described in 9.10.4) is performed prior to replay detection.

8.4 RSNA security association management

8.4.3 RSNA policy selection in an ESS

Change the third paragraph of 8.4.3 as follows:

The STA's SME initiating an association shall insert an RSN information element into its (Re)Association ~~Request;~~ Request via the MLME-ASSOCIATE.request primitive, when the targeted AP indicates RSNA support. The initiating STA's RSN information element shall include one authentication and pairwise cipher suite from among those advertised by the targeted AP in its Beacon and Probe Response frames. It shall also specify the group cipher suite specified by the targeted AP. If at least one RSN information element field from the AP's RSN information element fails to overlap with any value the STA supports, the STA shall decline to associate with that AP. An HT STA shall eliminate TKIP as a choice for the pairwise cipher suite if CCMP is advertised by the AP or if the AP included an HT Capabilities element in its Beacon and Probe Response frames. The elimination of TKIP as a choice for the pairwise cipher suite may result in a lack of overlap of the remaining pairwise cipher suite choices, in which case the STA shall decline to create an RSN association with that AP.

Change the heading for 8.4.4 as follows:

8.4.4 RSNA policy selection in an IBSS and for DLS

Change the first paragraph of 8.4.4 and insert the subsequent paragraph and note immediately after the first paragraph as follows:

In an IBSS, all STAs must use a single group cipher suite, and all STAs must support a common subset of pairwise cipher suites. However, the SMEs of any pair of non-HT STAs may negotiate to use any common pairwise cipher suite they both support. Each STA shall include the group cipher suite and its list of pairwise cipher suites in its Beacon and Probe Response messages. Two STAs shall not establish a PMKSA unless they have advertised the same group cipher suite. Similarly, the two STAs shall not establish a PMKSA if the STAs have advertised disjoint sets of pairwise cipher suites.

An HT STA that is in an IBSS or that is transmitting frames through a direct link shall eliminate TKIP as a choice for the pairwise cipher suite if CCMP is advertised by the other STA or if the other STA included an HT Capabilities element in any of its Beacon, Probe Response, DLS Request, or DLS Response messages.

NOTE—The elimination of TKIP as a choice for the pairwise cipher suite might result in a lack of overlap of the remaining pairwise cipher suites choices, in which case the STAs will not exchange encrypted frames.

8.7 Per-frame pseudo-code

8.7.2 RSNA frame pseudo-code

Change 8.7.2 as follows:

STAs transmit protected MSDUs, A-MSDUs, and Robust Management frames to an RA when temporal keys are configured and an MLME.SETPROTECTION.request primitive has been invoked with ProtectType parameter Tx or Rx_Tx to that RA. STAs expect to receive protected MSDUs, A-MSDUs, and Robust Management frames from a TA when temporal keys are configured and an MLME.SET-PROTECTION.request primitive has been invoked with ProtectType parameter Rx or Rx_Tx from that TA. MSDUs, A-MSDUs, and Robust Management frames that do not match these conditions are sent in the clear and are received in the clear.

Change the heading for 8.7.2.1 as follows:

8.7.2.1 Per-MSDU/Per-A-MSDU Tx pseudo-code

Change 8.7.2.1 as follows:

```
if dot11RSNAEnabled = trueTRUE then
    if MSDU or A-MSDU has an individual RA and Protection for RA is off for Tx then
        transmit the MSDU or A-MSDU without protections
    else if (MPDU has individual RA and Pairwise key exists for the MPDU's RA) or
        (MPDU has a multicast or broadcast group-addressed RA
            and network type is IBSS and IBSS GTK exists for MPDU's TA) then
        // If we find a suitable Pairwise or GTK for the mode we are in…
        if key is a null key then
            discard the entire MSDU or A-MSDU and generate one or more an
                MA-UNITDATA.confirm primitives to notify LLC that the MSDUs waswere
                undeliverable due to a null key
        else
            // Note that it is assumed that no entry will be in the key
```


// mapping table of a cipher type that is unsupported.
Set the Key ID subfield of the IV field to zero.
if cipher type of entry is AES-CCM **then**
Transmit the MSDU or A-MSDU, to be protected after fragmentation using AES-CCM
else if cipher type of entry is TKIP **then**
Compute MIC using Michael algorithm and entry's Tx MIC key.
Append MIC to MSDU
Transmit the MSDU, to be protected with TKIP
else if cipher type of entry is WEP **then**
Transmit the MSDU, to be protected with WEP
endif
endif
else // Else we didn't find a key but we are protected, so handle the default key case or discard
if GTK entry for Key ID contains null **then**
discard the MSDU or A-MSDU and generate ~~an~~one or more MA-UNITDATA.confirm primitives to notify LLC that the ~~entire~~ MSDUs ~~was~~were undeliverable due to a null GTK
else if GTK entry for Key ID is not null **then**
Set the Key ID subfield of the IV field to the Key ID.
if MPDU has an individual RA **and** cipher type of entry is not TKIP **then**
discard the entire MSDU or A-MSDU and generate ~~an~~one or more MA-UNITDATA.confirm primitives to notify LLC that the ~~entire~~ MSDUs ~~was~~were undeliverable due to a null key
else if cipher type of entry is AES-CCM **then**
Transmit the MSDU or A-MSDU, to be protected after fragmentation using AES-CCM
else if cipher type of entry is TKIP **then**
Compute MIC using Michael algorithm and entry's Tx MIC key.
Append MIC to MSDU
Transmit the MSDU, to be protected with TKIP
else if cipher type of entry is WEP **then**
Transmit the MSDU, to be protected with WEP
endif
endif
endif
endif

8.7.2.2 Per-MPDU Tx pseudo-code

Change 8.7.2.2 as follows:

if *dot11RSNAEnabled* = TRUE **then**
if MPDU is member of an MSDU that is to be transmitted without protections
transmit the MPDU without protections
else if MSDU or A-MSDU that MPDU is a member of is to be protected using AES-CCM
Protect the MPDU using entry's key and AES-CCM
Transmit the MPDU
else if MSDU that MPDU is a member of is to be protected using TKIP
Protect the MPDU using TKIP encryption
Transmit the MPDU
else if MSDU that MPDU is a member of is to be protected using WEP
Encrypt the MPDU using entry's key and WEP
Transmit the MPDU

```
        else
            // should not arrive here
        endif
    endif
```

Change the heading for 8.7.2.4 as follows:

8.7.2.4 Per-MSDU/A-MSDU Rx pseudo-code

Change 8.7.2.4 as follows:

```
    if dot11RSNAEnabled = TRUE then
        if the frame was not protected then
            Receive the MSDU or A-MSDU unprotected
            Make MSDU(s) available to higher layers
        else// Have a protected MSDU or A-MSDU
            if Pairwise key is an AES-CCM key then
                Accept the MSDU or A-MSDU if its MPDUs had sequential PNs (or if it consists of only
                    one MPDU); otherwise, discard the MSDU or A-MSDU as a replay attack and
                    increment dot11RSNAStatsCCMPReplays
                Make MSDU(s) available to higher layers
            else if Pairwise key is a TKIP key then
                Compute the MIC using the Michael algorithm
                Compare the received MIC against the computed MIC
                discard the frame if the MIC fails increment dot11RSNAStatsTKIPLocalMICFailures
                    and invoke countermeasures if appropriate
                compare TSC against replay counter, if replay check fails increment
                    dot11RSNAStatsTKIPReplays otherwise accept the MSDU
                Make MSDU available to higher layers
            else if dot11WEPKeyMappings has a WEP key then
                Accept the MSDU since the decryption took place at the MPDU
                Make MSDU available to higher layers
            endif
        endif
    endif
```

9. MAC sublayer functional description

Change the first paragraph of Clause 9 as follows:

The MAC functional description is presented in this clause. The architecture of the MAC sublayer, including the distributed coordination function (DCF), the point coordination function (PCF), the hybrid coordination function (HCF), and their coexistence in an IEEE 802.11 local area network (LAN) are introduced in 9.1. These functions are expanded on in 9.2 (DCF), 9.3 (PCF), and 9.9 (HCF). Fragmentation and defragmentation are defined in 9.4 and 9.5. Multirate support is addressed in 9.6. A number of additional restrictions to limit the cases in which MSDUs are reordered or discarded are described in 9.7. Operation across regulatory domains is defined in 9.8. The Block Ack mechanism is described in 9.10. The No Ack mechanism is described in 9.11. ~~The allowable frame exchange sequences are defined in 9.12.~~ The protection mechanism is described in 9.13.

9.1 MAC architecture

9.1.3 Hybrid coordination function (HCF)

9.1.3.1 HCF contention-based channel access (EDCA)

Change list item e) of 9.1.3.1 as follows:

e) 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. The duration of this EDCA TXOP is bounded, for an AC, by the value in dot11QAPEDCATXOPLimit MIB variable for an AP and in dot11EDCATableTXOPLimit MIB table for a non-AP STA. A value of 0 for this duration means that the EDCA TXOP is limited as defined by the rule for TXOP Limit value 0 found in 9.9.1.2. ~~to a single MSDU or MMPDU at any rate in the operational set of the BSS~~.

9.1.5 Fragmentation/defragmentation overview

Change the second and third paragraphs of 9.1.5 as follows:

~~Only MPDUs with a unicast receiver address shall be fragmented.~~ An MSDU transmitted under HT-immediate or HT-delayed Block Ack agreement shall not be fragmented even if its length exceeds dot11FragmentationThreshold. An MSDU transmitted within an A-MPDU shall not be fragmented even if its length exceeds dot11FragmentationThreshold. ~~Broadcast/multicast~~ Group-addressed ~~frames~~ MSDUs or MMPDUs shall not be fragmented even if their length exceeds dot11FragmentationThreshold.

NOTE 1—A fragmented MSDU or MMPDU transmitted by an HT STA to another HT STA can be acknowledged only using immediate acknowledgment (i.e., transmission of an ACK frame after a SIFS).

NOTE 2—As specified in 9.7c, A-MSDUs are never fragmented.

Except as described below, ~~W~~when an individually addressed MSDU is received from the LLC or an individually addressed MMPDU is received from the MAC sublayer management entity (MLME) that would result in an MPDU of length greater than dot11FragmentationThreshold ~~when~~ after any encryption and the MAC header and FCS are added, the MSDU or MMPDU shall be fragmented. The exception applies when an MSDU is transmitted using an HT-immediate or HT-delayed Block Ack agreement or when the MSDU or MMPDU is carried in an A-MPDU, in which case the MSDU or MMPDU is transmitted without fragmentation. ~~The MSDU or MMPDU is divided into MPDUs.~~ Each fragment is a frame no larger than dot11FragmentationThreshold. It is possible that any fragment may be a frame smaller than dot11FragmentationThreshold. An illustration of fragmentation is shown in Figure 9-2.

9.1.6 MAC data service

Change the second and third paragraphs of 9.1.6 as follows:

The transmission process is started by receipt of an MA-UNITDATA.request primitive containing an MSDU and the associated parameters. This ~~may~~ might cause one or more data MPDUs containing the MSDU to be transmitted following A-MSDU aggregation, fragmentation, and security encapsulation, as appropriate.

The MA-UNITDATA.indication primitive is generated in response to one or more received data MPDUs containing an MSDU following validation, address filtering, decryption, decapsulation, ~~and~~ defragmentation, and A-MSDU deaggregation, as appropriate.

9.2 DCF

Change paragraph 11 of 9.2 as follows:

~~The medium access protocol allows for STAs to support different sets of data rates.~~ All STAs that are members of a BSS ~~shall be~~are able to receive and transmit at all the data rates in the BSSBasicRateSet parameter of the MLME-START.request or BSSBasicRateSet parameter of the BSSDescription representing the SelectedBSS parameter of the MLME-JOIN.request; see 10.3.3.1.4 and 10.3.10.1.4. All HT STAs that are members of a BSS are able to receive and transmit using all the MCSs in the BSSBasicMCSSet parameter of the MLME-START.request or BSSBasicMCSSet parameter of the BSSDescription representing the SelectedBSS parameter of the MLME-JOIN.request; see 10.3.3.1.4 and 10.3.10.1.4. To support the proper operation of the RTS/CTS and the virtual CS mechanism, all STAs shall be able to ~~detect the~~ interpret control frames with the Subtype field set to RTS ~~and~~or CTS ~~frames~~.

9.2.2 MAC-Level acknowledgments

Change the first paragraph of 9.2.2 as follows:

The reception of some frames, as described in 9.2.8~~,~~ and 9.3.3.4~~, and 9.12~~, requires the receiving STA to respond with an acknowledgment, generally an ACK frame, if the FCS of the received frame is correct. This technique is known as positive acknowledgment.

9.2.3 IFS

Insert the following heading immediately after the heading for 9.2.3:

9.2.3.0a Overview

Change the first paragraph of the new 9.2.3.0a as follows:

The time interval between frames is called the IFS. A STA shall determine that the medium is idle through the use of the CS function for the interval specified. ~~Five~~Six different IFSs are defined to provide priority levels for access to the wireless media. Figure 9-3 shows some of these relationships. All timings are referenced from PHY interface signals PHY-TXEND.confirm, PHY-TXSTART.confirm, PHY-RXSTART.indication, and PHY-RXEND.indication.

a) RIFS reduced interframe space
b) ~~a)~~ SIFS short interframe space
c) ~~b)~~ PIFS PCF interframe space
d) ~~c)~~ DIFS DCF interframe space
e) ~~d)~~ AIFS arbitration interframe space (used by the QoS facility)

f) ~~e)~~ EIFS extended interframe space

Insert the following subclause (9.2.3.0b) after the new 9.2.3.0a:

9.2.3.0b RIFS

RIFS is a means of reducing overhead and thereby increasing network efficiency.

RIFS may be used in place of SIFS to separate multiple transmissions from a single transmitter, when no SIFS-separated response transmission is expected. RIFS shall not be used between frames with different RA values. The duration of RIFS is defined by the aRIFS PHY characteristic (see Table 20-24). The RIFS is the time from the end of the last symbol of the previous frame to the beginning of the first symbol of the preamble of the subsequent frame as seen at the air interface. A STA shall not allow the space between frames that are defined to be separated by a RIFS time, as measured on the medium, to vary from the nominal RIFS value (aRIFSTime) by more than ± 10% of aRIFSTime. Two frames separated by a RIFS shall both be HT PPDUs.

There are additional restrictions regarding when RIFS may be employed as defined in 9.15 and 9.16. See also 9.13.3.3.

9.2.3.1 SIFS

Change the first paragraph of 9.2.3.1 as follows:

The SIFS shall be used prior to transmission of an ACK frame, a CTS frame, a PPDU containing a BlockAck frame that is an immediate response to either a BlockAckReq frame or an A-MPDU, the second or subsequent MPDU of a fragment burst, and by a STA responding to any polling by the PCF. The SIFS may also be used by a PC for any types of frames during the CFP (see 9.3). The SIFS is the time from the end of the last symbol, or signal extension if present, of the previous frame to the beginning of the first symbol of the preamble of the subsequent frame as seen at the air interface. ~~The valid cases where the SIFS may or shall be used are listed in the frame exchange sequences in 9.12.~~

Change the third paragraph of 9.2.3.1 as follows:

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.

9.2.3.2 PIFS

Delete the text (starting "The PIFS shall be used..." and ending "...is described in 11.9.") of 9.2.3.2.

Insert the following paragraphs in 9.2.3.2:

The PIFS is used to gain priority access to the medium.

The PIFS may be used as described in the following list and shall not be used otherwise:
- A STA operating under the PCF as described in 9.3
- A STA transmitting a Channel Switch Announcement frame as described in 11.9
- An HC starting a CFP or a TXOP as described in 9.9.2.1.2

— An HC or a non-AP QoS STA that is a polled TXOP holder recovering from the absence of an expected reception in a CAP as described in 9.9.2.1.3
— An HT STA using dual CTS protection before transmission of the CTS2 as described in 9.2.5.5a
— A TXOP holder continuing to transmit after a transmission failure as described in 9.9.1.4
— An RD initiator continuing to transmit using error recovery as described in 9.15.3
— An HT AP during a PSMP sequence transmitting a PSMP recovery frame as described in 9.16.1.3
— An HT STA performing clear channel assessment (CCA) in the secondary channel before transmitting a 40 MHz mask PPDU using EDCA channel access as described in 11.14.9

With the exception of performing CCA in the secondary channel (where the timing is defined in 11.14.9), a STA using PIFS starts its transmission after its CS mechanism (see 9.2.1) determines that the medium is idle at the TxPIFS slot boundary as defined in 9.2.10.

9.2.3.5 EIFS

Insert the following paragraph at the end of 9.2.3.5:

EIFS shall not be invoked if the NAV is updated by the frame that would have caused an EIFS, such as when the MAC FCS fails and L-SIG TXOP function employs L-SIG information to update the NAV. EIFS shall not be invoked for an A-MPDU if one or more of its frames are received correctly.

9.2.4 Random backoff time

Change the cross-reference in the second paragraph of 9.2.4 from "9.12" to "Annex S."

9.2.5 DCF access procedure

9.2.5.1 Basic access

Change the second paragraph of 9.2.5.1 as follows:

In general, a STA may transmit a pending MPDU when it is operating under the DCF access method, either in the absence of a PC, or in the CP of the PCF access method, when the STA determines that the medium is idle for greater than or equal to a DIFS period, or an EIFS period if the immediately preceding medium-busy event was caused by detection of a frame that was not received at this STA with a correct MAC FCS value. If, under these conditions, the medium is determined by the CS mechanism to be busy when a STA desires to initiate the initial frame of a ~~one of the~~ frame exchange sequence~~s~~ (described in ~~9.12~~Annex S), exclusive of the CF period, the random backoff procedure described in 9.2.5.2 shall be followed. There are conditions, specified in 9.2.5.2 and 9.2.5.5, where the random backoff procedure shall be followed even for the first attempt to initiate a frame exchange sequence.

9.2.5.3 Recovery procedures and retransmit limits

Change the first paragraph of 9.2.5.3 as follows:

Under DCF, e~~E~~rror recovery is always the responsibility of the STA that initiates a frame exchange sequence~~, as defined in 9.12~~ (described in Annex S). Many circumstances may cause an error to occur that requires recovery. For example, the CTS frame may not be returned after an RTS frame is transmitted. This may happen due to a collision with another transmission, due to interference in the channel during the RTS or CTS frame, or because the STA receiving the RTS frame has an active virtual CS condition (indicating a busy medium time period).

9.2.5.4 Setting and resetting the NAV

Change the first paragraph of 9.2.5.4 as follows:

~~STAs receiving a~~ A STA that receives at least one valid frame within a received PSDU shall update ~~their~~its NAV with the information received in ~~the~~any valid Duration field from within that PSDU for all frames where the new NAV value is greater than the current NAV value~~,~~ except ~~the NAV shall not be updated~~for those where the RA is equal to the ~~receiving STA's~~ MAC address of the STA. Upon receipt of a PS-Poll frame, a the STA shall update its NAV settings as appropriate under the data rate selection rules using a duration value equal to the time, in microseconds, required to transmit one ACK frame plus one SIFS interval, but only when the new NAV value is greater than the current NAV value. If the calculated duration includes a fractional microsecond, that value is rounded up the next higher integer. Various additional conditions may set or reset the NAV, as described in 9.3.2.2. When the NAV is reset, a PHY-CCARESET.request shall be issued. This NAV update operation is performed when the PHY-RXEND.indication primitive is received.

Insert the following paragraph at the end of 9.2.5.4:

A STA supporting L-SIG TXOP that used the information from a frame with different L-SIG duration and MAC duration endpoints (characteristics of an L-SIG TXOP initiating frame; see 9.13.5.4 for details) as the most recent basis to update its NAV setting may reset its NAV if no PHY-RXSTART.indication is detected from the PHY during a period with a duration of $\mathrm{aSIFSTime} + \mathrm{aPHY\text{-}RX\text{-}START\text{-}Delay} + (2 \times \mathrm{aSlotTime})$ starting at the expiration of the L-SIG duration. For details of L-SIG duration, see 9.13.5.

Insert the following subclauses (9.2.5.5a through 9.2.5.5a.2) after 9.2.5.5:

9.2.5.5a Dual CTS protection

9.2.5.5a.1 Dual CTS protection procedure

If the Dual CTS Protection field of the HT Operation element has value 1 in the Beacon frames transmitted by its AP, a non-AP HT STA shall start every TXOP with an RTS addressed to the AP. The RTS shall be an STBC frame if the STBC transmit and receive capabilities of the non-AP HT STA allow it to receive and transmit STBC frames using a single spatial stream; otherwise, the RTS shall be a non-STBC frame. The AP shall respond with a dual CTS (CTS1 followed by CTS2) separated by PIFS or SIFS. Table 9-1a describes the sequence of CTS transmissions and the required timing.

Table 9-1a—Dual CTS rules

Type of RTS	CTS description	Timing
RTS (non-STBC frame)	CTS1: Same rate or MCS as the RTS (non-STBC frame) CTS2: Basic STBC MCS (STBC frame)	PIFS shall be used as the interval between CTS1 and CTS2. If the CS mechanism (see 9.2.1) indicates that the medium is busy at the TxPIFS slot boundary (defined in 9.2.10) following CTS1, CTS2 shall not be transmitted as part of this frame exchange.
RTS (STBC frame)	CTS1: Basic STBC MCS (STBC frame) CTS2: Lowest basic rate (non-STBC frame)	SIFS shall be used as the interval between CTS1 and CTS2. The STA resumes transmission a SIFS+CTS2+SIFS after receiving CTS1, instead of after SIFS.

The dual CTS response applies only to the AP; a non-AP STA shall respond to an RTS request with a single CTS.

If dual CTS Protection is enabled, the AP shall begin each EDCA TXOP with a CTS frame. This CTS frame uses STBC when the immediately following frame uses non-STBC and vice versa. The RA of this CTS shall be identical to the RA of the immediately following frame. The AP may continue a PIFS after the CTS, only if the CS mechanism (see 9.2.1) indicates that the medium is busy at the TxPIFS slot boundary (defined in 9.2.10) following the transmission of the CTS.

To avoid the resetting of NAV by STAs that have set their NAV due to the reception of a non-STBC RTS that is part of a dual CTS exchange, but then do not hear the CTS2, a non-AP HT STA may create a NAV that is not resettable according to the RTS NAV reset rule defined in 9.2.5.4 at the receiving STAs by initiating the TXOP with a non-STBC CTS addressed to the AP (known as *CTS-to-AP*).

NOTE—Sending a CTS-to-AP allows NAV protection to be established without causing the AP to update its NAV, as opposed to, for example, the sending of a CTS-to-self, which would potentially have caused the AP NAV to become set and then prevented it from responding to the subsequent RTS. The AP does not set a NAV in the CTS-to-AP case and will be able to respond to the following RTS. The NAV at receiving STAs is not updated by the RTS because its duration does not exceed the duration of the preceding CTS, and subsequently, the NAV cannot be reset during CTS2.

An STBC CTS addressed to the AP may be transmitted prior to an STBC RTS to set a NAV that is not resettable according to the RTS NAV reset rule defined in 9.2.5.4 at receiving STAs.

NOTE—When an HT STA sends an RTS to the AP that is a non-STBC frame, the AP returns a CTS that is a non-STBC frame to the STA and then immediately transmits a CTS that is an STBC frame. The original non-AP STA is now free to transmit. But a non-HT STA that has set its NAV based on the original RTS may reset its NAV and then decrement its backoff counter, given that a SIFS + the duration of CTS2 is longer than a DIFS (i.e., the STA does not detect PHY-RXSTART.indication within the period specified in 9.2.5.4). Thus, without sending a CTS-to-AP, the NAV reservation will not always work.

If dual CTS protection is enabled and a STA obtains a TXOP and does not have any frames to transmit before the expiry of the TXOP duration, the STA may indicate truncation of the TXOP provided that the remaining duration of the TXOP after the transmission of the last frame can accommodate the CF-End frame, a CF-End frame that is an STBC frame duration at the basic STBC MCS, a CF-End frame that is a non-STBC frame at the lowest basic rate, and three SIFS durations. The STA indicates truncation of the TXOP by transmitting a CF-End frame with TXVECTOR parameter restrictions as specified in 9.6.0e.3.

On receiving a CF-End frame from a STA with a matching BSSID, an AP whose last transmitted HT Operation element contained the Dual CTS Protection field set to 1 shall respond with dual CF-End frames, one CF-End frame that is an STBC frame at the basic STBC MCS and one CF-End frame that is a non-STBC frame at the lowest basic rate, after a SIFS duration. Dual CF-End frames eliminate unfairness towards STAs that are not of the same mode as the one that owns the TXOP being truncated.

If the TXOP is owned by the AP and dual CTS Protection is enabled in the system, the AP may send dual CF-End frames if it runs out of frames to transmit, provided that the remaining TXOP duration after the transmission of the last frame can accommodate a STBC CF-End frame duration at the lowest STBC basic rate, a CF-End frame that is a non-STBC frame at the lowest basic rate, and two SIFS durations.

The spacing between the dual CF-End frames sent by the AP shall be SIFS. The first CF-End frame shall use the same encoding (STBC frame versus non-STBC frame) used for transmissions in the TXOP being truncated, and the second CF-End frame shall use the other encoding.

An STBC-capable STA shall choose between control frame operation using either STBC frames or non-STBC frames. In the non-STBC frame case, it discards control frames that are STBC frames it receives. In the STBC frame case, it discards control frames that are non-STBC frames received from its own BSS. This choice is a matter of policy local at the STA.

9.2.5.5a.2 Dual CTS protection examples

Figure 9-8a shows an example of the operation of the dual CTS protection mechanism. In this example, the initiating STA is an STBC non-AP STA.

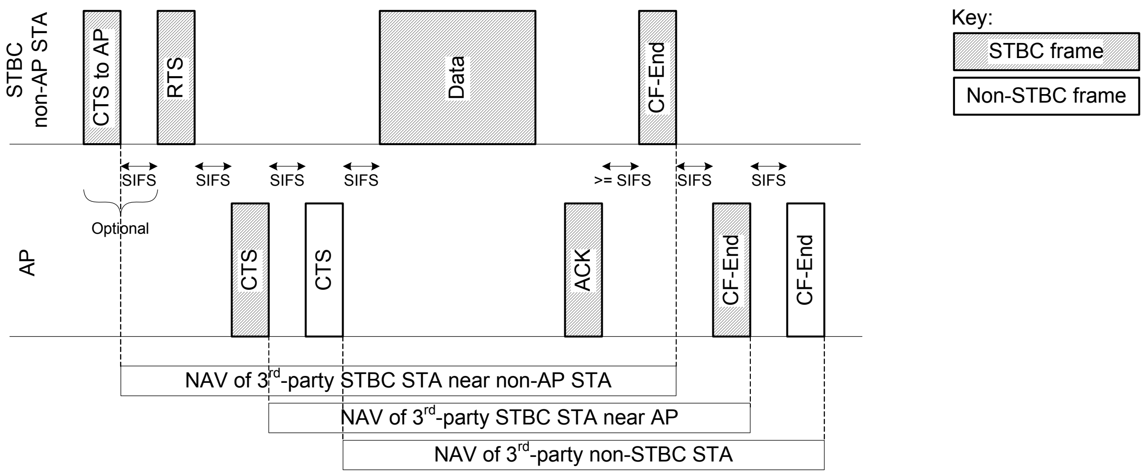


Figure 9-8a—Example of dual CTS mechanism (STBC initiator)

Figure 9-8b shows an example of the operation of the dual CTS protection mechanism. In this example, the initiating STA is a non-STBC non-AP HT STA.

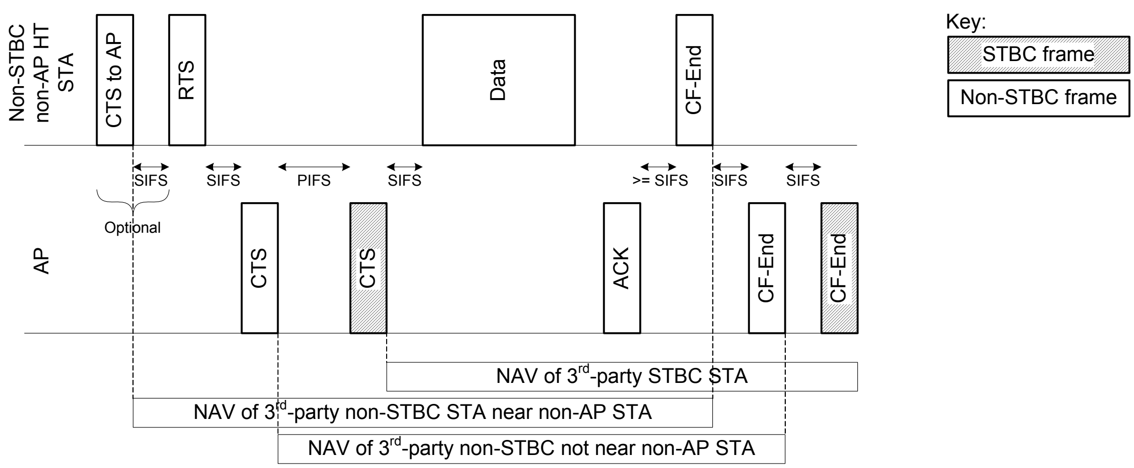


Figure 9-8b—Example of the dual CTS mechanism (non-STBC initiator)

9.2.5.7 CTS procedure

Change the cross-reference in the second paragraph of 9.2.5.7 from "9.12" to "Annex S."

9.2.6 Individually addressed MPDU transfer procedure

Change 9.2.6 as follows:

A STA shall use an RTS/CTS exchange for individually addressed frames ~~only~~ when the length of the ~~MPDU~~ PSDU is greater than the length threshold indicated by the dot11RTSThreshold attribute.

The dot11RTSThreshold attribute ~~shall be~~ is a managed object within the MAC MIB, and its value may be set and retrieved by the MLME. The value 0 shall be used to indicate that all MPDUs shall be delivered with the use of RTS/CTS. Values of dot11RTSThreshold larger than the maximum ~~MSDU~~ PSDU length shall indicate that all ~~MPDUs~~ PSDUs shall be delivered without RTS/CTS exchanges.

When an RTS/CTS exchange is used, the ~~asynchronous data frame~~ PSDU shall be transmitted starting one SIFS period after the end of the CTS frame. No regard shall be given to the busy or idle status of the medium when transmitting this ~~data frame~~PSDU.

When an RTS/CTS exchange is not used, the ~~asynchronous data frame~~ PSDU shall be transmitted following the success of the basic access procedure. With or without the use of the RTS/CTS exchange procedure, the STA that is the destination of a ~~an asynchronous~~ data frame shall follow the ACK procedure.

9.2.7 Broadcast and multicast MPDU transfer procedure

Insert the following paragraph at the end of 9.2.7:

An STBC-capable STA shall discard either all received group-addressed data frames that are STBC frames or all received group-addressed data frames that are non-STBC frames. How it makes this decision is outside the scope of this standard.

9.2.8 ACK procedure

Change the first paragraph of 9.2.8 as follows:

The cases when an ~~An~~ ACK frame can ~~shall~~ be generated are ~~as~~ shown in the frame exchange sequences listed in ~~9.12~~Annex S.

Insert the following paragraph after the first paragraph of 9.2.8:

On receipt of a management frame of subtype Action NoAck, a STA shall not send an ACK frame in response.

Change the cross-reference in the now fourth paragraph of 9.2.8 from “9.12” to “Annex S.”

Insert the following subclause (9.2.8a) after 9.2.8:

9.2.8a BlockAck procedure

Upon successful reception of a frame of a type that requires an immediate BlockAck response, the receiving STA shall transmit a BlockAck frame after a SIFS period, without regard to the busy/idle state of the medium. The rules that specify the contents of this BlockAck frame are defined in 9.10.

9.2.9 Duplicate detection and recovery

Change the second and third paragraphs of 9.2.9 as follows:

Duplicate frame filtering is facilitated through the inclusion of a Sequence Control field (consisting of a sequence number and fragment number) within data and management frames as well as TID subfield in the QoS Control field within QoS data frames. MPDUs that are part of the same MSDU or A-MSDU shall have the same sequence number, and different MSDUs or A-MSDUs shall (with a high probability) have a different sequence number.

The sequence number, for management frames and for data frames with the QoS subfield of the Subtype field set to 0, is generated by the transmitting STA as an incrementing sequence of integers. In a QoS STA, the sequence numbers for QoS (+)~~D~~data frames are generated by different counters for each TID and receiver pair and shall be incremented by one for each new MSDU or A-MSDU corresponding to the TID/receiver pair.

9.2.10 DCF timing relations

Change the second paragraph of 9.2.10 as follows:

All medium timings that are referenced from the end of the transmission are referenced from the end of the last symbol, or signal extension if present, of the PPDU ~~a frame on the medium~~. The beginning of transmission refers to the first symbol of the preamble of the next PPDU ~~frame on the medium~~. All MAC timings are referenced from PHY interface signals PHY-TXEND.confirm, PHY-TXSTART.confirm, PHY-RXSTART.indication, and PHY-RXEND.indication.

Change the eighth paragraph of 9.2.10 as follows:

The following equations define the MAC Slot Boundaries, using attributes provided by the PHY, which are such that they compensate for implementation timing variations. The starting reference of these slot boundaries is again the end of the last symbol of the previous PPDU. ~~the previous frame on the medium.~~

Insert the following new subclause (9.2.10a) after 9.2.10:

9.2.10a Signal Extension

Transmissions of frames with TXVECTOR parameter FORMAT of type NON_HT with NON_HT_MODULATION values of ERP-OFDM, DSSS-OFDM, and NON_HT_DUPOFDM and transmissions of frames with TXVECTOR parameter FORMAT with values of HT_MF and HT_GF include a period of no transmission of duration aSignalExtension, except for RIFS transmissions. The purpose of this signal extension is to ensure that the NAV value of Clause 18 STAs is set correctly.

When an HT STA transmits a PPDU using a RIFS and with the TXVECTOR parameter FORMAT set to NON_HT with the NON_HT_MODULATION parameter set to one of ERP-OFDM, DSSS-OFDM, and NON_HT_DUPOFDM or a PPDU using a RIFS and with the TXVECTOR parameter FORMAT set to HT_MF or HT_GF, it shall set the TXVECTOR parameter NO_SIG_EXTN to TRUE. Otherwise, it shall set the TXVECTOR parameter NO_SIG_EXTN to FALSE.

9.6 Multirate support

Insert the following subclause heading (9.6.0a) immediately after the heading for 9.6:

9.6.0a Overview

Insert the following paragraphs after the first paragraph (starting "Some PHYs have...") of the new 9.6.0a:

A STA that transmits a frame shall select a rate defined by the rules for determining the rates of transmission of protection frames in 9.13 when the following conditions apply:

— The STA's protection mechanism for non-ERP receivers is enabled.

— The frame is a protection mechanism frame.

— The frame initiates an exchange.

Otherwise, the frame shall be transmitted using a rate that is in accordance with rules defined in 9.6.0d and 9.6.0e.

Delete seven paragraphs from the paragraph starting "Control frames that initiate..." and through the end of the paragraph starting "An alternative rate..." in the new 9.6.0a.

Change the last paragraph of the new 9.6.0a as follows:

For ~~the~~ Clause 17, Clause 18~~, and~~ Clause 19, and Clause 20 PHYs, the time required to transmit a frame for use in calculating the value for the Duration/ID field is determined using the PLME-TXTIME.request primitive (see 10.4.6) and the PLME-TXTIME.confirm primitive (see 10.4.7), both defined in 17.4.3, 18.3.4, 19.8.3.1, 19.8.3.2, ~~or~~ 19.8.3.3, or 20.4.3 depending on the PHY options. In QoS STAs, the Duration/ID field may cover multiple frames and may involve using the PLME-TXTIME.request primitive several times.

Insert the following subclauses (9.6.0b through 9.6.0e.7) after the new 9.6.0a:

9.6.0b Basic MCS Set field

An AP that transmits a frame containing an HT Operation element with either the Dual Beacon field or the Dual CTS Protection field set to the value 1 shall include at least one MCS that has only one spatial stream in the Basic MCS Set field of the HT Operation element of that frame.

9.6.0c Basic STBC MCS

The basic STBC MCS has the value NULL when any of the following conditions is true:

- The Dual Beacon field in the HT Operation element is set to 0, and the Dual CTS Protection field in the HT Operation element is set to 0.
- No HT Operation element is present in the most recently received Association Response frame that was addressed to this STA.
- The BSSBasicMCSSet is empty or does not exist.
- The lowest MCS of the BSSBasicMCSSet has NSS value greater than 1 (the mapping of MCS to NSS is PHY dependent, for the HT PHY see 20.6).

If none of the above conditions is true, then the basic STBC MCS is the lowest MCS index of the BSSBasicMCSSet parameter.

When an MCS from the basic STBC MCS is required in 9.6.0d and 9.6.0e but the basic STBC MCS has the value NULL, the STA shall select a mandatory MCS of the attached PHY.

9.6.0d Rate selection for data and management frames

9.6.0d.1 Rate selection for non-STBC Beacon and non-STBC PSMP frames

If the BSSBasicRateSet parameter is not empty, a non-STBC Beacon or a non-STBC PSMP frame shall be transmitted in a non-HT PPDU using one of the rates included in the BSSBasicRateSet parameter.

If the BSSBasicRateSet parameter is empty, the frame shall be transmitted in a non-HT PPDU using one of the mandatory PHY rates.

9.6.0d.2 Rate selection for STBC group-addressed data and management frames

When a STA has the MIB attribute dot11TxSTBCOptionEnabled set to TRUE, it shall use the basic STBC MCS when it transmits an STBC Beacon frame or when it transmits a group-addressed data or management frame that is an STBC frame.

9.6.0d.3 Rate selection for other group-addressed data and management frames

This subclause describes the rate selection rules for group-addressed data and management frames, excluding the following:

— Non-STBC Beacon and non-STBC PSMP frames

— STBC group-addressed data and management frames

If the BSSBasicRateSet parameter is not empty, a data or management frame (excluding the frames listed above) with a group address in the Address 1 field shall be transmitted in a non-HT PPDU using one of the rates included in the BSSBasicRateSet parameter.

If the BSSBasicRateSet parameter is empty and the BSSBasicMCSSet parameter is not empty, the frame shall be transmitted in an HT PPDU using one of the MCSs included in the BSSBasicMCSSet parameter.

If both the BSSBasicRateSet parameter and the BSSBasicMCSSet parameter are empty (e.g., a scanning STA that is not yet associated with a BSS), the frame shall be transmitted in a non-HT PPDU using one of the mandatory PHY rates.

9.6.0d.4 Rate selection for polling frames

A data frame of a subtype that includes CF-Poll that does not also include CF-Ack and that is sent in the CP shall be transmitted at a rate selected as follows:

a) If an initial exchange has already established protection and the Duration/ID field in the frame establishing protection covers the entire TXOP, the rate or MCS is selected according to the rules in 9.6.0d.6.

b) Otherwise, the data frame shall be transmitted at a rate or MCS as defined in 9.6.0d.3, treating the frame as though it has a group address in the Address 1 field, solely for the purpose of determining the appropriate rate or MCS.

9.6.0d.5 Rate selection for +CF-Ack frames

For a frame of type (QoS) Data+CF-Ack, (QoS) Data+CF-Poll+CFAck, or (QoS) CF-Poll+CF-Ack, the rate or MCS and TXVECTOR parameter CH_BANDWIDTH used to transmit the frame shall be chosen from among those supported by both the addressed recipient STA and the STA to which the ACK frame is intended.

9.6.0d.6 Rate selection for other data and management frames

A data or management frame not identified in 9.6.0d.1 through 9.6.0d.5 shall be sent using any data rate or MCS subject to the following constraints:

— A STA shall not transmit a frame using a rate or MCS that is not supported by the receiver STA or STAs, as reported in any Supported Rates element, Extended Supported Rates element, or Supported MCS field in management frames transmitted by the receiver STA.

— A STA shall not transmit a frame using a value for the CH_BANDWIDTH parameter of the TXVECTOR that is not supported by the receiver STA.

— A STA shall not initiate transmission of a frame at a data rate higher than the greatest rate in the OperationalRateSet or the HTOperationalMCSset, which are parameters of the MLME-JOIN.request primitive.

When the supported rate set of the receiving STA or STAs is not known, the transmitting STA shall transmit using a rate in the BSSBasicRateSet parameter, or an MCS in the BSSBasicMCSSet parameter, or a rate from the mandatory rate set of the attached PHY if both the BSSBasicRateSet and the BSSBasicMCSSet are empty.

The rules in this subclause also apply to A-MPDUs that aggregate MPDUs of type Data or Management with any other types of MPDU.

9.6.0e Rate selection for control frames

9.6.0e.1 General rules for rate selection for control frames

Control frames carried in an A-MPDU shall be sent at a rate selected from the rules defined in 9.6.0d.6.

NOTE—The rules defined in 9.6.0e.2 through 9.6.0e.5 apply only to control frames not carried in an A-MPDU.

The following rules determine whether a control frame is carried in an HT PPDU or non-HT PPDU:

a) A control frame shall be carried in an HT PPDU when the control frame meets any of the following conditions:
   1) The control frame contains an L-SIG duration value (see 9.13.5), or
   2) The control frame is sent using an STBC frame.
b) A control response frame shall be carried in an HT PPDU when the control frame is a response to a frame that meets any of the following conditions:
   1) The frame eliciting the response included an HT Control field with the TRQ field set to 1 and the NDP Announcement subfield set to 0, and this responder set the Implicit Transmit Beamforming Receiving Capable field to 1 in its last transmitted HT Capabilities element; or
   2) The frame eliciting the response was an RTS frame carried in an HT PPDU; or
   3) The frame eliciting the response was an STBC frame, and the Dual CTS Protection field was set to 1 in the last HT Operation element received from its AP or transmitted by the STA (see 9.2.5.5a).
c) A control frame may be carried in an HT PPDU when the control frame meets any of the following conditions:
   1) The control frame contains an HT Control field with the MRQ subfield set to 1, or
   2) The control frame contains an HT Control field with the TRQ field set to 1.

   NOTE—In these cases, requirements specified in 9.17, 9.18.2, and 9.19 further constrain the choice of non-HT or HT PPDU.
d) Otherwise, the control frame shall be carried in a non-HT PPDU.

Selection of channel width is defined in 9.6.0e.6.

A control response frame is a control frame that is transmitted as a response to the reception of a frame a SIFS time after the PPDU containing the frame that elicited the response, e.g. a CTS in response to an RTS reception, an ACK in response to a DATA reception, a BlockAck in response to a BlockAckReq reception. In some situations, the transmission of a control frame is not a control response transmission, such as when a CTS is used to initiate a TXOP.

9.6.0e.2 Rate selection for control frames that initiate a TXOP

This subclause describes the rate selection rules for control frames that initiate a TXOP and that are not carried in an A-MPDU.

If a control frame other than a Basic BlockAckReq or Basic BlockAck is carried in a non-HT PPDU, the transmitting STA shall transmit the frame using one of the rates in the BSSBasicRateSet parameter or a rate from the mandatory rate set of the attached PHY if the BSSBasicRateSet is empty.

If a Basic BlockAckReq or Basic BlockAck frame is carried in a non-HT PPDU, the transmitting STA shall transmit the frame using a rate supported by the receiver STA, if known (as reported in the Supported Rates element and/or Extended Supported Rates element in frames transmitted by that STA). If the supported rate set of the receiving STA or STAs is not known, the transmitting STA shall transmit using a rate from the BSSBasicRateSet parameter or using a rate from the mandatory rate set of the attached PHY if the BSSBasicRateSet is empty.

NOTE—Because of their utility in resolving contention and in establishing a NAV, most control subtype frames that initiate a frame exchange are subject to explicit limitations regarding the choice of transmission rate with the intent of ensuring maximum possible coverage and receptibility of the frame. But the Basic BlockAckReq and Basic BlockAck frames are subject to fewer restrictions because their use at times will mimic a typical data-ACK exchange, where no BSS BasicRateSet rate restriction exists on the data frame. In addition, the Basic BlockAck frame is significantly larger than the other control frames.

When L-SIG TXOP protection is not used for an HT PPDU, an HT STA shall select an MCS from the BasicMCSSet parameter when protection is required (as defined in 9.13) and shall select an MCS from the SupportedMCSSet parameter of the intended receiver when protection is not required.

When L-SIG TXOP protection is used, an HT STA shall select an MCS from the SupportedMCSSet parameter of the intended receiver.

9.6.0e.3 Rate selection for CF_End control frames

If not operating during the 40 MHz phase of PCO, a STA that transmits a CF-End control frame that is not at the end of a TXOP that was obtained through the use of the dual CTS mechanism shall transmit the frame using a rate in BSSBasicRateSet or from the mandatory rate set of the attached PHY if the BSSBasicRateSet is empty.

If operating during the 40 MHz phase of PCO, a STA that transmits a CF-End control frame that is not at the end of a TXOP that was obtained through the use of the dual CTS mechanism shall transmit the frame using an MCS from the BSSBasicMCSSet parameter.

A STA that transmits a CF-End control frame at the end of a TXOP that was obtained by a non-AP STA through the use of the dual CTS mechanism shall transmit the CF-End control frame with the same value for the TXVECTOR parameter STBC, TXVECTOR parameter MCS (if present), and TXVECTOR parameter RATE as was used for the transmission of the matching control frame at the beginning of the TXOP. The matching control frame is defined as follows:

- For the first CF-End transmitted in the TXOP, the matching control frame is the first RTS transmitted in the TXOP.
- For the second CF-End transmitted in the TXOP, the matching control frame is the first CTS that follows the first RTS transmitted in the TXOP.
- For the third CF-End transmitted in the TXOP, the matching control frame is the second CTS that follows the first RTS transmitted in the TXOP.

A STA that transmits a CF-End control frame at the end of a TXOP that was obtained by an AP through the use of the dual CTS mechanism shall transmit the CF-End control frame with the same value for the TXVECTOR parameter STBC, TXVECTOR parameter MCS (if present), and TXVECTOR parameter RATE as was used for the transmission of the matching control frame at the beginning of the TXOP. The matching control frame is defined as follows:

- For the first CF-End transmitted in the TXOP, the matching control frame is the first CTS-to-self transmitted in the TXOP.
- For the second CF-End transmitted in the TXOP, the matching control frame is the first RTS transmitted in the TXOP.

9.6.0e.4 Rate selection for control frames that are not control response frames

This subclause describes the rate selection rules for control frames that are not control response frames, are not the frame that initiates a TXOP, are not the frame that terminates a TXOP, and are not carried in an A-MPDU.

A frame other than a BlockAckReq or BlockAck that is carried in a non-HT PPDU shall be transmitted by the STA using a rate no higher than the highest rate in the BSSBasicRateSet parameter that is less than or equal to the rate or non-HT reference rate (see 9.6.2) of the previously transmitted frame that was directed to the same receiving STA. If no rate in the BSSBasicRateSet parameter meets these conditions, the control frame shall be transmitted at a rate no higher than the highest mandatory rate of the attached PHY that is less than or equal to the rate or non-HT reference rate (see 9.6.2) of the previously transmitted frame that was directed to the same receiving STA.

A BlockAckReq or BlockAck that is carried in a non-HT PPDU shall be transmitted by the STA using a rate supported by the receiver STA, as reported in the Supported Rates element and/or Extended Supported Rates element in frames transmitted by that STA. When the supported rate set of the receiving STA or STAs is not known, the transmitting STA shall transmit using a rate from the BSSBasicRateSet parameter or from the mandatory rate set of the attached PHY if the BSSBasicRateSet is empty.

A frame that is carried in an HT PPDU shall be transmitted by the STA using an MCS supported by the receiver STA, as reported in the Supported MCS field in the HT capabilities element in management frames transmitted by that STA. When the supported rate set of the receiving STA or STAs is not known, the transmitting STA shall transmit using an MCS in the BSSBasicMCSSet parameter.

9.6.0e.5 Rate selection for control response frames

9.6.0e.5.1 Introduction

Subclauses 9.6.0e.5.2 through 9.6.0e.5.5 describe the rate selection rules for control response frames that are not carried in an A-MPDU.

9.6.0e.5.2 Selection of a rate or MCS

To allow the transmitting STA to calculate the contents of the Duration/ID field, a STA responding to a received frame transmits its control response frame at a primary rate, or at an alternate rate, or at an MCS, as specified by the following rules:

- If a CTS or ACK control response frame is carried in a non-HT PPDU, the primary rate is defined to be the highest rate in the BSSBasicRateSet parameter that is less than or equal to the rate (or non-HT reference rate; see 9.6.2) of the previous frame. If no rate in the BSSBasicRateSet parameter meets these conditions, the primary rate is defined to be the highest mandatory rate of the attached PHY that is less than or equal to the rate (or non-HT reference rate; see 9.6.2) of the previous frame. The STA may select an alternate rate according to the rules in 9.6.0e.5.4. The STA shall transmit the non-HT PPDU CTS or ACK control response frame at either the primary rate or the alternate rate, if one exists.

- If a BlockAck frame is sent as an immediate response to either an implicit BlockAck request or to a BlockAckReq frame that was carried in an HT PPDU and the BlockAck frame is carried in a non-HT PPDU, the primary rate is defined to be the highest rate in the BSSBasicRateSet parameter that is less than or equal to the rate (or non-HT reference rate; see 9.6.2) of the previous frame. If no rate in the BSSBasicRateSet parameter meets these conditions, the primary rate is defined to be the highest mandatory rate of the attached PHY that is less than or equal to the rate (or non-HT reference rate; see 9.6.2) of the previous frame. The STA may select an alternate rate according to the rules in 9.6.0e.5.4. The STA shall transmit the non-HT PPDU BlockAck control response frame at either the primary rate or the alternate rate, if one exists.
- If a Basic BlockAck frame is sent as an immediate response to a BlockAckReq frame that was carried in a non-HT PPDU and the Basic BlockAck frame is carried in a non-HT PPDU, the primary rate is defined to be the same rate and modulation class as the BlockAckReq frame, and the STA shall transmit the Basic BlockAck frame at the primary rate.
- If a Compressed BlockAck frame is sent as an immediate response to a BlockAckReq frame that was carried in a non-HT PPDU and the Compressed BlockAck frame is carried in a non-HT PPDU, the primary rate is defined to be the highest rate in the BSSBasicRateSet parameter that is less than or equal to the rate (or non-HT reference rate; see 9.6.2) of the previous frame. If no rate in the BSSBasicRateSet parameter meets these conditions, the primary rate is defined to be the highest mandatory rate of the attached PHY that is less than or equal to the rate (or non-HT reference rate; see 9.6.2) of the previous frame. The STA may select an alternate rate according to the rules in 9.6.0e.5.4. The STA shall transmit the non-HT PPDU Compressed BlockAck control response frame at either the primary rate or the alternate rate, if one exists.
- If the control response frame is carried in an HT PPDU, then it is transmitted at an MCS as determined by the procedure defined in 9.6.0e.5.3.

The modulation class of the control response frame shall be selected according to the following rules:

- If the received frame is of a modulation class other than HT and the control response frame is carried in a non-HT PPDU, the control response frame shall be transmitted using the same modulation class as the received frame. In addition, the control response frame shall be sent using the same value for the TXVECTOR parameter PREAMBLE_TYPE as the received frame.
- If the received frame is of the modulation class HT and the control response frame is carried in a non-HT PPDU, the control response frame shall be transmitted using one of the ERP-OFDM or OFDM modulation classes.
- If the control response frame is carried in an HT PPDU, the modulation class shall be HT.

The selection of the value for the channel width (CH_BANDWIDTH parameter of the TXVECTOR) of the response transmission is defined in 9.6.0e.6.

9.6.0e.5.3 Control response frame MCS computation

If a control response frame is to be transmitted within an HT PPDU, the channel width (CH_BANDWIDTH parameter of the TXVECTOR) shall be selected first according to 9.6.0e.6, and then the MCS shall be selected from a set of MCSs called the *CandidateMCSSet* as described in this subclause.

The Rx Supported MCS Set of the STA that transmitted the frame eliciting the response is determined from its Supported MCS Set field as follows:

- If a bit in the Rx MCS Bitmask subfield is set to 0, the corresponding MCS is not supported.
- If a bit in the Rx MCS Bitmask subfield is set to 1 and the integer part of the data rate (expressed in megabits per second) of the corresponding MCS is less than or equal to the rate represented by the

Rx Highest Supported Data Rate subfield, then the MCS is supported by the STA on receive. If the Rx Highest Supported Data Rate subfield is set to 0 and a bit in the Rx MCS Bitmask is set to 1, then the corresponding MCS is supported by the STA on receive.

The CandidateMCSSet is determined using the following rules:

- If the frame eliciting the response was an STBC frame and the Dual CTS Protection bit is set to 1, the CandidateMCSSet shall contain only the basic STBC MCS.
- If the frame eliciting the response had an L-SIG duration value (see 9.13.5) and initiates a TXOP, the CandidateMCSSet is the MCS Set consisting of the intersection of the Rx Supported MCS Set of the STA that sent the frame that is eliciting the response and the set of MCSs that the responding STA is capable of transmitting.
- If none of the above conditions is true, the CandidateMCSSet is the BSSBasicMCSSet parameter. If the BSSBasicMCSSet parameter is empty, the CandidateMCSSet shall consist of the set of mandatory HT PHY MCSs.

MCS values from the CandidateMCSSet that cannot be transmitted with the selected CH_BANDWIDTH parameter value shall be eliminated from the CandidateMCSSet.

The choice of a response MCS is made as follows:

a) If the frame eliciting the response is within a non-HT PPDU,
   1) Eliminate from the CandidateMCSSet all MCSs that have a data rate greater than the data rate of the received PPDU (the mapping of MCS to data rate is defined in 20.6).
   2) Find the highest indexed MCS from the CandidateMCSSet. The index of this MCS is the index of the MCS that is the primary MCS for the response transmission.
   3) If the CandidateMCSSet is empty, the primary MCS is the lowest indexed MCS of the mandatory MCSs.
b) If the frame eliciting the response is within an HT PPDU,
   1) Eliminate from the CandidateMCSSet all MCSs that have an index that is higher than the index of the MCS of the received frame.
   2) Determine the highest number of spatial streams (N_{SS}) value of the MCSs in the CandidateMCSSet that is less than or equal to the N_{SS} value of the MCS of the received frame. Eliminate all MCSs from the CandidateMCSSet that have an N_{SS} value that is not equal to this N_{SS} value. The mapping from MCS to N_{SS} is dependent on the attached PHY. For the HT PHY, see 20.6.
   3) Find the highest indexed MCS of the CandidateMCSSet for which the modulation value of each stream is less than or equal to the modulation value of each stream of the MCS of the received frame and for which the coding rate value is less than or equal to the coding rate value of the MCS from the received frame. The index of this MCS is the index of the MCS that is the primary MCS for the response transmission. The mapping from MCS to modulation and coding rate is dependent on the attached PHY. For the HT PHY, see 20.6. For the purpose of comparing modulation values, the following sequence shows increasing modulation values: BPSK, QPSK, 16-QAM, 64-QAM.
   4) If no MCS meets the condition in step 3), remove each MCS from the CandidateMCSSet that has the highest value of N_{SS} in the CandidateMCSSet. If the resulting CandidateMCSSet is empty, then set the CandidateMCSSet to the HT PHY mandatory MCSs. Repeat step 3) using the modified CandidateMCSSet.

Once the primary MCS has been selected, the STA may select an alternate MCS according to 9.6.0e.5.4. The STA shall transmit the HT PPDU control response frame using either the primary MCS or the alternate MCS, if one exists.

9.6.0e.5.4 Selection of an alternate rate or MCS for a control response frame

An alternate rate may be selected provided that all of the following conditions are met:

- The duration of frame at the alternate rate is the same as the duration of the frame at the primary rate determined by 9.6.0e.5.2.
- The alternate rate is in either the BSSBasicRateSet parameter or is a mandatory rate of the attached PHY.
- The modulation class of the frame at the alternate rate is the same class as that of the primary rate selected by 9.6.0e.5.2.

An alternate MCS may be selected provided that both of the following conditions are met:

- The duration of the frame at the alternate MCS is the same as the duration of the frame at the primary MCS.
- The alternate MCS is in the CandidateMCSSet that was generated according to the procedure of 9.6.0e.5.3.

9.6.0e.5.5 Control response frame TXVECTOR parameter restrictions

A STA shall not transmit a control response frame with TXVECTOR parameter GI_TYPE set to SHORT_GI unless it is in response to a reception of a frame with the RXVECTOR parameter GI_TYPE set to SHORT_GI.

A STA shall not transmit a control response frame with TXVECTOR parameter FEC_CODING set to LDPC_CODING unless it is in response to a reception of a frame with the RXVECTOR parameter FEC_CODING set to LDPC_CODING.

A STA shall not transmit a control response frame with the TXVECTOR parameter FORMAT set to HT_GF.

9.6.0e.6 Channel Width selection for control frames

An HT STA that receives a frame that elicits a control frame transmission shall send the control frame response using a value for the CH_BANDWIDTH parameter that is based on the CH_BANDWIDTH parameter value of the received frame according to Table 9-1b.

Table 9-1b—CH_BANDWIDTH control frame response mapping

CH_BANDWIDTH RXVECTOR value	CH_BANDWIDTH TXVECTOR value
HT_CBW20	HT_CBW20 or NON_HT_CBW20
HT_CBW40	HT_CBW40 or NON_HT_CBW40
NON_HT_CBW20	HT_CBW20 or NON_HT_CBW20
NON_HT_CBW40	HT_CBW40 or NON_HT_CBW40

NOTE—This rule, combined with the rules in 9.6.0e.1, determines the format of control response frames.

A frame that is intended to provide protection is transmitted using a channel width selected by the rules defined in 9.13.

An HT STA that uses a non-HT duplicate frame to establish protection of its TXOP shall send any CF-End frame using a non-HT duplicate frame except during the 40 MHz phase of PCO operation. During the 40 MHz phase of PCO operation, the rules in 11.15 apply.

9.6.0e.7 Control frame TXVECTOR parameter restrictions

A STA shall not transmit a control frame that initiates a TXOP with the TXVECTOR parameter GI_TYPE set to a value of SHORT_GI.

A STA shall not transmit a control frame that initiates a TXOP with the TXVECTOR parameter FEC_CODING set to a value of LDPC_CODING.

9.6.1 Modulation classes

Change 9.6.1 (including Table 9-2) as follows:

In order to determine the rules for response frames given in 9.6, the following modulation classes are defined in Table 9-2. Each row defines a modulation class. Modulations described within the same row have the same modulation class, while modulations described in different rows have different modulation classes. <u>For Clause 20 PHY transmissions, the modulation class is determined by the FORMAT and NON_HT_MODULATION parameters of the TXVECTOR/RXVECTOR. Otherwise, the modulation class is determined by the clause or subclause number defining that modulation.</u>

Table 9-2—Modulation classes

Modulation class	Description of modulation	<u>Condition that selects this modulation class</u>	
		<u>Clause 14–19 PHYs</u>	<u>Clause 20 PHY</u>
1	Infrared (IR) ~~PHY (Clause 16)~~	<u>Clause 16 transmission</u>	<u>N/A</u>
2	Frequency-hopping spread spectrum (FHSS) ~~PHY (Clause 14)~~	<u>Clause 14 transmission</u>	<u>N/A</u>
3	DSSS ~~PHY (Clause 15)~~ and HR/DSSS ~~PHY (Clause 18)~~	<u>Clause 15 or Clause 18 transmission</u>	<u>FORMAT is NON_HT. NON_HT_MODULATION is ERP-DSSS or ERP-CCK.</u>
4	ERP-PBCC ~~PHY (19.6)~~	<u>19.6 transmission</u>	<u>FORMAT is NON_HT. NON_HT_MODULATION is ERP-PBCC.</u>
5	DSSS-OFDM ~~PHY (19.7)~~	<u>19.7 transmission</u>	<u>FORMAT is NON_HT. NON_HT_MODULATION is DSSS-OFDM.</u>
6	ERP-OFDM ~~PHY (19.5)~~	<u>19.5 transmission</u>	<u>FORMAT is NON_HT. NON_HT_MODULATION is ERP-OFDM.</u>

Table 9-2—Modulation classes *(continued)*

Modulation class	Description of modulation	Condition that selects this modulation class	
		Clause 14–19 PHYs	Clause 20 PHY
7	OFDM ~~PHY (Clause 17)~~	Clause 17 transmission	FORMAT is NON_HT. NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM.
8	HT	N/A	FORMAT is HT_MF or HT_GF.

Insert the following subclause (9.6.2) after 9.6.1 :

9.6.2 Non-HT basic rate calculation

This subclause defines how to convert an HT MCS to a non-HT basic rate for the purpose of determining the rate of the response frame. It consists of two steps as follows:

a) Use the modulation and coding rate determined from the HT MCS (defined in 20.6) to a non-HT reference rate by lookup into Table 9-2a.[1] In the case of an MCS with UEQM, the modulation of stream 1 is used.

b) The non-HT basic rate is the highest rate in the BSSBasicRateSet that is less than or equal to this non-HT reference rate.

Table 9-2a—Non-HT reference rate

Modulation	Coding rate (R)	Non-HT reference rate (Mb/s)
BPSK	1/2	6
BPSK	3/4	9
QPSK	1/2	12
QPSK	3/4	18
16-QAM	1/2	24
16-QAM	3/4	36
64-QAM	1/2	48
64-QAM	2/3	48
64-QAM	3/4	54
64-QAM	5/6	54

[1] For example, if an HT PPDU transmission uses 64-QAM and coding rate of 3/4, the related non-HT reference rate is 54 Mb/s.

9.7 MSDU transmission restrictions

Change the second and third paragraphs of 9.7 as follows:.

A non-QoS STA shall ensure that no more than one MSDU or MMPDU from a particular SA to a particular individual RA is outstanding at a time. ~~Note that a~~

NOTE—A simpler, more restrictive ~~invariant to maintain~~ alternative to the rule in the above paragraph that may be used is that no more than one MSDU with a particular individual RA may be outstanding at a time.

For ~~all transmissions not using the acknowledgment policy of Block Ack,~~ frames that are not sent within the context of a Block Ack agreement, a QoS STA shall ensure that no more than one MSDU or A-MSDU ~~or MMPDU with a particular~~ for each TID or MMPDU from a particular SA to a particular individual RA is outstanding at any time. ~~Note that a~~

NOTE—A simpler, more restrictive ~~invariant to maintain~~ alternative to the rule in the above paragraph that may be used is that no more than one MSDU or A-MSDU with any particular TID with a particular individual RA may be outstanding at any time. ~~This restriction is not applicable for MSDUs that are to be transmitted using the Block Ack mechanism.~~

Change the fifth and sixth paragraphs of 9.7 as follows:

It is recommended that the STA select a value of dot11MaxTransmitMSDULifetime that is sufficiently large that the STA does not discard MSDUs or A-MSDUs due to excessive Transmit MSDU timeouts under normal operating conditions.

An A-MSDU shall contain only MSDUs of a single service class and inherits that service class for the purpose of the following rules. For MSDUs or A-MSDUs belonging to the service class of QoSAck when the receiver is a QoS STA, the QoS data frames that are used to send these MSDUs or A-MSDUs shall have the Ack Policy subfield in the QoS Control field set to Normal Ack, ~~or~~ Block Ack, Implicit Block Ack Request, or PSMP Ack. For MSDUs or A-MSDUs belonging to the service class of QoSNoAck when the receiver is a QoS STA, the QoS data frames that are used to send these MSDUs or A-MSDUs shall have the Ack Policy subfield in the QoS Control field set to No Ack.

Insert the following subclauses (9.7a through 9.7i) after 9.7:

9.7a HT Control field operation

If the value of its MIB variable dot11HTControlFieldSupported is TRUE, a STA shall set the +HTC Support subfield of the HT Extended Capabilities field of the HT Capabilities element to 1 in HT Capabilities elements that it transmits.

A STA that has a value of TRUE for at least one of its MIB variables dot11RDResponderOption-Implemented and dot11MCSFeedbackOptionImplemented shall set dot11HTControlFieldSupported to TRUE.

An HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC in the HT Extended Capabilities field of its HT Capabilities element (see 7.3.2.56).

NOTE—An HT STA that does not support +HTC that receives a +HTC frame addressed to another STA still performs the CRC on the actual length of the MPDU and uses the Duration/ID field to update the NAV, as described in 9.2.5.4.

If the HT Control field is present in an MPDU aggregated in an A-MPDU, then all MPDUs of the same frame type (i.e., having the same value for the Type subfield of the Frame Control field) aggregated in the same A-MPDU shall contain an HT Control field. The HT Control field of all MPDUs containing the HT Control field aggregated in the same A-MPDU shall be set to the same value.

9.7b Control Wrapper operation

A STA supporting the HT Control field that receives a Control Wrapper frame shall process it as though it received a frame of the subtype of the wrapped frame.

NOTE—A STA supporting the HT Control field can reset the NAV set by a wrapped RTS frame following the rules defined in 9.2.5.4.

9.7c A-MSDU operation

An A-MSDU shall contain only MSDUs whose DA and SA parameter values map to the same RA and TA values.

The constituent MSDUs of an A-MSDU shall all have the same priority parameter value from the corresponding MA-UNITDATA.request.

An A-MSDU shall be carried, without fragmentation, within a single QoS data MPDU.

The Address 1 field of an MPDU carrying an A-MSDU shall be set to an individual address.

The channel access rules for a QoS data MPDU carrying an A-MSDU are the same as a data MPDU carrying an MSDU (or fragment thereof) of the same TID.

The expiration of the A-MSDU lifetime timer occurs only when the lifetime timer of all of the constituent MSDUs of the A-MSDU have expired.

NOTE 1—This rule implicitly allows an MSDU that is a constituent of an A-MSDU to potentially be transmitted after the expiry of its lifetime.

NOTE 2—Selecting any other value for the timeout would result in loss of MSDUs. Selecting the maximum value avoids this loss of MSDUs at the cost of transmitting MSDUs that have exceeded their lifetime.

A STA that has a value of FALSE for the MIB attribute dot11HighthroughputOptionImplemented shall not transmit an A-MSDU. A STA shall not transmit an A-MSDU to a STA from which it has not received a frame containing an HT Capabilities element.

Support for the reception of an A-MSDU, where the A-MSDU is carried in a QoS data MPDU with Ack Policy set to Normal Ack and the A-MSDU is not aggregated within an A-MPDU, is mandatory for an HT STA.

The use of an A-MSDU carried in a QoS data MPDU under a Block Ack agreement is determined per Block Ack agreement. A STA shall not transmit an A-MSDU within a QoS data MPDU under a Block Ack agreement unless the recipient indicates support for A-MSDU by setting the A-MSDU Supported field to 1 in its BlockAck Parameter Set field of the ADDBA Response frame.

A STA shall not transmit an A-MSDU to a STA that exceeds its maximum A-MSDU length capability.

NOTE—Support for A-MSDU aggregation does not affect the maximum size of MSDU transported by the MA-UNITDATA primitives.

9.7d A-MPDU operation

9.7d.1 A-MPDU contents

According to its context (defined in Table 7-57x), an A-MPDU shall be constrained so that it contains only MPDUs as specified in the relevant table referenced from Table 7-57x.

9.7d.2 A-MPDU length limit rules

An HT STA indicates a value in the Maximum A-MPDU Length Exponent field in its HT Capabilities element that defines the maximum A-MPDU length that it can receive. The encoding of this field is defined in Table 7-43k. Using this field, the STA establishes at association the maximum length of A-MPDUs that will be sent to it. The STA shall be capable of receiving A-MPDUs of length up to the value indicated by this field.

An HT STA shall not transmit an A-MPDU that is longer than the value indicated by the Maximum A-MPDU Length Exponent field declared by the intended receiver.

NOTE—The A-MPDU length limit applies to the maximum length of the PSDU that may be received. If the A-MPDU includes any padding delimiters (i.e., delimiters with the Length field set to 0) in order to meet the MPDU start spacing requirement, this padding is included in this length limit.

9.7d.3 Minimum MPDU Start Spacing field

An HT STA shall not start the transmission of more than one MPDU within the time limit described in the Minimum MPDU Start Spacing field declared by the intended receiver. To satisfy this requirement, the number of octets between the start of two consecutive MPDUs in an A-MPDU, measured at the PHY SAP, shall be equal or greater than

$$t_{MMSS} \times r / 8$$

where

t_{MMSS} is the time (in microseconds) defined in the “Encoding” column of Table 7-43k for the value of the Minimum MPDU Start Spacing field

r is the value of the PHY Data Rate (in megabits per second) defined in 20.6 based on the TXVECTOR parameters: MCS, GI_TYPE, and CH_BANDWIDTH

If necessary, in order to satisfy this requirement, a STA shall add padding between MPDUs in an A-MPDU. Any such padding shall be in the form of one or more MPDU delimiters with the MPDU Length field set to 0.

9.7d.4 A-MPDU aggregation of group-addressed data frames

A non-AP HT STA shall not transmit an A-MPDU containing an MPDU with a group-addressed RA.

NOTE—An HT AP can transmit an A-MPDU containing MPDUs with a group-addressed RA.

An HT AP shall not transmit an A-MPDU containing group-addressed MPDUs if the HT Protection field is set to non-HT mixed mode.

When an HT AP transmits an A-MPDU containing MPDUs with a group-addressed RA, both of the following shall apply:

— The value of maximum A-MPDU length exponent that applies is the minimum value in the Maximum A-MPDU Length Exponent subfield of the A-MPDU Parameters field of the HT Capabilities element across all HT STAs associated with the AP.

— The value of minimum MPDU start spacing that applies is the maximum value in the Minimum MPDU Start Spacing subfield of the A-MPDU Parameters field of the HT Capabilities element across all HT STAs associated with the AP.

9.7d.5 Transport of A-MPDU by the PHY data service

An A-MPDU shall be transmitted in a PSDU associated with a PHY-TXSTART.request with the TXVECTOR AGGREGATION parameter set to 1. A received PSDU is determined to be an A-MPDU when the associated PHY-RXSTART.indication RXVECTOR AGGREGATION parameter is set to 1.

9.7e PPDU duration constraint

An HT STA shall not transmit a PPDU that has a duration (as determined by the PHY-TXTIME.confirm primitive defined in 10.4.6) that is greater than aPPDUMaxTime.

9.7f LDPC operation

An HT STA shall not transmit a frame with the TXVECTOR parameter FORMAT set to HT_MF or HT_GF and the TXVECTOR parameter FEC_CODING set to LDPC_CODING unless the RA of the frame corresponds to a STA for which the LDPC Coding Capability subfield of the most recently received HT Capabilities element from that STA contained a value of 1 and the MIB variable dot11LDPCCodingOptionEnabled is set to TRUE.

Further restrictions on TXVECTOR parameter values may apply due to rules found in 9.13 and 9.6.

9.7g STBC operation

Only a STA that sets the Tx STBC subfield to 1 in the HT Capabilities element may transmit frames with a TXVECTOR parameter STBC set to a nonzero value to a STA from which the most recently received value of the Rx STBC field of the HT Capabilities element is nonzero.

9.7h Short GI operation

A STA may transmit a frame with TXVECTOR parameters CH_BANDWIDTH set to HT_CBW20 and GI_TYPE set to SHORT_GI only if all of the following conditions are met:

— The STA is an HT STA.
— The TXVECTOR parameter FORMAT is set to HT_MF or HT_GF.
— The RA of the frame corresponds to a STA for which the Short GI for 20 MHz subfield of the most recently received HT Capabilities element contained a value of 1.
— The MIB variable dot11ShortGIOptionInTwentyEnabled is present and has a value of TRUE.

A STA may transmit a frame with TXVECTOR parameters CH_BANDWIDTH set to HT_CBW40 and GI_TYPE set to SHORT_GI only if all of the following conditions are met:

— The STA is an HT STA.
— The TXVECTOR parameter FORMAT is set to HT_MF or HT_GF.
— The RA of the frame corresponds to a STA for which the Short GI for 40 MHz subfield of the most recently received HT Capabilities element contained a value of 1.
— The MIB variable dot11ShortGIOptionInFortyEnabled is present and has a value of TRUE.

An HT STA shall not transmit a frame with the TXVECTOR parameter FORMAT set to HT_GF and the GI_TYPE parameter set to SHORT_GI when the MCS parameter indicates a single spatial stream.

Further restrictions on TXVECTOR parameter values may apply due to rules found in 9.13 and 9.6.

9.7i Greenfield operation

An HT STA shall not transmit a frame with the TXVECTOR parameter FORMAT set to HT_GF unless the RA of the frame corresponds to a STA for which the HT-Greenfield subfield of the most recently received HT Capabilities element contained a value of 1 and the MIB variable dot11HTGreenfieldOptionEnabled is set to TRUE. Further restrictions may apply due to rules found in 9.13, 9.6, and 11.9.7.3.

9.9 HCF

9.9.1 HCF contention-based channel access (EDCA)

9.9.1.2 EDCA TXOPs

Change the second paragraph of 9.9.1.2 and insert the subsequent new paragraph and notes after the second paragraph as follows:

The TXOP limit duration values are advertised by the AP in the EDCA Parameter Set information element in Beacon and Probe Response frames transmitted by the AP. ~~A TXOP limit value of 0 indicates that a single MSDU or MMPDU, in addition to a possible RTS/CTS exchange or CTS to itself, may be transmitted at any rate for each TXOP.~~

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:

a) A single MSDU, MMPDU, A-MSDU, or A-MPDU at any rate, subject to the rules in 9.6
b) Any required acknowledgments
c) Any frames required for protection, including one of the following:
   1) An RTS/CTS exchange
   2) CTS to itself
   3) Dual CTS as specified in 9.2.5.5a
d) Any frames required for beamforming as specified in 9.17
e) Any frames required for link adaptation as specified in 9.16.2
f) Any number of BlockAckReq and BlockAck 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. Behavior at the TXOP responder is restricted by the Duration/ID field value(s) in frames it receives from the TXOP holder.

NOTE 2—The TXOP holder can control how much time, if any, the TXOP responder has to transmit frames required for beamforming (e.g., CSI feedback).

NOTE 3—This rule prevents the use of RD when the TXOP limit is set to 0.

Change the now fifth paragraph 9.9.1.2 as follows:

A STA shall fragment an ~~unicast~~individually addressed MSDU so that the transmission of the first MPDU of the TXOP does not cause the TXOP limit to be exceeded at the PHY rate selected for the initial transmission attempt of that MPDU. The TXOP limit may be exceeded, when using a lower PHY rate than selected for the initial transmission attempt of the first MPDU, for a retransmission of an MPDU, for the initial transmission of an MPDU if any previous MPDU in the current MSDU has been retransmitted, or for group-addressed ~~broadcast/multicast~~ MSDUs. When the TXOP limit is exceeded due to the retransmission of an MPDU at a reduced PHY rate, the STA shall not transmit more than one MPDU in the TXOP.

9.9.1.4 Multiple frame transmission in an EDCA TXOP

Change the first paragraph of 9.9.1.4 as follows:

Multiple frames may be transmitted in an ~~acquired~~ EDCA TXOP that was acquired following the rules in 9.9.1.3 if there ~~are~~is more than one frame pending in the 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. If a TXOP holder~~STA~~ has in its transmit queue an additional frame of the same AC as the one just transmitted and the duration of transmission of that frame plus any expected acknowledgment for that frame is less than the remaining TXNAV~~medium occupancy~~ timer value, then the STA may commence transmission of that frame ~~at~~ a SIFS (or RIFS, under the conditions defined in 9.2.3.0b) after the completion of the immediately preceding frame exchange sequence. 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 BlockAck response is less than the remaining TXNAV timer value.

NOTE—An RD responder can transmit multiple MPDUs as described in 9.15.4.

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 BlockAck 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. ~~The intention of using the multiple frame transmission shall be indicated by the STA through the setting of the duration/ID values in one of the following two ways (see 7.1.4):~~

~~a) Long enough to cover the response frame, the next frame, and its response frame.~~

~~b) Long enough to cover the transmission of a burst of MPDUs subject to the limit set by dot11EDCATableTXOPLimit.~~

Change the now third and fourth paragraph of 9.9.1.4 as follows:

After a valid response to the initial frame of a TXOP, if ~~If~~ the Duration/ID field is set for multiple frame transmission and there is a subsequent transmission failure, the corresponding channel access function may ~~recover~~ transmit after the CS mechanism (see 9.2.1) indicates that the medium is idle at the TxPIFS slot boundary (defined in 9.2.10) before the expiry of the TXNAV timer. ~~NAV setting due to the setting of the Duration/ID field in the frame that resulted in a transmission failure. The backoff procedure is described in 9.9.1.5. However, at~~ At the expiry of the TXNAV timer, ~~NAV set by the frame that resulted in a transmission failure,~~ if the channel access function has not regained access to the medium, ~~recovered,~~ then the EDCAF shall invoke the backoff procedure that is described in 9.9.1.5. Transmission failure is defined in 9.9.1.5.

~~No other AC at the STA shall transmit before the expiry of the NAV set by the frame that resulted in a transmission failure.~~ All other ~~ACs~~ channel access functions at the STA shall treat the medium as busy until the expiry of the TXNAV timer. ~~NAV set by the frame that resulted in a transmission failure, just as they would if they had received that transmission from another STA.~~

Change the last paragraph of 9.9.1.4 as follows:

Note that, as for an EDCA TXOP, a multiple frame transmission is granted to an EDCAF, not to a non-AP STA or AP, 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. In such a case, 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 9.16 do apply.

9.9.1.5 EDCA backoff procedure

Change 9.9.1.5 as follows:

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

For the purposes of this subclause, successful transmission and transmission failure are defined as follows:

— After transmitting an MPDU (regardless of whether it is carried in an A-MPDU) that requires an immediate frame as a response, the STA shall wait for a timeout interval of duration of aSIFSTime + aSlotTime + aPHY-RX-START-Delay, starting at the PHY-TXEND.confirm. If a PHY-RXSTART.indication does not occur during the timeout interval, the STA concludes that the transmission of the MPDU has failed.

— If a PHY-RXSTART.indication does occur during the timeout interval, the STA shall wait for the corresponding PHY-RXEND.indication 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, shall be interpreted as a successful response.

— The recognition of anything else, including any other valid frame, shall be interpreted as failure of the MPDU transmission. The recognition of a valid data frame sent by the recipient of a PS-Poll frame shall also be accepted as successful acknowledgment of the PS-Poll frame. A transmission that does not require an immediate frame as a response is defined as a successful transmission.

~~If a frame is successfully transmitted by a specific EDCAF, indicated by the successful reception of a CTS in response to an RTS, the successful reception of an ACK frame in response to a unicast MPDU or BlockAck, the successful reception of a BlockAck or ACK frame in response to a BlockAckReq frame, or the transmission of a multicast frame or a frame with No Ack policy, CW[AC] shall be reset to CWmin[AC].~~

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

a) A frame with that AC is requested to be transmitted, the medium is busy as indicated by either physical or virtual CS, and the backoff timer has a value of zero for that AC.

b) The final transmission by the TXOP holder initiated during the TXOP for that AC was successful and the TXNAV timer has expired.

c) The transmission of ~~a~~ the initial frame of a TXOP of that AC fails~~, indicated by a failure to receive a CTS in response to an RTS, a failure to receive an ACK frame that was expected in response to a unicast MPDU, or a failure to receive a BlockAck or ACK frame in response to a BlockAckReq frame~~.

d) 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.

In addition, the backoff procedure may be invoked for an EDCAF when the transmission of a non-initial frame by the TXOP holder fails.

NOTE—A STA can perform a PIFS recovery as described in 9.9.1.4 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.

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

NOTE—In other words, the backoff is a continuation of the TXOP, not the start of a new TXOP.

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].

If the backoff procedure is invoked because of a failure event [~~either~~ reason c) or d) 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:

— ~~a)~~ If the QSRC[AC] or the QLRC[AC] for the QoS STA has reached dot11ShortRetryLimit or dot11LongRetryLimit respectively, CW[AC] shall be reset to CWmin[AC].

— ~~b)~~ Otherwise,

  — ~~1)~~ If CW[AC] is less than CWmax[AC], CW[AC] shall be set to the value (CW[AC] + 1) × 2 – 1.

  — ~~2)~~ If CW[AC] is equal to CWmax[AC], CW[AC] shall remain unchanged for the remainder of any retries.

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

All backoff slots occur following an AIFS[AC] period during which the medium is determined to be idle 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 for the duration of the EIFS – DIFS + AIFS[AC] period, as appropriate (see 9.2.3).

If the backoff procedure is invoked following the transmission of a 40 MHz mask PPDU, the backoff counter shall be decremented based on a medium busy indication that ignores activity in the secondary channel. Additional 40 MHz mask PPDU backoff rules are found in 11.14.9.

9.9.1.6 Retransmit procedures

Change the first through fourth paragraphs of 9.9.1.6 as follows:

QoS STAs shall maintain a short retry counter and a long retry counter for each MSDU, A-MSDU, or MMPDU that belongs to a TC requiring acknowledgment. The initial value for the short and long retry counters shall be zero. 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 zero.

After transmitting a frame that requires acknowledgment, the STA shall perform either of the acknowledgment procedures, as appropriate, that are defined in 9.2.8 and 9.10.3. The short retry count for an MSDU or A-MSDU that is not part of a Block Ack agreement or for an MMPDU ~~and the QSRC[AC]~~ shall be incremented every time transmission of a ~~MAC~~ frame of length less than or equal to dot11RTSThreshold fails for that MSDU, A-MSDU, or MMPDU. QSRC[AC] shall be incremented every time transmission of an A-MPDU or frame of length less than or equal to dot11RTSThreshold fails. This short retry count and the QoS STA QSRC[AC] shall be reset when an A-MPDU or ~~MAC~~ frame of length less than or equal to dot11RTSThreshold succeeds ~~for that MSDU or MMPDU~~. The long retry count for an MSDU or A-MSDU that is not part of a Block Ack agreement or for an MMPDU ~~and the QLRC[AC]~~ shall be incremented every time transmission of a MAC frame of length greater than dot11RTSThreshold fails for that MSDU, A-MSDU, or MMPDU. QLRC[AC] shall be incremented every time transmission of an A-MPDU or frame of length greater than or equal to dot11RTSThreshold fails. This long retry count and the QLRC[AC] shall be reset when an A-MPDU or ~~MAC~~ frame of length greater than dot11RTSThreshold succeeds ~~for that MSDU or MMPDU~~. All retransmission attempts for an MPDU that is not sent under a 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 management frame.

Retries for failed transmission attempts shall continue until the short retry count for the MSDU, A-MSDU, or MMPDU is equal to dot11ShortRetryLimit or until the long retry count for the MSDU, A-MSDU, or MMPDU is equal to dot11LongRetryLimit. When either of these limits is reached, retry attempts shall cease, and the MSDU, A-MSDU, or MMPDU shall be discarded.

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 transmissions that use Block Ack, the rules in 9.10.3 also apply. STAs shall retry failed transmissions until the transmission is successful or until the relevant retry limit is reached.

Insert the following paragraph at the end of 9.9.1.6:

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. This procedure ensures that no MSDU in the A-MSDU is discarded before a period of dot11EDCATableMSDULifetime has elapsed.

Insert the following subclause (9.9.1.7) after 9.9.1.6:

9.9.1.7 Truncation of TXOP

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.

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

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

A STA shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to zero at the end of the PPDU containing this frame. After receiving a CF-End frame with a matching BSSID, an AP may respond by transmitting a CF-End frame after SIFS.

NOTE—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 will be prevented from contending for the medium until the original NAV reservation expires.

Figure 9-18a 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) (using the terminology of Annex S). 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 send that fits within the TXOP; therefore, it truncates the TXOP by transmitting a CF-End frame.

STAs that receive the CF-End frame reset their NAV and can start contending for the medium without further delay.

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

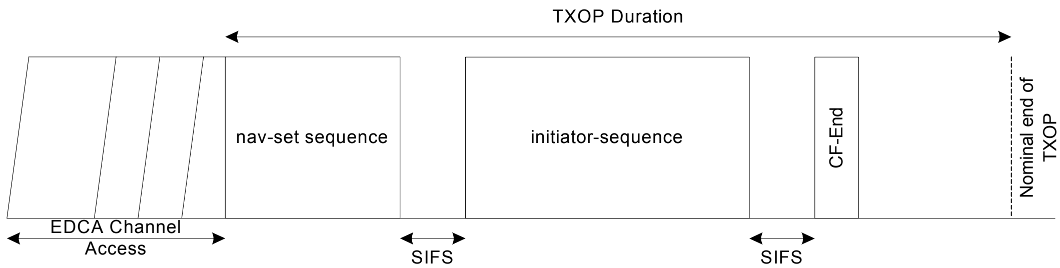


Figure 9-18a—Example of TXOP truncation

9.9.2 HCCA

9.9.2.1 HCCA procedure

9.9.2.1.3 Recovery from the absence of an expected reception

Change the second paragraph of 9.9.2.1.3 as follows:

~~If t~~The beginning of reception of an expected response~~, as~~ is detected by the occurrence of PHYCCA.indication(~~busy~~BUSY,channel-list) primitive at the STA that is expecting the~~ response,~~ response where

— The channel-list parameter is absent, or

— The channel-list is equal to {primary} and the HT STA expected to transmit the expected response supports 20 MHz operation only, or

— The channel-list is equal to either {primary} or {primary, secondary} and the HT STA expected to transmit the expected response supports both 20 MHz and 40 MHz operation (see 11.14.2).

If the beginning of such reception does not occur during the first slot time following SIFS, then[23]

a) If the transmitting STA is the HC, it may initiate recovery by transmitting at a PIFS after the end of the HC’s last transmission only if PHY-CCA.indication primitive is clear.

b) If the transmitting STA is a non-AP QoS STA, it shall initiate recovery by transmitting at a PIFS after the end of the last transmission, if PHY-CCA.indication primitive is clear, the polled TXOP limit is greater than 0, and at least one frame (re)transmissions can be completed within the remaining duration of a nonzero polled TXOP limit.

9.9.2.2 TXOP structure and timing

Change the second paragraph of 9.9.2.2 as follows:

A TXOP or transmission within a TXOP shall not extend across TBTT, dot11CFPMaxDuration (if during CFP), dot11MaxDwellTime (if using an FH PHY), or dot11CAPLimit. The HC shall ensure that the full duration of any granted TXOP meets these requirements so that non-AP STAs may use the time prior to the TXOP limit of a polled TXOP without checking for these constraints. Subject to these limitations, all decisions regarding what MSDUs, A-MSDUs, and/or MMPDUs are transmitted during any given TXOP are made by the STA that holds the TXOP.[25, 26]

9.9.2.3 HCCA transfer rules

Change the third paragraph of 9.9.2.3 as follows:

If a STA has set up at least one TS for which the Aggregation subfield in the associated TSPEC is set to 0, the AP shall use only QoS CF-Poll or QoS CF-Ack+CF-Poll frames to poll the STA and shall never use QoS (+)Data+CF-Poll to poll the STA. It should be noted that although QoS (+)CF-Poll is a data frame, but it should be transmitted at one of the rates in the BSSBasicRateSet parameter in order to set the NAV of all STAs that are not being polled (see 9.6). If a CF-Poll is piggybacked with a QoS data frame, then the frame containing all or part of an MSDU or A-MSDU may be transmitted at the rate that is below the negotiated minimum PHY rate.

9.10 Block Acknowledgment (Block Ack)

9.10.1 Introduction

Change the third paragraph of 9.10.1 as follows:

The Block Ack mechanism does not require the setting up of a TS; however, QoS STAs using the TS facility may choose to signal their intention to use Block Ack mechanism for the scheduler's consideration in assigning TXOPs. Acknowledgments of frames belonging to the same TID, but transmitted during multiple TXOPs, may also be combined into a single BlockAck frame. This mechanism allows the originator to have flexibility regarding the transmission of data MPDUs. The originator may split the block of frames across TXOPs, separate the data transfer and the Block Ack exchange, and interleave blocks of MPDUs carrying all or part of MSDUs or A-MSDUs for different TIDs or RAs.

Insert the following paragraph at the end of 9.10.1:

All operations on sequence numbers are performed modulo 2^{12}. Comparisons between sequence numbers are circular modulo 2^{12}, i.e., the sequence number space is considered divided into two parts, one of which is "old" and one of which is "new," by means of a boundary created by adding half the sequence number range to the current start of receive window (modulo 2^{12}).

9.10.2 Setup and modification of the Block Ack parameters

Change 9.10.2 as follows:

An originator~~STA~~ that intends to use the Block Ack mechanism for the transmission of QoS data frames to an intended recipient~~peer~~ should first check whether the intended ~~peer~~ recipient STA is capable of participating in Block Ack mechanism by discovering and examining its Delayed Block Ack and Immediate Block Ack capability bits. If the intended ~~peer~~ recipient STA is capable of participating, the originator sends an ADDBA Request frame indicating the TID for which the Block Ack is being set up. For an ADDBA set up between STAs where one is a non-HT STA, the ~~The~~ Block Ack Policy and Buffer Size fields in the ADDBA Request frame are advisory and may be changed by the recipient. The Buffer Size field in the ADDBA Request frame is advisory and may be changed by the recipient for an ADDBA set up between HT STAs.

The receiving STA shall respond by an ADDBA Response frame. The receiving STA, which is the intended ~~peer~~ recipient, has the option of accepting or rejecting the request. When the intended recipient ~~STA~~ accepts, then a Block Ack agreement exists between the originator and recipient.

When the intended recipient ~~STA~~ accepts, it indicates the type of Block Ack and the number of buffers that it shall allocate for the support of this ~~block~~Block Ack agreement within the ADDBA Response frame. Each Block Ack agreement that is established by a STA may have a different buffer allocation. If the receiving STA rejects the request, then the originator shall not use the Block Ack mechanism.

When the Block Ack Policy subfield value is set to 1 by the originator of an ADDBA Request frame between HT STAs, then the ADDBA Response frame accepting the ADDBA Request frame shall contain 1 in the Block Ack Policy subfield.

When a Block Ack agreement is established between two HT STAs, the originator may change the size of its transmission window if the value in the Buffer Size field of the ADDBA Response frame is larger than the value in the ADDBA Request frame. If the value in the Buffer Size field of the ADDBA Response frame is smaller than the value in the ADDBA Request frame, the originator shall change the size of its transmission window ($WinSize_O$) so that it is not greater than the value in the Buffer Size field of the ADDBA Response frame and is not greater than the value 64.

The A-MSDU Supported field indicates whether an A-MSDU may be sent under the particular Block Ack agreement. The originator sets this field to 1 to indicate that it might transmit A-MSDUs with this TID. The recipient sets this field to 1 to indicate that it is capable of receiving an A-MSDU with this TID.

NOTE—The recipient is free to respond with any setting of the A-MSDU supported field. If the value in the ADDBA Response frame is not acceptable to the originator, it can delete the Block Ack agreement and transmit data using normal acknowledgment.

If the Block Ack mechanism is being set up for a TS, bandwidth negotiation (using ADDTS Request and Response frames) should precede the setup of the Block Ack mechanism.

Once the Block Ack exchange has been set up, data and ACK frames are transferred using the procedure descibed in 9.10.3.

Change the heading for 9.10.3 as follows:

9.10.3 Data and acknowledgment transfer using immediate Block Ack policy and delayed Block Ack policy

Change the first paragraph of 9.10.3 as follows:

After setting up ~~for the~~ either an immediate Block Ack agreement or a Delayed Block agreement ~~exchange~~ following the procedure in 9.10.2, the originator may transmit a block of QoS data frames separated by SIFS period, with the total number of frames not exceeding the Buffer Size subfield value in the associated ADDBA Response frame. Each of the frames shall have the Ack Policy subfield in the QoS Control field set to Block Ack. The RA field of the frames shall be the recipient's *unicast* address. The originator requests acknowledgment of outstanding QoS data frames by sending a Basic BlockAckReq frame. The recipient shall maintain a Block Ack record for the block.

Change the first item in the dashed list after the second paragraph of 9.10.3 as follows:

— Separate the Block and Basic BlockAckReq frames into separate TXOPs

Change the sixth through ninth paragraphs of 9.10.3 as follows:

If the immediate Block Ack policy is used, the recipient shall respond to a Basic BlockAckReq frame with a Basic BlockAck frame. If the recipient sends the Basic BlockAck frame, the originator updates its own record and retries any frames that are not acknowledged in the Basic BlockAck frame, either in another block or individually.

If the delayed Block Ack policy is used, the recipient shall respond to a Basic BlockAckReq frame with an ACK frame. The recipient shall then send its Basic BlockAck ~~Block Ack~~ response in a subsequently obtained TXOP. Once the contents of the Basic BlockAck frame have been prepared, the recipient shall send this frame in the earliest possible TXOP using the highest priority AC. The originator shall respond with an ACK frame upon receipt of the Basic BlockAck frame. If delayed Block Ack policy is used and if the HC is the recipient, then the HC may respond with a +CF-Ack frame if the Basic BlockAckReq frame is the final frame of the polled TXOP's frame exchange. If delayed Block Ack policy is used and if the HC is the originator, then the HC may respond with a +CF-Ack frame if the Basic BlockAck frame is the final frame of the TXOP's frame exchange.

The Basic BlockAck frame contains acknowledgments for the MPDUs of up to 64 previous MSDUs. In the Basic BlockAck frame, the STA acknowledges only the MPDUs starting from the starting sequence control until the MPDU with the highest sequence number ~~(modulo 2^{12})~~ that has been received, and the STA shall set bits in the Block Ack bitmap corresponding to all other MPDUs to 0. The status of MPDUs that are considered "old" and prior to the sequence number range for which the receiver maintains status shall be reported as successfully received (i.e., the corresponding bit in the bitmap shall be set to 1). ~~The sequence number space is considered divided into two parts, one of which is "old" and one of which is "new" by means of a boundary created by adding half the sequence number range to the current start of receive window (modulo 2^{12}).~~ If the Basic BlockAck frame indicates that an MPDU was not received correctly, the originator shall retry that MPDU subject to that MPDU's appropriate lifetime limit.

A typical Block Ack ~~BlockAck~~ frame exchange sequence using the immediate Block Ack for a single TID is shown in Figure 9-22.

Replace Figure 9-22 with the following figure:

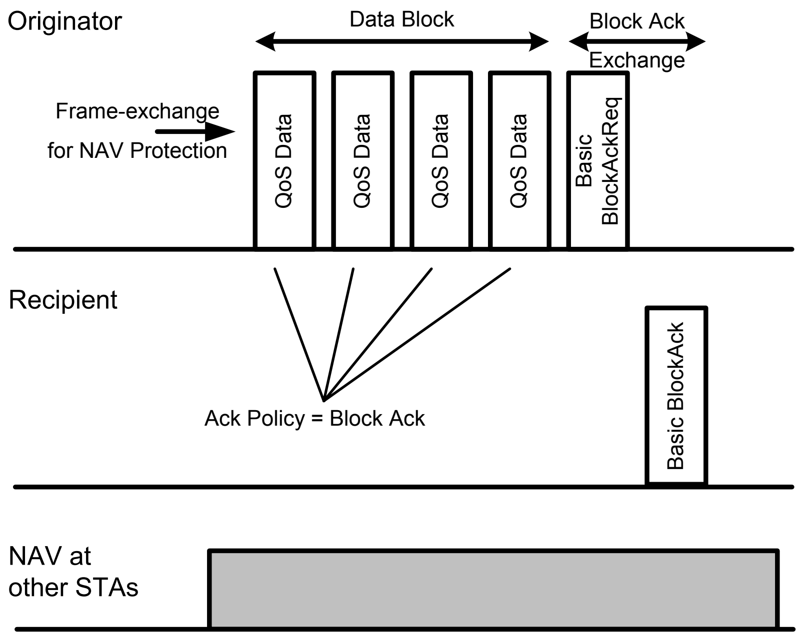


Figure 9-22—A typical Block Ack sequence when immediate policy is used

Replace Figure 9-23 with the following figure:

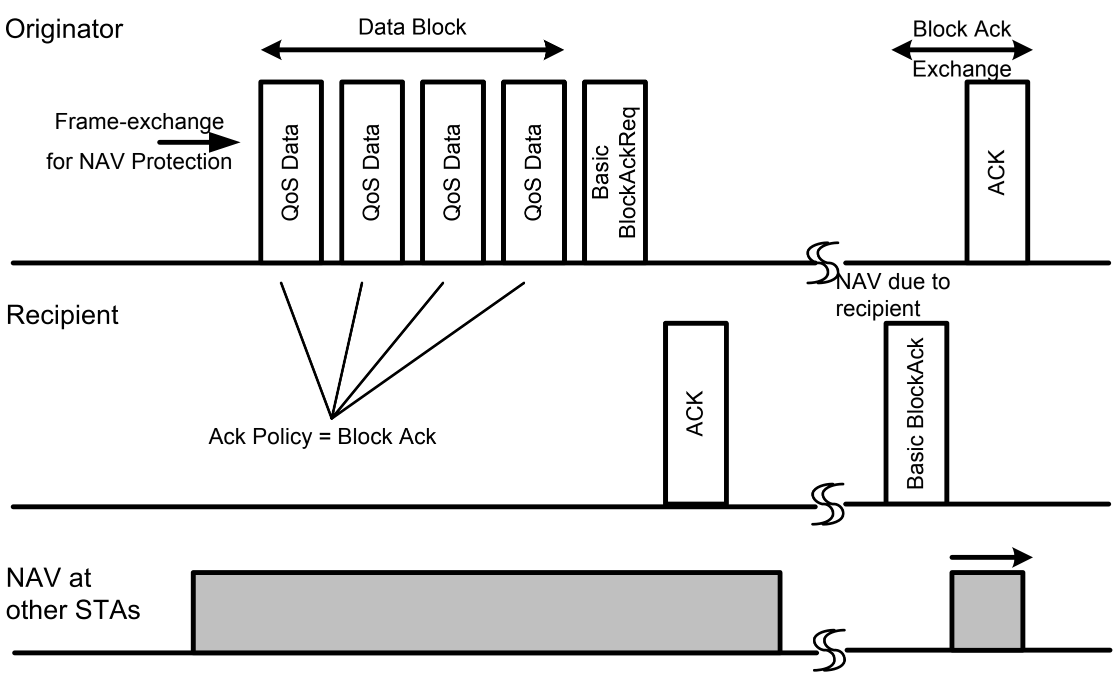


Figure 9-23—A typical BlockAck sequence when delayed policy is used

Change paragraphs 11 through 14 in 9.10.3 as follows:

The subsequent Basic BlockAckReq frame's ~~Block Ack request~~ starting sequence number shall be higher than or equal to the starting sequence number ~~(modulo 2^{12})~~ of the immediately preceding Basic BlockAckReq frame for the same TID.

The originator may continue to transmit MPDUs to the recipient after transmitting the Basic BlockAckReq frame, but before receiving the Basic BlockAck frame (applicable only to delayed Block Ack). The bitmap in the Basic BlockAck frame shall include the status of frames received between the start sequence number and the transmission of the Basic BlockAckReq frame. A recipient sending a delayed Basic BlockAck frame may update the bitmap with information on QoS data frames received between the receipt of the Basic BlockAckReq frame and the transmission of the Basic BlockAck frame.

If there is no response (i.e., neither a Basic BlockAck nor an ACK frame) to the Basic BlockAckReq frame, the originator may retransmit the Basic BlockAckReq frame within the current TXOP (if time permits) or within a subsequent TXOP. MSDUs that are sent using the Block Ack mechanism are not subject to retry limits but only to MSDU lifetime. The originator need not set the retry bit for any possible retransmissions of the MPDUs.

The Basic BlockAckReq frame shall be discarded if all MSDUs referenced by this Basic BlockAckReq frame have been discarded from the transmit buffer due to expiry of their lifetime limit.

Change the last paragraph of 9.10.3 as follows:

The frame exchange sequences are provided in ~~9.12~~Annex S.

9.10.4 Receive buffer operation

Change the third through sixth paragraphs of 9.10.4 as follows:

If a BlockAckReq frame is received, all complete MSDUs and A-MSDUs with lower sequence numbers than the starting sequence number contained in the BlockAckReq frame shall be ~~indicated to the MAC client using the MAUNIDATA. indication primitive.~~ passed up to the next MAC process as shown in Figure 6-1. Upon arrival of a BlockAckReq frame, the recipient shall ~~indicate~~ pass up the MSDUs and A-MSDUs starting with the starting sequence number sequentially until there is an incomplete MSDU or A-MSDU in the buffer.

If, after an MPDU is received, the receive buffer is full, the complete MSDU or A-MSDU with the earliest sequence number shall be ~~indicated to the MAC client using the MA-UNIDATA.indication primitive.~~ passed up to the next MAC process.

~~All comparisons of sequence numbers are performed circularly modulo 2^{12}.~~

The recipient shall ~~always indicate the reception of~~ pass MSDUs and A-MSDUs up to the next MAC process ~~to its MAC client~~ in order of increasing sequence number.

Insert the following subclauses (9.10.6 to 9.10.9) after 9.10.5:

9.10.6 Selection of BlockAck and BlockAckReq variants

The Compressed Bitmap subfield of the BA Control field or BAR Control field shall be set to 1 in all BlockAck and BlockAckReq frames sent from one HT STA to another HT STA and shall be set to 0 otherwise.

The Multi-TID subfield of the BA Control field shall be set to 1 in all BlockAck frames related to an HT-immediate agreement transmitted inside a PSMP sequence and shall be set to 0 otherwise. The Multi-TID subfield of the BAR Control field shall be set to 1 in all BlockAckReq frames related to an HT-immediate agreement transmitted inside a PSMP sequence and shall be set to 0 otherwise.

Where the terms BlockAck and BlockAckReq are used within 9.10.7 and 9.10.8, the appropriate variant according to this subclause (e.g., Compressed, Multi-TID) is referenced by the generic term.

9.10.7 HT-immediate Block Ack extensions

9.10.7.1 Introduction to HT-immediate Block Ack extensions

An HT extension to the Block Ack feature (defined in 9.10.1 through 9.10.5), called *HT-immediate Block Ack*, is defined in 9.10.7.2 through 9.10.7.9.

The HT-immediate extensions simplify immediate Block Ack use with A-MPDUs and reduce recipient resource requirements.

An HT STA shall support HT-immediate Block Ack in the role of recipient.

9.10.7.2 HT-immediate Block Ack architecture

The HT-immediate Block Ack rules are explained in terms of the architecture shown in Figure 9-24 and explained in this subclause.

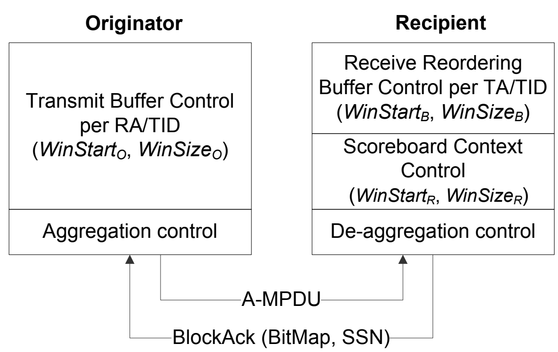


Figure 9-24—HT-immediate Block Ack architecture

The originator contains a transmit buffer control that uses $WinStart_O$ and $WinSize_O$ to submit MPDUs for transmission and releases transmit buffers upon receiving BlockAck frames from the recipient.

$WinStart_O$ is the starting sequence number of the transmit window, and $WinSize_O$ is the number of buffers negotiated in the Block Ack agreement.

The Aggregation control creates A-MPDUs. It may adjust the Ack Policy field of transmitted QoS data frames according to the rules defined in 9.10.7.7 in order to solicit BlockAck responses.

The recipient contains a receive reordering buffer control per TA/TID, which contains a related control state. The receive reordering buffer is responsible for reordering MSDUs or A-MSDUs so that MSDUs or A-MSDUs are eventually passed up to the next MAC process in order of received sequence number. It maintains its own state independent of the scoreboard context control to perform this reordering as specified in 9.10.7.6.

For each HT-immediate Block Ack agreement, the recipient chooses either full-state or partial-state operation (this choice is known only to the recipient). A STA may simultaneously use full-state operation for some agreements and partial-state operation for other agreements. The scoreboard context control stores an acknowledgment bitmap containing the current reception status of MSDUs or A-MSDUs for HT-immediate Block Ack agreements. Under full-state operation, status is maintained in statically assigned memory. Under partial-state operation, status is maintained in a cache memory; therefore, the status information is subject to cache replacement. This entity provides the bitmap and the value for the Starting Sequence Number subfield to be sent in BlockAck responses to the originator.

The deaggregation control entity separates frames contained in an A-MPDU.

Each received MPDU is analyzed by the scoreboard context control as well as by the receive reordering buffer control.

Each HT-immediate Block Ack agreement is uniquely identified by a tuple of Address 1, Address 2, and TID from the ADDBA Response frame that successfully established the HT-immediate Block Ack agreement. The STA that corresponds to Address 1 of the ADDBA Response frame is the originator. The STA that corresponds to Address 2 of the ADDBA Response frame is the recipient. Data MPDUs that contain the same values for Address 1, Address 2, and TID as a successful ADDBA Response frame are related with the HT-immediate Block Ack agreement that was established by the successful receipt of that ADDBA Response frame provided that the HT-immediate Block Ack agreement is still active.

9.10.7.3 Scoreboard context control during full-state operation

For each HT-immediate Block Ack agreement that uses full-state operation, a recipient shall maintain a block acknowledgment record as defined in 9.10.3. This record includes a bitmap, indexed by sequence number; a 12-bit unsigned integer starting sequence number, $WinStart_R$, representing the lowest sequence number position in the bitmap; a variable $WinEnd_R$; and the maximum transmission window size, $WinSize_R$, which is set to the smaller of 64 and the value of the Buffer Size field of the associated ADDBA Response frame that established the Block Ack agreement. $WinEnd_R$ is defined as the highest sequence number in the current transmission window. A STA implementing full-state operation for an HT-immediate Block Ack agreement shall maintain the block acknowledgment record for that agreement according to the following rules:

a) At HT-immediate Block Ack agreement establishment:
   1) $WinStart_R = SSN$ from the ADDBA Request frame that elicited the ADDBA Response frame that established the HT-immediate Block Ack agreement.
   2) $WinEnd_R = WinStart_R + WinSize_R - 1$.
b) For each received data MPDU that is related with a specific full-state operation HT-immediate Block Ack agreement, the block acknowledgment record for that agreement is modified as follows, where *SN* is the value of the Sequence Number subfield of the received data MPDU:
   1) If $WinStart_R \le SN \le WinEnd_R$, set to 1 the bit in position *SN* within the bitmap.
   2) If $WinEnd_R < SN < WinStart_R + 2^{11}$,
      i) Set to 0 the bits corresponding to MPDUs with Sequence Number subfield values from $WinEnd_R+1$ to $SN - 1$.
      ii) Set $WinStart_R = SN - WinSize_R + 1$.
      iii) Set $WinEnd_R = SN$.
      iv) Set to 1 the bit at position *SN* in the bitmap.
   3) If $WinStart_R + 2^{11} \le SN < WinStart_R$, make no changes to the record.

NOTE—A later-arriving data MPDU may validly contain a sequence number that is lower than an earlier-arriving one. This can happen because the transmitter may choose to send data MPDUs in a nonsequential sequence number order or because a previous data MPDU transmission with lower sequence number is not successful and is being retransmitted.

c) For each received BlockAckReq frame that is related with a specific full-state operation HT-immediate non-Protected Block Ack agreement, the block acknowledgment record for that agreement is modified as follows, where *SSN* is the value from the Starting Sequence Number subfield of the received BlockAckReq frame:

1) If $WinStart_R < SSN \leq WinEnd_R$,

i) Set $WinStart_R = SSN$.

ii) Set to 0 the bits corresponding to MPDUs with Sequence Number subfield values from $WinEnd_R + 1$ through $WinStart_R + WinSize_R - 1$.

iii) Set $WinEnd_R = WinStart_R + WinSize_R - 1$.

2) If $WinEnd_R < SSN < WinStart_R + 2^{11}$,

i) Set $WinStart_R = SSN$.

ii) Set $WinEnd_R = WinStart_R + WinSize_R - 1$.

iii) Set to 0 bits the corresponding to MPDU with Sequence Number subfield values from $WinStart_R$ to $WinEnd_R$.

3) If $WinStart_R + 2^{11} \leq SSN \leq WinStart_R$, make no changes to the record.

9.10.7.4 Scoreboard context control during partial-state operation

For an HT-immediate Block Ack agreement that uses partial-state operation, a recipient shall maintain a temporary block acknowledgment record as defined in 9.10.3. This temporary record includes a bitmap, indexed by sequence number; a 12-bit unsigned integer $WinStart_R$ (the lowest sequence number represented in the bitmap); a 12-bit unsigned integer $WinEnd_R$ (the highest sequence number in the bitmap); the originator address; TID; and the maximum transmission window size, $WinSize_R$, which is set to the smaller of 64 and the value of the Buffer Size field of the associated ADDBA Response frame that established the Block Ack agreement.

During partial-state operation of scoreboard context control, the recipient retains the current record for an HT-immediate Block Ack agreement at least as long as it receives data from the same originator. If a frame for an HT-immediate Block Ack agreement from a different originator is received, the temporary record may be discarded if the resources it uses are needed to store the temporary record corresponding to the newly arriving frame.

A STA implementing partial-state operation for an HT-immediate Block Ack agreement shall maintain the temporary block acknowledgment record for that agreement according to the following rules:

a) During partial-state operation, $WinStart_R$ is determined by the Sequence Number subfield value of received data MPDUs and by the Starting Sequence Number subfield value of received BlockAckReq frames as described below.

b) For each received data MPDU that is related with a specific partial-state operation HT-immediate Block Ack agreement, when no temporary record for the agreement related with the received data MPDU exists at the time of receipt of the data MPDU, a temporary block acknowledgment record is created as follows, where *SN* is the value of the Sequence Number subfield of the received data MPDU:

1) $WinEnd_R = SN$.

2) $WinStart_R = WinEnd_R - WinSize_R + 1$.

3) Create a bitmap of size $WinSize_R$, with the first bit corresponding to sequence number $WinStart_R$ and the last bit corresponding to sequence number $WinEnd_R$, and set all bits in the bitmap to 0.

4) Set to 1 the bit in the position in the bitmap that corresponds to *SN*.

c) For each received data MPDU that is related with a specific partial-state operation HT-immediate Block Ack agreement, when a temporary record for the agreement related with the received data MPDU exists at the time of receipt of the data MPDU, the temporary block acknowledgment record for that agreement is modified in the same manner as the acknowledgment record for a full-state agreement described in 9.10.7.3.

d) For each received BlockAckReq frame that is related with a specific partial-state operation HT-immediate non-Protected Block Ack agreement, when no temporary record for the agreement related with the received frame exists at the time of receipt of the frame, a temporary block acknowledgment record is created as follows, where *SSN* is the starting value of the Sequence Number subfield of the received BlockAckReq frame:

1) $WinStart_R = SSN$.

2) $WinEnd_R = WinStart_R + WinSize_R - 1$.

3) Create a bitmap of size $WinSize_R$, and set all bits in the bitmap to 0.

e) For each received BlockAckReq frame that is related with a specific partial-state operation HT-immediate non-Protected Block Ack agreement, when a temporary record for the agreement related with the received frame exists at the time of receipt of the frame, the temporary block acknowledgment record for that agreement is modified in the same manner as the acknowledgment record for a full-state agreement described in 9.10.7.3.

9.10.7.5 Generation and transmission of BlockAck by an HT STA

Except when operating within a PSMP exchange, a STA that receives a PPDU that contains a BlockAckReq in which the Address 1 field matches its MAC address during either full-state operation or partial-state operation shall transmit a PPDU containing a BlockAck frame that is separated on the air by a SIFS interval from the PPDU that elicited the BlockAck as a response. A STA that receives an A-MPDU that contains one or more MPDUs in which the Address 1 field matches its MAC address with the ACK Policy field set to Normal Ack (i.e., implicit Block Ack request) during either full-state operation or partial-state operation shall transmit a PPDU containing a BlockAck frame that is separated on the air by a SIFS interval from the PPDU that elicited the BlockAck as a response.

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with ACK Policy set to Normal Ack (i.e., implicit Block Ack request) during either full-state operation or partial-state operation, any adjustment to the value of $WinStart_R$ according to the procedures defined within 9.10.7.3 and 9.10.7.4 shall be performed before the generation and transmission of the response BlockAck frame. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield of the BlockAck frame shall be set to any value in the range from ($WinEnd_R$ – 63) to $WinStart_R$. The values in the recipient's record of status of MPDUs beginning with the MPDU for which the Sequence Number subfield value is equal to $WinStart_R$ and ending with the MPDU for which the Sequence Number subfield value is equal to $WinEnd_R$ shall be included in the bitmap of the BlockAck frame.

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with ACK Policy set to Normal Ack (i.e., implicit Block Ack request) during either full-state or partial-state operation, if the adjusted value of $WinStart_R$ is greater than the value of the starting sequence number of the BlockAck frame, within the bitmap of the BlockAck frame, the status of MPDUs with sequence numbers that are less than the adjusted value of $WinStart_R$ may be set to any value.

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with ACK Policy set to Normal Ack (i.e., implicit Block Ack request) during either full-state or partial-state operation, if the adjusted value of $WinEnd_R$ is less than the value of the starting sequence number of the BlockAck frame plus 63, within the bitmap of the BlockAck frame, the status of MPDUs with sequence numbers that are greater than the adjusted value of $WinEnd_R$ shall be reported as unsuccessfully received (i.e., the corresponding bit in the bitmap shall be set to 0).

If a BlockAckReq is received and no matching partial state is available, the recipient shall send a null BlockAck in which the bitmap is set to all zeros.

9.10.7.6 Receive reordering buffer control operation

9.10.7.6.1 General

The behavior described in this subclause, 9.10.7.6.2, and 9.10.7.6.3 applies to a STA that uses either partial-state operation or full-state operation for an HT-immediate Block Ack agreement.

A receive reordering buffer shall be maintained for each HT-immediate Block Ack agreement. Each receive reordering buffer includes a record comprising the following:

— Buffered MSDUs or A-MSDUs that have been received, but not yet passed up to the next MAC process
— A $WinStart_B$ parameter, indicating the value of the Sequence Number subfield of the first (in order of ascending sequence number) MSDU or A-MSDU that has not yet been received
— A $WinEnd_B$ parameter, indicating the highest sequence number expected to be received in the current reception window
— A $WinSize_B$ parameter, indicating the size of the reception window

$WinStart_B$ is initialized to the Starting Sequence Number subfield value of the ADDBA Request frame that elicited the ADDBA Response frame that established the HT-immediate Block Ack agreement.

$WinEnd_B$ is initialized to $WinStart_B + WinSize_B – 1$, where $WinSize_B$ is set to the smaller of 64 and the value of the Buffer Size field of the ADDBA Response frame that established the Block Ack agreement.

Any MSDU or A-MSDU that has been passed up to the next MAC process shall be deleted from the receive reordering buffer.

The recipient shall always pass MSDUs or A-MSDUs up to the next MAC process in order of increasing Sequence Number subfield value.

9.10.7.6.2 Operation for each received data MPDU

For each received data MPDU that is related to a specific HT-immediate Block Ack agreement, the receive reordering buffer record is modified as follows, where SN is the value of the Sequence Number subfield of the received MPDU:

a) If $WinStart_B \le SN \le WinEnd_B$,
   1) Store the received MPDU in the buffer.
   2) Pass MSDUs or A-MSDUs up to the next MAC process that are stored in the buffer in order of increasing value of the Sequence Number subfield starting with the MSDU or A-MSDU that has $SN = WinStart_B$ and proceeding sequentially until there is no buffered MSDU or A-MSDU for the next sequential value of the Sequence Number subfield.
   3) Set $WinStart_B$ to the value of the Sequence Number subfield of the last MSDU or A-MSDU that was passed up to the next MAC process plus one.
   4) Set $WinEnd_B = WinStart_B + WinSize_B – 1$.s

b) If $WinEnd_B < SN < WinStart_B + 2^{11}$,
   1) Store the received MPDU in the buffer.
   2) Set $WinEnd_B = SN$.
   3) Set $WinStart_B = WinEnd_B - WinSize_B + 1$.
   4) Pass any complete MSDUs or A-MSDUs stored in the buffer with Sequence Number subfield values that are lower than the new value of $WinStart_B$ up to the next MAC process in order of increasing Sequence Number subfield value. Gaps may exist in the Sequence Number subfield values of the MSDUs or A-MSDUs that are passed up to the next MAC process.
   5) Pass MSDUs or A-MSDUs stored in the buffer up to the next MAC process in order of increasing value of the Sequence Number subfield starting with $WinStart_B$ and proceeding sequentially until there is no buffered MSDU or A-MSDU for the next sequential Sequence Number subfield value.
   6) Set $WinStart_B$ to the Sequence Number subfield value of the last MSDU or A-MSDU that was passed up to the next MAC process plus one.
   7) Set $WinEnd_B = WinStart_B + WinSize_B - 1$.
c) If $WinStart_B + 2^{11} \le SN < WinStart_B$, discard the MPDU (do not store the MPDU in the buffer, and do not pass the MSDU or A-MSDU up to the next MAC process).

9.10.7.6.3 Operation for each received BlockAckReq

For each received BlockAckReq frame that is related with a specific HT-immediate Block Ack agreement, the receive reordering buffer record is modified as follows, where *SSN* is the Starting Sequence Number subfield value of the received BlockAckReq frame:

a) If $WinStart_B < SSN < WinStart_B + 2^{11}$,
   1) For a non-Protected Block Ack agreement, set $WinStart_B = SSN$. See 9.10.9 for a Protected Block Ack agreement.
   2) Set $WinEnd_B = WinStart_B + WinSize_B - 1$.
   3) Pass any complete MSDUs or A-MSDUs stored in the buffer with Sequence Number subfield values that are lower than the new value of $WinStart_B$ up to the next MAC process in order of increasing Sequence Number subfield value. Gaps may exist in the Sequence Number subfield values of the MSDUs or A-MSDUs that are passed up to the next MAC process.
   4) Pass MSDUs or A-MSDUs stored in the buffer up to the next MAC process in order of increasing Sequence Number subfield value starting with $SN = WinStart_B$ and proceeding sequentially until there is no buffered MSDU or A-MSDU for the next sequential Sequence Number subfield value.
   5) Set $WinStart_B$ to the Sequence Number subfield value of the last MSDU or A-MSDU that was passed up to the next MAC process plus one.
   6) Set $WinEnd_B = WinStart_B + WinSize_B - 1$.
b) If $WinStart_B + 2^{11} \le SSN < WinStart_B$, do not make any changes to the receive reordering buffer record.

9.10.7.7 Originator's behavior

A STA may send a block of data in a single A-MPDU where each data MPDU has its Ack Policy field set to Normal Ack. The originator expects to receive a BlockAck response immediately following the A-MPDU if at least one data frame is received without error.

Alternatively, the originator may send an A-MPDU where each data MPDU has its Ack Policy field set to Block Ack under an HT-immediate Block Ack agreement if it does not require a BlockAck response immediately following the A-MPDU.

If the BlockAck is lost, the originator may transmit a BlockAckReq to solicit an immediate BlockAck or it may retransmit the data frames.

A BlockAckReq sent using HT-delayed operation may be transmitted within an A-MPDU provided that its BAR Ack Policy subfield is set to No Acknowledgment.

The originator may transmit QoS data MPDUs with a TID matching an established Block Ack agreement in any order provided that their sequence numbers lie within the current transmission window. The originator may transmit an MPDU with a sequence number that is beyond the current transmission window ($SN > WinStart_O + WinSize_O - 1$), in which case the originator's transmission window (and the recipient's window) will be moved forward. The originator should not transmit MPDUs that are lower than (i.e., $SN < WinStart_O$) the current transmission window.

The originator shall not retransmit an MPDU after that MPDU's appropriate lifetime limit.

The originator may send a BlockAckReq for non-Protected Block Ack agreement or a Robust Management ADDBA frame for Protected Block Ack agreement when a data MPDU that was previously transmitted within an A-MPDU that had the Ack Policy field set to Normal Ack is discarded due to exhausted MSDU lifetime. The purpose of this BlockAckReq is to shift the recipient's $WinStart_B$ value past the hole in the sequence number space that is created by the discarded data MPDU and thereby to allow the earliest possible passing of buffered frames up to the next MAC process.

9.10.7.8 Maintaining BlockAck state at the originator

If an originator successfully receives a BlockAck in response to a BlockAckReq, the originator shall maintain BlockAck state as defined in 9.10.3.

If the originator receives a BlockAck in response to HT-immediate BlockAckReq, it shall, in addition,

— Not update the status of MPDUs with Sequence Number subfield values between $WinStart_O$ and *SSN* of the received BlockAck, and

NOTE—It is possible for the Starting Sequence Number subfield value (*SSN*) of the received BlockAck to be greater than $WinStart_O$ because of the failed reception of a nonzero number of MPDUs beginning with the MPDU with Sequence Number subfield value equal to $WinStart_O$ at a recipient that is using partial-state operation.

— Not update the status of MPDUs that have been already positively acknowledged.

NOTE—This second rule means that if an originator successfully delivered an MPDU and received the BlockAck in one TXOP and then receives a BlockAck in a later TXOP in which the MPDU is not indicated as successfully received (because the partial state has been reset), the originator knows not to retry the MPDU.

9.10.7.9 Originator's support of recipient's partial state

A recipient may choose to employ either full-state operation or partial-state operation for each individual Block Ack agreement. An originator is unaware of the recipient's choice of full-state or partial-state operation.

NOTE—The originator can solicit a BlockAck as the last activity associated with that Block Ack agreement in the current TXOP to reduce the probability that data are unnecessarily retransmitted due to loss of partial state.

9.10.8 HT-delayed Block Ack extensions

9.10.8.1 Introduction

Subclauses 9.10.8.2 and 9.10.8.3 define an HT extension to the Block Ack feature to support operation on delayed Block Ack agreements established between HT STAs. Other than the exceptions noted in 9.10.8.1 through 9.10.8.3, the operation of HT Delayed Block Ack is the same as is described in 9.10.7.

The HT-delayed extensions simplify the use of delayed Block Ack in an A-MPDU and reduce resource requirements.

9.10.8.2 HT-delayed Block Ack negotiation

HT-delayed Block Ack is an optional feature. An HT STA declares support for HT-delayed Block Ack in the HT Capabilities element.

An HT STA shall not attempt to create a BlockAck agreement under HT-delayed Block Ack Policy unless the recipient HT STA declares support for this feature.

9.10.8.3 Operation of HT-delayed Block Ack

The BlockAck response to an HT-delayed BlockAckReq is transmitted after an unspecified delay and when the recipient of the BlockAckReq next has the opportunity to transmit. This response may be transmitted in a later TXOP owned by the recipient of the BlockAckReq or in the current or a later TXOP owned by the sender of the BlockAckReq using the RD feature (see 9.15).

The No Ack feature of the BlockAckReq and BlockAck frame may be used under an HT-delayed Block Ack agreement.

A BlockAckReq or BlockAck frame containing a BAR Ack Policy or BA Ack Policy subfield set to 1 indicates that no acknowledgment is expected to these control frames. Otherwise, an Ack MPDU response is expected after a SIFS.

Setting of the BAR Ack Policy and BA Ack Policy subfields may be performed independently for BlockAckReq and BlockAck frames associated with the same HT-delayed Block Ack agreement. All four combinations of the values of these fields are valid.

Setting of the BAR Ack Policy and BA Ack Policy subfields is dynamic and can change from PPDU to PPDU.

9.10.9 Protected Block Ack Agreement

A STA indicates support for Protected Block Ack by setting the MFPC, MFPR, and PBAC RSN Capabilities subfields to 1. Such a STA is a PBAC STA; otherwise, the STA is a non-PBAC STA. A Block Ack agreement that is successfully negotiated between two PBAC STAs is a Protected Block Ack agreement. A Block Ack agreement that is successfully negotiated between two STAs when either or both of the STAs is not a PBAC STA is a non-Protected Block Ack agreement.

A PBAC STA may choose to negotiate a Block Ack agreement with a non-PBAC STA if dot11RSNAPBACRequired is set to 0; otherwise, it shall negotiate a Block Ack agreement only with other PBAC STAs. If a PBAC STA is communicating with a non-PBAC STA, it shall follow the rules for an non-Protected Block Ack agreement.

A STA that has successfully negotiated a Protected Block Ack agreement shall obey the following rule as a Block Ack originator in addition to rules specified in 9.10.7.7 and 9.10.7.8:

— To change the value of $WinStart_B$ at the receiver, the STA shall use a Robust Management ADDBA Request action frame.

A STA that has successfully negotiated a Protected Block Ack agreement shall obey the following rules as a Block Ack recipient in addition to rules specified in 9.10.7.3 to 9.10.7.6:

— The recipient STA shall respond to a BlockAckReq from a PBAC enabled originator with an immediate BlockAck. The Block Ack Starting Sequence Control subfield value shall be ignored for the purposes of updating the value of $WinStart_B$. The Block Ack Starting Sequence Control subfield value may be utilized for the purposes of updating the value of $WinStart_R$. If the Block Ack Starting Sequence Control subfield value is greater than $WinEnd_B$ or less than $WinStart_B$, dot11PBACErrors shall be incremented by 1.

— Upon receipt of a valid Robust Management ADDBA Request action frame for an established Protected Block Ack agreement whose TID and transmitter address are the same as those of the Block Ack agreement, the STA shall update its $WinStart_R$ and $WinStart_B$ values based on the starting sequence number in the Robust Management ADDBA Request frame according to the procedures outlined for reception of BlockAckReq frames in 9.10.7.3, 9.10.7.4, 9.10.7.6.1, and 9.10.7.6.3, while treating the starting sequence number as though it were the *SSN* of a received BlockAckReq frame. Values in other fields of the ADDBA frame shall be ignored.

Delete 9.12 (including Table 9-6). However, do not change the numbering on the subsequent subclauses. For a description of frame exchange sequences, see Annex S.

~~9.12 Frame exchange sequences~~

~~The allowable frame ... cf-ack-piggybacked-qos-poll-sequence)) ;~~

~~Table 9-6—Attributes ... definition~~

Change the heading of 9.13 as follows:

9.13 Protection mechanism<u>s</u>~~ for non-ERP receivers~~

Insert the following subclause (9.13.1) immediately following the heading for 9.13:

9.13.1 Introduction

These protection mechanisms ensure that a STA that is a potential interferer defers any transmission for a known period of time. These mechanisms are used to ensure that non-ERP STAs do not interfere with frame exchanges using ERP PPDUs between ERP STAs and that non-HT STAs do not interfere with frame exchanges using HT PPDUs between HT STAs. As a result, non-ERP and/or non-HT STAs are allowed to coexist with ERP and/or HT STAs.

Insert the following heading (9.13.2) immediately after the new 9.13.1 and before the paragraph starting "The intent of a protection mechanism...":

9.13.2 Protection mechanism for non-ERP receivers

Insert the following subclauses (9.13.3 through 9.13.5.4, including Table 9-7, Table 9-8, Figure 9-25, and Figure 9-26) after the new 9.13.2 :

9.13.3 Protection mechanisms for transmissions of HT PPDUs

9.13.3.1 General

Transmissions of HT PPDUs, referred to as *HT transmissions*, are protected if there are other STAs present that cannot interpret HT transmissions correctly. The HT Protection and Nongreenfield HT STAs Present fields in the HT Operation element within Beacon and Probe Response frames are used to indicate the protection requirements for HT transmissions.

The HT Protection field may be set to no protection mode only if the following are true:

- All STAs detected (by any means) in the primary or the secondary channel are HT STAs, and
- All STAs that are known by the transmitting STA to be a member of this BSS are either
  - 20/40 MHz HT STAs in a 20/40 MHz BSS, or
  - 20 MHz HT STAs in a 20 MHz BSS.

The HT Protection field may be set to nonmember protection mode only if the following are true:

- A non-HT STA is detected (by any means) in either the primary or the secondary channel or in both the primary and secondary channels, that is not known by the transmitting STA to be a member of this BSS, and
- All STAs that are known by the transmitting STA to be a member of this BSS are HT STAs.

The HT Protection field may be set to 20 MHz protection mode only if the following are true:

- All STAs detected (by any means) in the primary channel and all STAs detected (by any means) in the secondary channel are HT STAs and all STAs that are members of this BSS are HT STAs, and
- This BSS is a 20/40 MHz BSS, and
- There is at least one 20 MHz HT STA associated with this BSS.

The HT Protection field is set to non-HT mixed mode otherwise.

NOTE—The rules stated above allow an HT AP to select non-HT mixed mode at any time.

In an IBSS, the HT Protection field is reserved, but an HT STA shall protect HT transmissions as though the HT Protection field were set to non-HT mixed mode. A STA that is a member of an IBSS shall protect HT-greenfield format PPDUs and RIFS sequences, adhering to the same requirements as described in the line of Table 9-7 labeled “Use_Protection = 0 or ERP information element is not present (HT Protection field set to non-HT mixed mode).”

In an IBSS, the RIFS Mode field of the HT Operation element is also reserved, but an HT STA shall operate as though this field were set to 1.

During the 40 MHz phase of PCO operation, a PCO active STA may act as though the HT Protection field were set to no protection mode, regardless of the actual value of the HT Protection field transmitted by the AP.

When the HT Protection field is set to no protection mode or 20 MHz protection mode and the Nongreenfield HT STAs Present field is set to 0, no protection is required since all HT STAs in the BSS are capable of decoding HT-mixed format and HT-greenfield format transmissions.

When the HT Protection field is set to no protection mode or 20 MHz protection mode and the Nongreenfield HT STAs Present field is set to 1, HT transmissions that use the HT-greenfield format shall be protected. This protection may be established by transmitting a PPDU with the TXVECTOR FORMAT parameter set to HT_MF or any of the methods described in Table 9-8.

When the HT Protection field is set to nonmember protection mode and the Use_Protection field in the ERP Information element is set to 0, HT transmissions should be protected. When the HT Protection field is set to nonmember protection mode, the Use_Protection field in the ERP Information element is set to 0, and the Nongreenfield HT STAs Present field is set to 1, HT transmissions using HT-greenfield format shall be protected. When the HT Protection field is set to nonmember protection mode and the Use_Protection field in the ERP Information element is set to 1, HT transmissions shall be protected according to the requirements described in Table 9-7.

When the HT Protection field is set to non-HT mixed mode, HT transmissions shall be protected. The type of protection required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. Protection requirements that apply when the HT Protection field is set to non-HT mixed mode are described in Table 9-7.

Table 9-7—Protection requirements for HT Protection field values nonmember protection mode and non-HT mixed mode

Condition	Requirements
Use_Protection = 0 or ERP information element is not present (HT Protection field set to non-HT mixed mode)	The protection requirements for HT transmissions using HT-greenfield format are specified in 9.13.3.1. The protection requirements for HT transmissions using RIFS within the HT transmission burst are specified in 9.13.3.3. The protection mechanism for other transmissions not already described above is based on one of the sequences defined in Table 9-8.
Use_Protection = 1 (HT Protection field set to nonmember protection mode or non-HT mixed mode)	All HT transmissions shall be protected using mechanisms as described in 9.13.2. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and the Use_Protection field within the ERP Information element is set to 0 or the ERP Information element is not present in the Beacon, HT transmissions shall be protected using one of the mechanisms identified in Table 9-8.

NOTE—Rules for rate selection for the HT protection mechanisms listed in Table 9-8 are described in 9.6.

If the HT Protection field is set to no protection mode and the Secondary Channel Offset field is set to SCA or SCB, a STA may transmit a 40 MHz HT PPDU (TXVECTOR parameter CH_BANDWIDTH set to HT_CBW40) to initiate a TXOP provided that the restrictions specified in 9.6 are obeyed. When the HT Protection field is not set to no protection mode or the Secondary Channel Offset field is set to SCN, a STA shall not transmit a 40 MHz HT PPDU (TXVECTOR parameter CH_BANDWIDTH set to HT_CBW40) to initiate a TXOP.

Table 9-8—Applicable HT protection mechanisms

HT protection mechanism
Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions: a) 20 MHz transmissions use the rates defined in Clause 17 or Clause 19 b) 40 MHz transmissions use non-HT duplicate frames defined in Clause 20.
Transmit an initial frame within a non-HT PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain PPDUs using HT-greenfield format and/or separated by RIFS.
L-SIG TXOP protection
Using a PPDU with the TXVECTOR FORMAT parameter set to HT_MF, transmit first a PPDU that requires a response that is sent using a non-HT PPDU. The remaining TXOP following the first PPDU exchange may contain HT-greenfield format and/or RIFS sequences.

9.13.3.2 Protection rules for HT STA operating a direct link

An HT STA operating a direct link with another HT STA in a non-HT BSS shall operate according to the rules found in 9.13 as though the following fields have the settings indicated:

a) The RIFS Mode field of the HT Operation element set to 1
b) The HT Protection field set to non-HT mixed mode
c) The Nongreenfield HT STAs Present field set to 1
d) The OBSS Non-HT STAs Present field set to 1
e) The L-SIG TXOP Full Support field set to 0
f) The PCO Active field set to 0
g) The Basic MCS Set field set to all zeros

9.13.3.3 RIFS protection

If the HT Protection field is set to nonmember protection mode or non-HT mixed mode, the AP may set the RIFS Mode field to 0 according to implementation-specific criteria (i.e., such as to protect overlapping non-HT BSSs in the primary or secondary channels).

If the HT Protection field is not set to nonmember protection mode and it is not set to non-HT mixed mode, the RIFS Mode field shall be set to 1.

If the RIFS Mode field of an AP’s HT Operation element is set to 1,

a) A STA that is associated with the AP may protect RIFS sequences when the HT Protection field of the HT Operation element transmitted by the AP is set to nonmember protection mode.
b) A STA that is associated with the AP shall protect RIFS sequences when the HT Protection field of the HT Operation element transmitted by the AP is set to non-HT mixed mode.

A STA shall not transmit PPDUs separated by a RIFS unless the RIFS Mode field of the HT Operation element is set to 1.

9.13.3.4 Use of OBSS Non-HT STAs Present field

The OBSS Non-HT STAs Present field allows HT APs to report the presence of non-HT STAs that are not members of its BSS in the primary channel, the secondary channel, or in both primary and secondary channels.

A second HT AP that detects a first HT AP's Beacon frame with the OBSS Non-HT STAs Present field set to 1 may cause HT-greenfield format and RIFS sequence transmissions of the second AP's BSS to be protected by setting the HT Protection field of its HT Operation element to non-HT mixed mode. If the NonERP_Present field is set to 1 in the first AP's Beacon frame, the Use_Protection field may also be set to 1 by the second AP.

An HT STA may also scan for the presence of non-HT devices either autonomously or, for example, after the STA's AP transmits an HT Operation element with the HT Protection field set to nonmember protection mode. Non-HT devices can be detected as follows:

- Reception of a management frame that does not carry an HT Capabilities element and the frame is required to carry this element when transmitted by an HT STA, or
- Reception of a Beacon containing an HT Operation element with the OBSS Non-HT STAs Present field set to 1.

When non-HT devices are detected, the STA may enable protection of its HT-greenfield format and RIFS sequence transmissions.

NOTE—If a non-HT device is detected and the STA determines that its HT-greenfield format or RIFS sequence transmissions are affecting the operation of the non-HT device, then the STA can enable protection of its HT-greenfield format and RIFS sequence transmissions.

See also 11.9.7.3, which defines rules for the OBSS Non-HT STAs Present field related to HT-greenfield transmissions in certain regulatory classes.

9.13.4 L_LENGTH and L_DATARATE parameter values for HT-mixed format PPDUs

L_LENGTH and L_DATARATE determine the duration that non-HT STAs will not transmit, equal to the remaining duration of the HT PPDU or the L-SIG duration when L-SIG TXOP protection is used as defined in 9.13.5, following the non-HT portion of the preamble of the HT-mixed format PPDU.

The L_DATARATE parameter of the TXVECTOR shall be set to the value 6 Mb/s.

A STA that is transmitting a PPDU with the FORMAT parameter of the TXVECTOR set to HT_MF and that is not operating by the L-SIG TXOP protection rules described in 9.13.5 shall set the value of the L_LENGTH parameter to the value (in octets) given by Equation (9-1) :

$$\mathrm{L\_LENGTH} = \left\lceil \frac{((\mathrm{TXTIME} - \mathrm{Signal\ Extension}) - (\mathrm{aPreambleLength} + \mathrm{aPLCPHeaderLength}))}{\mathrm{aSymbolLength}} \right\rceil \times N_{OPS} - \left\lceil \frac{\mathrm{aPLCPServiceLength} + \mathrm{aPLCPConvolutionalTailLength}}{8} \right\rceil \quad (9\text{-}1)$$

where

$\lceil x \rceil$	denotes the smallest integer greater than or equal to x
TXTIME	is the duration (in microseconds) of the HT PPDU defined in 10.4.6
Signal Extension	is 0 μs when TXVECTOR parameter NO_SIG_EXTN is TRUE and is the duration of signal extension as defined by aSignalExtension in Table 20-4 of 20.4.4 when TXVECTOR parameter NO_SIG_EXTN is FALSE
aSymbolLength	is the duration of a symbol (in microseconds), defined in 10.4.3
(aPreambleLength + aPLCPHeaderLength)	is the duration (in microseconds) of the non-HT PLCP preamble and L-SIG, defined in 10.4.3

N_{OPS} is the number of octets transmitted during a period of aSymbolLength at the rate specified by L_DATARATE

aPLCPServiceLength is the number of bits in the PLCP SERVICE field, defined in 10.4.3 (PLME-CHARACTERISTICS.confirm)

aPLCPConvolutionalTailLength is the number of bits in the convolutional code tail bit sequence, defined in 10.4.3

NOTE 1—The last term of the L_LENGTH definition corrects for the fact that non-HT STAs add the length of the SERVICE field and tail bits (assuming a single convolutional encoder) to the value communicated by the L_LENGTH field.

NOTE 2—For a Clause 20 PHY, this equation simplifies to $\mathrm{L\_LENGTH} = \left\lceil \frac{((\mathrm{TXTIME} - \mathrm{Signal\ Extension}) - 20)}{4} \right\rceil \times 3 - 3$.

A STA that is operating under L-SIG TXOP protection shall set the L_LENGTH parameter according to rules described in 9.13.5.

A STA shall not transmit a PPDU with the FORMAT parameter set to HT_MF in TXVECTOR if the corresponding L_LENGTH value calculated with Equation (9-1) exceeds 4095 octets.

NOTE—The transmission of frames with L_LENGTH above 2340 octets can be accompanied by a protection mechanism (e.g., RTS/CTS or CTS-to-self protection) if it is determined that the use of L_LENGTH fails to effectively suppress non-HT transmissions. How this is determined is outside the scope of this standard.

9.13.5 L-SIG TXOP protection

9.13.5.1 General rules

Figure 9-25 illustrates the basic concept of L-SIG TXOP protection. The terms used in this figure are defined below and in 20.3.2.

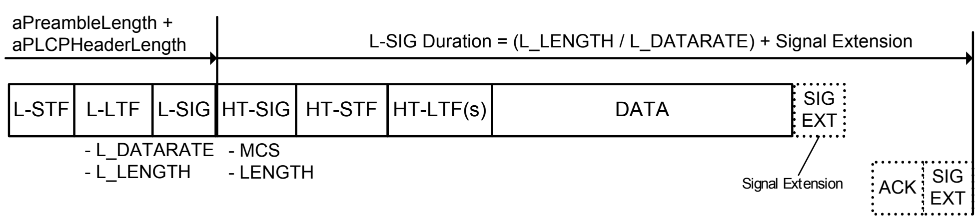


Figure 9-25—Basic concept of L-SIG TXOP protection

The AP determines whether all HT STAs associated with its BSS support L-SIG TXOP protection and indicates this determination in the L-SIG TXOP Protection Full Support field of its HT Operation element. This field shall not be set to 1 unless the L-SIG TXOP Protection field is set to 1 by all HT STAs in the BSS.

Support for L-SIG TXOP protection at an intended recipient can be determined through examination of its HT Capability element.

In an IBSS, the L-SIG TXOP Protection Full Support field of the HT Operation element is reserved, but HT STAs shall operate as though the field were set to 0.

A STA shall not transmit a frame using L-SIG TXOP protection directed to a recipient that does not support L-SIG TXOP protection.

A STA that transmits an L-SIG TXOP Protected frame should use an MCS from the BasicMCSSet for the transmission of that frame if

— The frame initiates a TXOP in an IBSS, or

— The L-SIG TXOP Protection Full Support field is set to 0 by its AP.

Under L-SIG TXOP protection operation, the L-SIG field with an HT-mixed format PHY preamble represents a duration value equivalent (except in the case of the initial frame that establishes the TXOP, as described below) to the sum of

a) The value of Duration/ID field contained in the MAC header and

b) The duration remaining in the current packet after the L-SIG, which is equal to the duration of the current packet less (aPreambleLength + aPLCPHeaderLength)

A duration value determined from the L_DATARATE and L_LENGTH parameters of the TXVECTOR or RXVECTOR rounded up to a multiple of aSymbolLength that is not equal to the remaining duration of the frame is called an *L-SIG duration*. The TXVECTOR L_LENGTH (defined in 20.2.2), when L-SIG TXOP protection is used, shall contain the value (in octets) given by Equation (9-2).

$$\mathrm{L\_LENGTH} = \left\lceil \frac{\text{L-SIG Duration} - \text{Signal Extension}}{\text{aSymbolLength}} \right\rceil \times N_{OPS} - \left\lceil \frac{\text{aPLCPServiceLength} + \text{aPLCPConvolutionalTailLength}}{8} \right\rceil \quad (9\text{-}2)$$

where

$\lceil x \rceil$	denotes the lowest integer greater than or equal to x
Signal Extension	is defined in 9.13.4
aSymbolLength	is the duration of symbol, defined in 10.4.3
N_{OPS}	is the number of octets transmitted during a period of aSymbolLength at the rate specified by L_DATARATE
aPLCPServiceLength	is the number of bits in the PLCP SERVICE field, defined in 10.4.3 (PLME-CHARACTERISTICS.confirm)
aPLCPConvolutionalTailLength	is the number of bits in the convolutional code tail bit sequence, defined in 10.4.3 (PLME-CHARACTERISTICS.confirm)
durations	are expressed in microseconds

NOTE—For a Clause 20 PHY, this equation simplifies to $\mathrm{L\_LENGTH} = \left\lceil \frac{(\text{L-SIG Duration} - \text{Signal Extension})}{4} \right\rceil \times 3 - 3$.

Non-HT STAs are not able to receive any PPDUs that start during the L-SIG duration. Therefore, no frame shall be transmitted to a non-HT STA during an L-SIG protected TXOP.

See also 9.2.5.4, which describes a rule for resetting a NAV value that was set by an L-SIG TXOP protected frame.

9.13.5.2 L-SIG TXOP protection rules at the TXOP holder

Figure 9-26 illustrates an example of how L-SIG durations are set when using L-SIG TXOP protection.

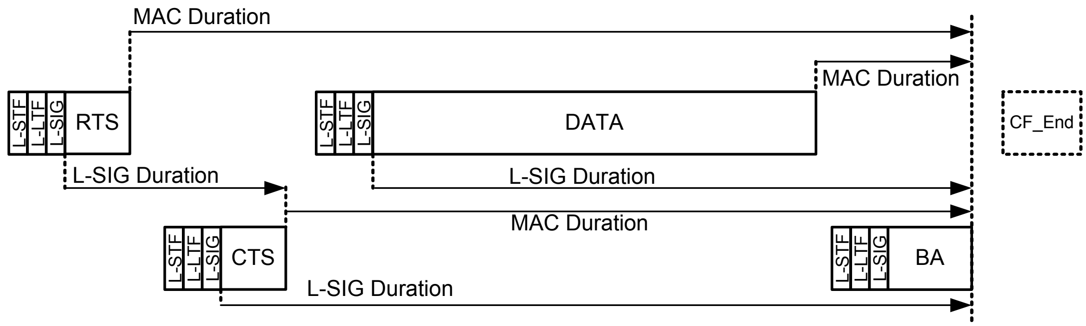


Figure 9-26—Example of L-SIG duration setting

An L-SIG TXOP protected sequence shall start with one of the following:

— an initial handshake, which is the exchange of two frames (each inside an HT-mixed format PPDU) that establish protection (e.g., RTS/CTS) or
— an initial frame that establishes protection but generates no response (e.g., a CTS to self)

provided that this initial sequence is also valid for the start of a TXOP. The term *L-SIG TXOP protected sequence* includes these initial frames and any subsequent frames transmitted within the protected duration.

Under L-SIG TXOP protection operation, when the initial PPDU that establishes protection requires a response, the L-SIG duration of the initial PPDU shall be as follows:

$$\text{L-SIG Duration} = (T_{Init\_PPDU} - (\text{aPreambleLength} + \text{aPLCPHeaderLength})) + \text{SIFS} + T_{Res\_PPDU}$$

where

T_{Init_PPDU} is the length in time (in microseconds) of the entire initial PPDU

T_{Res_PPDU} is the length in time (in microseconds) of the expected response PPDU

$(\text{aPreambleLength} + \text{aPLCPHeaderLength})$ is the length in time (in microseconds) of the non-HT PCLP header, defined in 10.4.3 (PLME-CHARACTERISTICS.confirm)

When the initial PPDU that establishes protection requires no response, the L-SIG duration shall contain the following value:

$$\text{L-SIG Duration} = (T_{Init\_MACDur} + T_{Init\_PPDU} - (\text{aPreambleLength} + \text{aPLCPHeaderLength}))$$

where

T_{Init_MACDur} is the Duration/ID field value carried in the MAC header of the initial PPDU

An HT STA using L-SIG TXOP protection should use an accurate prediction of the TXOP duration inside the Duration/ID field of the MAC header to avoid inefficient use of the channel capability.

The L-SIG duration of the initial frame shall allow for the longest possible duration of the response frame (i.e., taking into account wrapped +HTC in the case of control response frames). If the actual duration of the response frame is less than this allowed duration, the TXOP holder shall delay transmission of the third PPDU in the L-SIG TXOP protected sequence until a SIFS after this L-SIG duration expires.

NOTE—This step ensures that a non-HT STA sees a SIFS interval between the end of the first PPDU and the start of the third PPDU.

If the initial frame handshake succeeds (i.e., upon reception of a response frame with L-SIG TXOP protection addressed to the TXOP holder), all HT-mixed format PPDUs transmitted inside an L-SIG TXOP protection protected TXOP shall contain an L-SIG duration that extends to the endpoint indicated by the MAC Duration/ID field. The first PPDU transmitted after a successful initial handshake (i.e., upon reception of a response frame with L-SIG TXOP protection addressed to the TXOP holder) shall have the TXVECTOR FORMAT parameter set to HT_MF.

NOTE—The requirement to use HT_MF for the third PPDU arises as follows. A third-party STA receives the first PPDU, but cannot receive any MPDU correctly from it. It sets its NAV based on the L-SIG duration. The STA does not receive the second PPDU. It is necessary for the STA to be able to determine either an L-SIG duration or MAC duration value from the third PPDU in order to protect the remaining time in the TXOP. The ability of the STA to make this determination is enabled by sending the third PPDU using HT-mixed format, containing an L-SIG duration as shown in Figure 9-26.

The TXOP holder should transmit a CF_End frame starting a SIFS after the L-SIG TXOP protected period. This step enables STAs to terminate the EIFS procedure to avoid potential unfairness or a capture effect.

NOTE—This case is not an instance of TXOP truncation, because it is not transmitted to reset the NAV.

9.13.5.3 L-SIG TXOP protection rules at the TXOP responder

On receiving a PPDU containing an L-SIG duration addressed to itself, a TXOP responder that set the L-SIG TXOP Protection Support field to 1 on association shall generate an L-SIG TXOP protection response frame with the L-SIG duration equivalent to the following:

$$\text{L-SIG Duration} = (T_{MACDur} - \text{SIFS} - (\text{aPreambleLength} + \text{aPLCPHeaderLength}))$$

where

T_{MACDur} is the Duration/ID field value carried in the MAC header of frame(s) received in the PPDU that generated the response

A STA shall not transmit a response frame containing an L-SIG duration unless it is in response to a frame that also contained an L-SIG duration.

9.13.5.4 L-SIG TXOP protection NAV update rule

An HT STA that set the L-SIG TXOP Protection Support field to 1 on association that receives a PHY-RXSTART.indication with RXVECTOR parameter FORMAT set to HT_MF and LSIGVALID set to TRUE and that receives no valid MPDU from which a Duration/ID field value can be determined shall, when the PHY-RXEND.indication is received, update its NAV to a value equal to the following:

$$\text{L-SIG duration} - (\text{TXTIME} - (\text{aPreambleLength} + \text{aPLCPHeaderLength}))$$

where

TXTIME is the time required to send the entire PPDU

Insert the following subclauses (9.15 through 9.21.4, including Table 9-9 through Table 9-12 and Figure 9-27 through Figure 9-37) after 9.14.2:

9.15 Reverse Direction Protocol

9.15.1 Reverse direction (RD) exchange sequence

An RD exchange sequence comprises the following:

a) The transmission of a PPDU by a TXOP holder containing an RD grant (the *RDG PPDU*), which is indicated by the PPDU containing one or more +HTC MPDUs in which the RDG/More PPDU subfield is set to 1. The STA that transmits this PPDU is known as the *RD initiator*. The rules for an RD initiator apply only during a single RD exchange sequence, i.e., after the transmission of an RDG PPDU and up to the end of the last PPDU in the RD exchange sequence.

b) The transmission of one or more PPDUs (the *RD response burst*) by the STA addressed in the MPDUs of the RDG PPDU. The first (or only) PPDU of the RD response burst contains at most one immediate BlockAck or ACK response frame. The last (or only) PPDU of the RD response burst contains any MPDUs requiring an immediate BlockAck or ACK response. The STA that transmits the RD response burst is known as the *RD responder*. The rules for an RD responder apply only during a single RD exchange sequence, i.e., following the reception of an RDG PPDU and up to the transmission of a PPDU by the RD responder in which the RDG/More PPDU subfield is set to 0.

c) The transmission of a PPDU by the RD initiator containing an immediate BlockAck or ACK MPDU (the *RD initiator final PPDU*), if so required by the last PPDU of the RD response burst.

NOTE—An RD initiator can include multiple RD exchange sequences within a single TXOP. Each RD exchange sequence within a single TXOP can be addressed to a different receipient, and any single recipient can be given more than one RDG within a single TXOP.

An example of an RD exchange sequence is given in T.3.

9.15.2 Support for RD

Support of the RD feature is an option for an HT STA. It is optional in the sense that a TXOP holder is never required to generate an RDG, and a STA receiving an RDG is never required to use the grant.

Support of the RD feature as an RD responder is indicated using the RD Responder subfield of the HT Extended Capabilities field of the HT Capabilities element. A STA shall set the RD Responder subfield to 1 in frames that it transmits containing the HT Capabilities element if dot11RDResponderOptionImplemented is TRUE. Otherwise, the STA shall set the RD Responder subfield to 0.

9.15.3 Rules for RD initiator

An RDG shall not be present unless the MPDU carrying the grant, or every MPDU carrying the grant in an A-MPDU, matches one of the following conditions:

— A QoS data MPDU with the Ack Policy field set to any value except PSMP Ack (i.e., including Implicit Block Ack Request), or

— A BlockAckReq related to an HT-immediate Block Ack agreement, or

— An MPDU not needing an immediate response (e.g., BlockAck under an HT-immediate Block Ack agreement, or Action No Ack).

An RDG shall not be present within a PSMP sequence.

NOTE 1—These rules together with the rules in 7.4a.3 ensure that an RDG is delivered in a PPDU that either requires no immediate response or requires an immediate BlockAck or ACK response.

NOTE 2—An RD initiator is not required to examine the RD Responder field of a potential responder before deciding whether to send a PPDU to that STA in which the RDG/More PPDU subfield is set to 1.

NOTE 3—An RD initiator is required according to 9.7a to examine the +HTC Support field of a potential responder before deciding whether to send a PPDU to that STA in which the RDG/More PPDU subfield is set to 1.

Transmission of a +HTC frame by an RD initiator with the RDG/More PPDU subfield set to 1 (either transmitted as a non-A-MPDU frame or within an A-MPDU) indicates that the duration indicated by the Duration/ID field is available for the RD response burst and RD initiator final PPDU (if present).

An RD initiator that sets the RDG/More PPDU field to 1 in a +HTC frame shall set the AC Constraint subfield to 1 in that frame if the TXOP was gained through the EDCA channel access mechanism and shall otherwise set it to 0.

An RD initiator shall not transmit a +HTC frame with the RDG/More PPDU subfield set to 1 that requires a response MPDU that is not one of the following:

— Ack
— Compressed BlockAck

Subject to TXOP constraints, after transmitting an RDG PPDU, an RD initiator may transmit its next PPDU as follows:

a) *Normal continuation:* The RD initiator may transmit its next PPDU a minimum of a SIFS after receiving a response PPDU that meets one of the following conditions:
   1) Contains one or more correctly received +HTC frames with the RDG/More PPDU subfield set to 0, or
   2) Contains one or more correctly received frames that are capable of carrying the HT Control field but did not contain an HT Control field, or
   3) Contains a correctly received frame that requires an immediate response
b) *Error recovery:* The RD initiator may transmit its next PPDU when the CS mechanism (see 9.2.1) indicates that the medium is idle at the TxPIFS slot boundary (defined in 9.2.10) (this transmission is a continuation of the current TXOP).

NOTE 1—Error recovery of the RDG mechanism is the responsibility of the RD initiator.

NOTE 2—After transmitting a PPDU containing an RDG, if the response is corrupted so that the state of the RDG/More PPDU subfield is unknown, the RD initiator of the RD exchange is not allowed to transmit after a SIFS interval. Transmission can occur a PIFS interval after deassertion of CS.

NOTE 3—After transmitting a PPDU requiring a response but not containing an RDG, the state of the RDG/More PPDU subfield in the response does not affect the behavior of the RD initiator.

A STA that transmits a QoS +CF-ACK data frame according to the rules in 9.9.2.3 may also include an RDG in that frame provided that

— It is a non-A-MPDU frame, and
— The target of the +CF-ACK is equal to the Address 1 field of the frame.

NOTE—The RD initiator can transmit a CF-End frame according to the rules for TXOP truncation in 9.9.1.7 following a RD transmit sequence. An RD responder never transmits a CF-End.

9.15.4 Rules for RD responder

An RD responder shall transmit the initial PPDU of the RD response burst a SIFS after the reception of the RDG PPDU. PPDUs in a response burst are separated by SIFS or RIFS. The RIFS rules in the RD are the same as in the forward direction; the use of RIFS is constrained as defined in 9.2.3.0b and 9.13.3.3.

NOTE—The transmission of a response by the RD responder does not constitute a new channel access but a continuation of the RD initiator's TXOP. An RD responder ignores the NAV when responding to an RDG.

The recipient of an RDG may decline the RDG by

— Not transmitting any frames following the RDG PPDU when no response is otherwise required, or
— Transmitting a control response frame with the RDG/More PPDU subfield set to 0, or
— Transmitting a control response frame that contains no HT Control field

An RD responder may transmit a +CF-ACK non-A-MPDU frame in response to a non-A-MPDU QoS Data +HTC MPDU that has the Ack Policy field set to Normal Ack and the RDG/More PPDU subfield set to 1.

The RD responder shall ensure that its PPDU transmission(s) and any expected responses fit entirely within the remaining TXOP duration, as indicated in the Duration/ID field of MPDUs within the RDG PPDU.

An RD responder shall not transmit an MPDU (either individually or aggregated within an A-MPDU) that is not one of the following:

— Ack
— Compressed BlockAck
— Compressed BlockAckReq
— QoS data
— Management

If the AC Constraint subfield is set to 1, the RD responder shall transmit data frames of only the same AC as the last frame received from the RD initiator. For a BlockAckReq or BlockAck frame, the AC is determined by examining the TID field. For a management frame, the AC is AC_VO. The RD initiator shall not transmit a +HTC MPDU with the RDG/More PPDU subfield set to 1 from which the AC cannot be determined. If the AC Constraint subfield is set to 0, the RD responder may transmit data frames of any TID.

During an RDG, the RD responder shall not transmit any frames with an Address 1 field that does not match the MAC address of the RD initiator.

If an RDG PPDU also requires an immediate BlockAck response, the BlockAck response frame shall be included in the first PPDU of the response.

When a PPDU is not the final PPDU of a response burst, an HT Control field carrying the RDG/More PPDU subfield set to 1 shall be present in every MPDU within the PPDU capable of carrying the HT Control field. The last PPDU of a response burst shall have the RDG/More PPDU subfield set to 0 in all +HTC MPDUs contained in that PPDU.

The RD responder shall not set the RDG/More PPDU subfield to 1 in any MPDU in a PPDU that contains an MPDU that requires an immediate response.

NOTE— If the RD responder transmits a PPDU that expects a transmission by the RD initiator after SIFS and no such transmission is detected, the RD responder has to wait for either another RDG or its own TXOP before it can retry the exchange.

After transmitting a PPDU containing one or more +HTC MPDUs in which the RDG/More PPDU subfield is set to 0, the RD responder shall not transmit any more PPDUs within the current response burst.

NOTE— If an RD-capable STA that is not the TXOP holder receives a PPDU that does not indicate an RDG, there is no difference in its response compared to a STA that is not RD-capable.

9.16 PSMP Operation

9.16.1 Frame transmission mechanism during PSMP

9.16.1.1 PSMP frame transmission (PSMP-DTT and PSMP-UTT)

The attribute aDTT2UTTTime is the minimum time between the end of the PSMP-DTT and the start of a PSMP-UTT addressed to the same STA. This value represents the minimum time the STA is provided to react to Multi-TID BlockAck, BlockAck, Multi-TID BlockAckReq, BlockAckReq, and data frames received during the PSMP-DTT with data, BlockAck, BlockAckReq, Multi-TID BlockAckReq, and Multi-TID BlockAck frames transmitted in the PSMP-UTT. In a PSMP sequence, if the traffic conditions are such that the time between the PSMP-DTT and PSMP-UTT of a STA would otherwise be less than the value of aDTT2UTTTime, the AP shall delay the start of entire PSMP-UTT phase to meet this requirement.

A PSMP sequence may be used to transmit group-addressed frames along with individually addressed frames. Individually addressed frames shall be scheduled after group-addressed frames.

In a PSMP frame, the STA_ID subfields of all its STA Info fields with STA_INFO Type set to 2 (individually addressed) shall be unique, i.e., each STA identified in the PSMP frame is identified exactly once.

Individually addressed entries in the PSMP frame should have their PSMP-DTT and PSMP-UTT start offsets scheduled to minimize the number of on/off transitions or to maximize the delay between their PSMP-DTT and PSMP-UTT periods. Entries that have only PSMP-DTT should be scheduled closer to the start of the PSMP-DTTs. Entries that have only PSMP-UTT should be scheduled toward the end of PSMP-UTTs. Entries that have both PSMP-DTT and PSMP-UTT should be scheduled closer to the transition point from downlink to uplink transmissions.

NOTE—For effective resource allocation, the AP should precisely estimate the PSMP-UTT duration for each STA using the information indicated in a TSPEC, such as Minimum Data Rate, Mean Data Rate, Peak Data Rate, Burst Size, and Delay Bound fields. However, when the traffic characteristic is quite bursty (e.g., a real-time video application), precise estimation of PSMP-UTT duration is difficult without timely and frequent feedback of the current traffic statistics. In order to avoid wasting the available bandwidth by overestimating the PSMP-UTT duration, the AP can allocate the minimum amount of time to each STA using the PSMP-UTT Duration subfield in the PSMP frame, based on the value of the Minimum Data Rate field specified in the TSPEC. When the STA receives the PSMP frame, it decides whether the allocated resource indicated by the PSMP-UTT duration is sufficient for its queued data. If the allocated resource is sufficient, the STA can transmit all the queued data at the allocated time.

Frames of different TIDs may be transmitted within a PSMP-DTT or PSMP-UTT allocation of a PSMP sequence without regard to user priority.

Within a PSMP-DTT or PSMP-UTT between HT STAs, BlockAckReq and BlockAck frames for which an HT-immediate Block Ack agreement exists shall be the multi-TID variants, i.e., Multi-TID BlockAckReq and Multi-TID BlockAck, respectively. Within a PSMP-DTT or PSMP-UTT between STAs where one is not an HT STA, BlockAckReq and BlockAck frames shall be exchanged through the use of an immediate Block Ack agreement and shall be the basic variants, i.e. Basic BlockAck Req and Basic BlockAck, respectively.

9.16.1.2 PSMP downlink transmission (PSMP-DTT)

During a PSMP sequence, a STA shall be able to receive frames during its scheduled PSMP-DTT and is not required to be able to receive frames at other times.

The AP shall ensure that any transmissions within a PSMP sequence to a STA participating in the PSMP sequence occur wholly within the STA's PSMP-DTT.

The PSMP-DTT may contain one or more PPDUs, each of which may contain either an A-MPDU or a single (non-A-MPDU) MPDU. Data may be transmitted using either format, provided that the format is supported by both the transmitter and the receiver.

PPDUs within a PSMP-DTT may be separated using RIFS or SIFS. The use of RIFS is limited as defined in 9.2.3.0b and 9.13.3.3.

Each PSMP-DTT shall contain only frames addressed to the RA signaled by the corresponding STA_INFO field. PPDUs from adjacent PSMP-DTTs shall be separated by at least SIFS. Inother words, PPDUs to a different RA are separated by at least SIFS.

9.16.1.3 PSMP uplink transmission (PSMP-UTT)

A STA that has frames to send that are valid for transmission within the PSMP-UTT shall start transmission without performing CCA and regardless of NAV at the start of its PSMP-UTT.

The STA shall complete its transmission within the allocated PSMP-UTT, even if it has more data queued than can be transmitted during its allocated PSMP-UTT.

NOTE—PSMP-UTT is a scheduled transmission period for the STA, and transmission within a PSMP-UTT does not imply that the STA is a TXOP holder. This lack of being a TXOP holder disallows a STA from using TXOP truncation during PSMP-UTT.

The uplink schedule in a PSMP frame shall include an interval between the end of one PSMP-UTT and the start of the following PSMP-UTT within the same PSMP sequence. This interval shall be either aIUStime or SIFS. The aIUStime value shall not be used unless the use of RIFS is permitted, as defined in 9.13.3.3. The PSMP-UTT Duration subfield in the PSMP frame does not include this interval.

PPDUs transmitted within a PSMP-UTT may be separated using RIFS or SIFS. The use of RIFS is limited as defined in 9.2.3.0b and 9.13.3.3.

An AP may transmit a PSMP frame (called a *PSMP recovery frame*) during a PSMP-UTT when both of the following conditions are met:

- The CS mechanism (see 9.2.1) indicates that the medium is idle at the TxPIFS slot boundary (defined in 9.2.10) after the start of the PSMP-UTT, and
- The PSMP-UTT duration is longer than the total time of the PSMP recovery frame plus PIFS.

The PSMP recovery frame shall not modify the schedule of a STA that is not scheduled to use this PSMP-UTT. The schedules of other STAs shall remain unchanged. The PSMP recovery frame may include

a) A modified PSMP-UTT (and/or PSMP-DTT) for the currently scheduled STA by adjusting the time remaining by a PIFS interval plus the duration of the PSMP recovery frame, and
b) PSMP-UTTs for other STAs that were originally scheduled after this PSMP-UTT in the PSMP sequence in which the PSMP-UTT start offset values are reduced by the time difference between the end of the original PSMP frame and the end of the PSMP recovery frame.

If the currently scheduled PSMP-UTT duration is shorter than the total time of PSMP recovery frame plus PIFS, no PSMP recovery frame is transmitted.

Figure 9-27 illustrates a PSMP sequence with and without PSMP recovery.

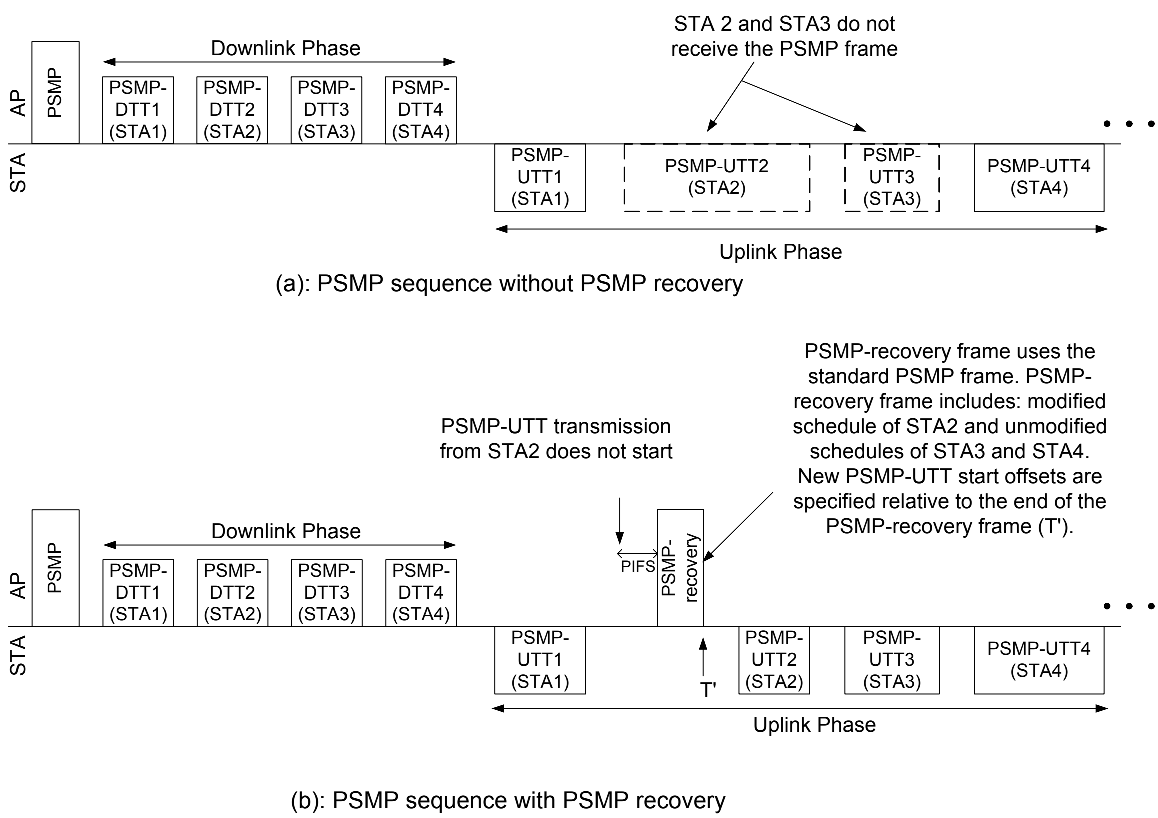


Figure 9-27—Illustration of PSMP sequence with and without PSMP recovery

9.16.1.4 PSMP burst

After transmission of an initial PSMP sequence, additional PSMP sequences can be transmitted by the AP in order to support resource allocation and error recovery. An initial PSMP sequence followed by one or more PSMP sequences is termed a *PSMP burst* and is shown in Figure 9-28.

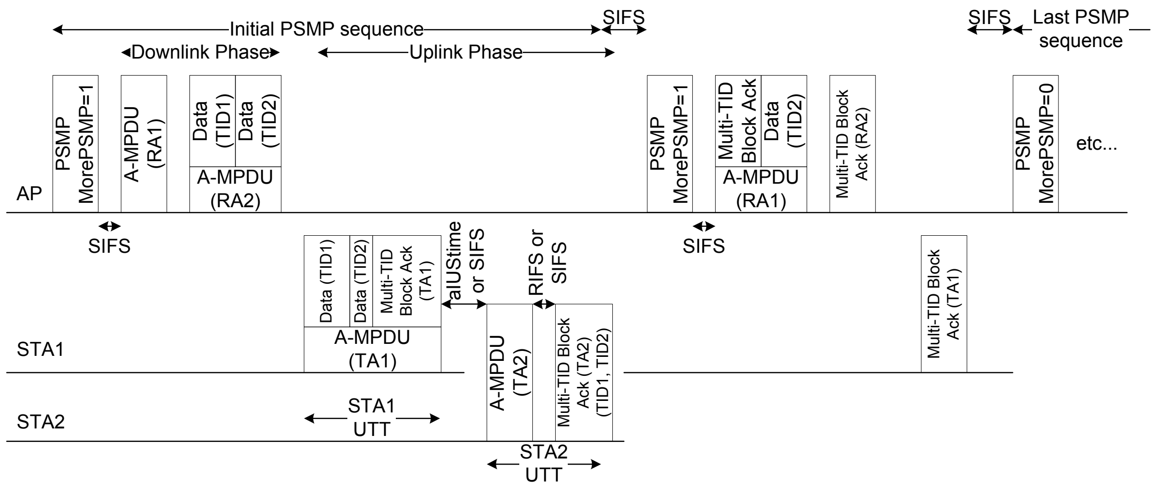


Figure 9-28—PSMP burst

A STA shall not transmit a +HTC MPDU in which the RDG/More PPDU subfield is set to 1 during a PSMP burst.

An AP may transmit a CF-End frame a SIFS period after the end of a PSMP sequence to end the PSMP burst.

NOTE—A non-AP STA does not transmit a CF-End frame during the PSMP burst because it is not a TXOP holder during its PSMP-UTT.

During the PSMP-DTT or PSMP-UTT, a STA shall not transmit a frame unless it is one of the following:

- Multi-TID BlockAck under HT-immediate policy
- Multi-TID BlockAckReq under HT-immediate policy
- BlockAck under an immediate policy with the BA Ack Policy subfield set to 1 (representing No Acknowledgment)
- BlockAckReq under an immediate policy with the BAR Ack Policy subfield set to 1 (representing No Acknowledgment)
- QoS data
- PSMP (a PSMP recovery frame as described in 9.16.1.3)
- BlockAckReq under HT-delayed policy with the BAR Ack Policy subfield set to 1 (representing No Acknowledgment)
- BlockAck under HT-delayed policy with the BA Ack Policy subfield set to 1 (representing No Acknowledgment)
- An MPDU that does not require an immediate response (e.g., Management Action No Ack)

NOTE—An AP can gain access to the channel after a PIFS in order to start transmission of a PSMP sequence.

9.16.1.5 Resource allocation within a PSMP burst

If the allocated PSMP-UTT duration is not long enough for its queued data, the STA transmits only the part of the queued data that fits within the allocated PSMP-UTT duration and may transmit a resource request to the AP within that PSMP-UTT. The resource request is communicated by setting either the Queue Size field or the TXOP Duration Request field of the QoS Control field that is carried in a QoS data frame (see Figure 9-29).

If a STA receives an PSMP-UTT that is not long enough to transmit data from its queues, it may transmit within the PSMP-UTT a QoS Null frame containing information about the state of its transmit queues.

NOTE 1—An HT AP can use this information to schedule a PSMP-UTT either in the current PSMP burst or a later PSMP burst.

NOTE 2—An HT AP can allocate a PSMP-UTT duration in the next PSMP sequence based on the resource request from the STA sufficient to allow transmission of the remaining queued data.

NOTE 3—The PSMP burst supports retransmission as well as additional resource allocation (see Figure 9-30). Frames transmitted under an HT-immediate Block Ack agreement during the PSMP-DTT are acknowledged by a Multi-TID BlockAck frame during the PSMP-UTT period of the current PSMP sequence. Frames transmitted under an immediate Block Ack agreement during the PSMP-DTT are acknowledged by a Basic BlockAck during the PSMP-UTT period of the current PSMP sequence. Frames transmitted under an HT-immediate Block Ack agreement during the PSMP UTT can be acknowledged using a Multi-TID BlockAck frame during the PSMP-DTT period of the next PSMP sequence. Frames transmitted under an immediate Block Ack agreement during the PSMP-UTT can be acknowledged using a Basic BlockAck during the PSMP-DTT period of the next PDMP sequence. Any failed transmissions during the PSMP-DTT or PSMP-UTT periods can be respectively retransmitted during the PSMP-DTT or PSMP-UTT period of the next PSMP sequence.

Figure 9-29 and Figure 9-30 illustrate the operation of resource allocation. STA1 requests the AP to provide additional resources in its transmission to the AP. The box labeled “Queued data” represents the duration that would be required to transmit data queued for transmission at the STA. In Figure 9-30, since the AP does not receive an acknowledgment from STA2, the AP retransmits the data addressed to STA2 and also allocates resources to STA2 so that STA2 can transmit in the next PSMP sequence.

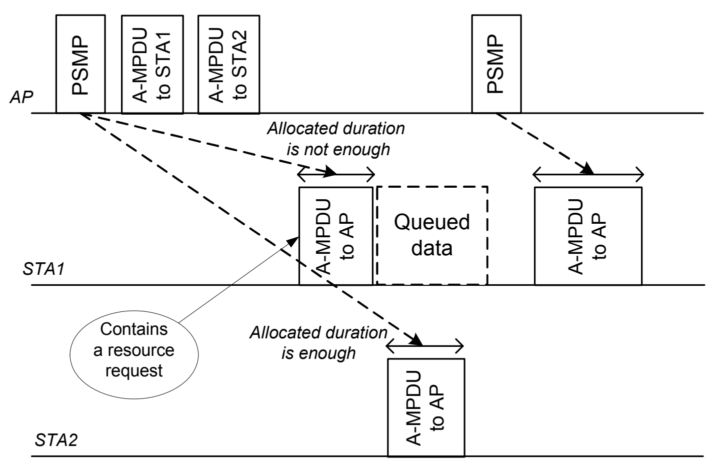


Figure 9-29—PSMP burst showing resource allocation

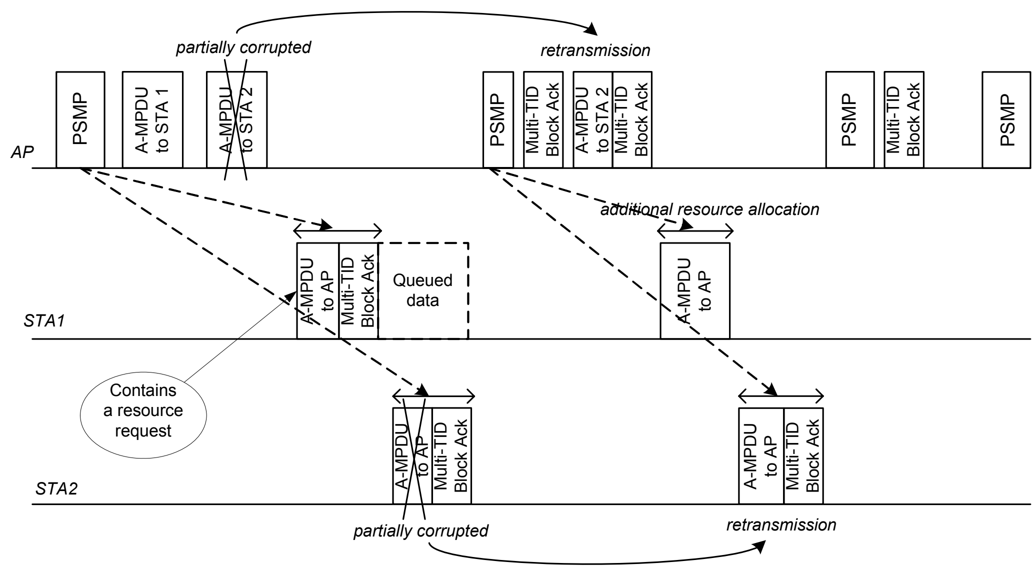


Figure 9-30—PSMP burst showing retransmission and resource allocation

9.16.1.6 PSMP-UTT retransmission

An AP transmits BlockAck or Multi-TID BlockAck responses, if any, to a STA's PSMP-UTT data transmissions under an immediate or HT-immediate Block Ack agreement, respectively, in the PSMP-DTT of a subsequent PSMP sequence.

NOTE—An AP can reserve a PSMP-UTT in a subsequent PSMP sequence to allow a STA to retransmit failed frames. The STA can retransmit failed frames in a PSMP sequence of the current PSMP burst if a PSMP-UTT reservation is present or in a subsequent SP.

A STA that cannot complete its retransmissions in the last PSMP sequence of the PSMP burst because not enough time is allocated in its PSMP-UTT may transmit the data outside any PSMP sequence.

NOTE 1—In the case of uplink frames transmitted outside the scheduled SP, the Multi-TID BlockAck frame that acknowledges these frames is delivered in the PSMP-DTT within the next SP.

NOTE 2—A non-AP STA can transmit data outside the PSMP sequence. The acknowledgment of such frames is based on their Ack Policy field value and whether a Block Ack agreement has been established, as follows:

— An Ack Policy of Block Ack, Normal Ack, or Implicit Block Ack Request results in the behavior defined in 7.1.3.5.3 (Ack Policy subfield).

— An Ack Policy of PSMP Ack causes the AP to record the received data frame and results in the transmission of a Multi-TID BlockAck frame in the next PSMP-DTT allocated to the STA.

9.16.1.7 PSMP acknowledgment rules

A non-AP STA shall transmit a Multi-TID BlockAck frame during its PSMP-UTT for data received with the ACK Policy field set to PSMP Ack or for TIDs in a received Multi-TID BlockAckReq frame for which a BlockAck (Compressed BlockAck or Multi-TID BlockAck) has not yet been transmitted. An AP shall transmit a Multi-TID BlockAck frame during a PSMP-DTT addressed to the STA for the data received from that STA with the ACK Policy field set to PSMP Ack or for TIDs in a Multi-TID BlockAckReq frame received from that STA for which a BlockAck (Compressed BlockAck or Multi-TID BlockAck) has not yet been transmitted.

Data sent and received by a non-AP STA within a PSMP sequence may be contained in an A-MPDU that contains MPDUs of multiple TIDs. Frames of differing TIDs may be transmitted in the same PSMP-DTT or PSMP-UTT and are not subject to AC prioritization.

The subtype subfield of data frames and the Ack Policy subfield of QoS data frames transmitted during either PSMP-DTT or PSMP-UTT periods are limited by the following rules:

— A QoS data frame transmitted under an immediate or HT-immediate Block Ack agreement during either a PSMP-DTT or a PSMP-UTT shall have one of the following Ack Policy values: PSMP Ack or Block Ack.
— A QoS data frame transmitted under an HT-delayed Block Ack agreement during either a PSMP-DTT or a PSMP-UTT shall have the Ack Policy field set to Block Ack.
— A data frame with the RA field containing an individual address transmitted during either a PSMP-DTT or a PSMP-UTT and for which no Block Ack agreement exists shall be a QoS data subtype and shall have the Ack Policy field set to No Ack.
— The Ack Policy field of a QoS data frame transmitted during a PSMP sequence shall not be set to either Normal ACK or Implicit Block ACK.

All TID values within a Multi-TID BlockAck frame or Multi-TID BlockAckReq frame shall identify a Block Ack agreement that is HT-immediate. QoS data frames transmitted with Ack Policy field set to PSMP Ack shall have a TID value that identifies a Block Ack agreement that is immediate or HT-immediate BlockAck.

NOTE—In this case, HT-immediate relates to the keeping of acknowledgment state for timely generation of a Multi-TID BlockAck frame. It does not imply that there is any response mechanism for sending a Multi-TID BlockAck frame after a SIFS interval. The timing of any response is determined by the PSMP schedule.

Acknowledgment for data transmitted under an immediate or HT-immediate Block Ack agreement may be requested implicitly using PSMP Ack setting of the Ack Policy field in data frames or explicitly with a Basic BlockAckReq or Multi-TID BlockAckReq frame. An AP that transmits data frames with the Ack Policy field set to PSMP Ack or that transmits a Basic BlockAckReq or Multi-TID BlockAckReq frame addressed to a STA in a PSMP-DTT shall allocate sufficient time for a Basic BlockAck or Multi-TID BlockAck transmission, respectively, in a PSMP-UTT allocated to that STA within the same PSMP sequence. A STA that has correctly received a PSMP frame and that receives a QoS data MPDU with the Ack Policy field set to PSMP Ack or that receives a Basic BlockAckReq or Multi-TID BlockAckReq frame shall transmit a Basic BlockAck frame or Multi-TID BlockAck frame, respectively, in the PSMP-UTT of the same PSMP sequence.

NOTE 1—If the STA does not receive the PSMP frame, it might still receive the downlink data, in which case it can record the status of the data in its Block Ack buffer, but it cannot transmit a Multi-TID BlockAck frame.

NOTE 2—A Multi-TID BlockAck frame or Multi-TID BlockAckReq frame can contain any TID related to an HT-Immediate Block ACK agreement regardless of the contents of any prior Multi-TID BlockAck or Multi-TID BlockAckReq or QoS data transmission.

An AP that receives a QoS data MPDU with the Ack Policy field set to PSMP Ack during a PSMP-UTT shall transmit a Basic BlockAck or Multi-TID BlockAck response in the next PSMP-DTT that it schedules for that STA, except if it has transmitted a BlockAck for such TIDs to the STA outside the PSMP mechanism.

NOTE 1—The exception may occur if the non-AP STA transmits one or more BlockAckReq frames or QoS data frames with Ack Policy set to Implicit Block Ack outside the PSMP mechanism.

NOTE 2—An AP might receive a Multi-TID BlockAck frame in the PSMP-UTT of the current PSMP sequence. If the Multi-TID BlockAck frame indicates lost frames or if the AP does not receive an expected Multi-TID BlockAck frame, the AP can schedule and retransmit those frames in a PSMP sequence within the current PSMP burst or in the next SP.

A Multi-TID BlockAck frame shall include all the TIDs for which data were received with ACK Policy field set to PSMP Ack and for the TIDs listed in any Multi-TID BlockAckReq frame received during the previous PSMP-DTT (STA) or PSMP-UTT (AP). The originator may ignore the bitmap for TIDs in the Multi-TID BlockAck frame for which the originator has not requested a Multi-TID BlockAck frame to be present either implicitly (by the transmission of data MPDUs with the Ack Policy field set to PSMP Ack) or explicitly (by the transmission of a Multi-TID BlockAckReq frame).

If a BlockAckReq frame for an HT-delayed Block Ack agreement is transmitted during a PSMP sequence, the BAR Ack Policy subfield of the BlockAckReq frame shall be set to the value representing No Acknowledgment.

NOTE—Multi-TID BlockAck and Multi-TID BlockAckReq frames transmitted during PSMP use the Normal Acknowledgment setting of the BA Ack Policy or BAR Ack Policy subfield.

9.16.1.8 PSMP group-addressed transmission rules

9.16.1.8.1 Rules at the AP

This subclause defines rules that shall be followed by a PSMP-capable AP for the transmission of group-addressed frames (data and management) during a PSMP sequence.

Each separate group address for which frames are transmitted during a PSMP sequence shall have a single STA_INFO record with STA_INFO Type set to 1 (group-addressed) present in the PSMP frame and transmit frames with the matching Address 1 field only during the PSMP-DTT indicated in this record.

The DA of the PSMP shall be set to the broadcast address, except if the PSMP contains only a single non-null PSMP-DTT and this PSMP-DTT contains frames for a group address, in which case the DA of the PSMP frame may be set to this group address.

NOTE—The transmission of a group-addressed frame within a PSMP sequence does not change the rules regarding when that frame can be transmitted. In other words, if there is a power-saving STA in the BSS, the group-addressed frame is transmitted following a DTIM beacon according to the rules in 11.2.1.

9.16.1.8.2 Rules at the STA

This subclause defines rules that shall be followed by a PSMP-capable STA for the reception of group-addressed frames during a PSMP sequence.

The STA shall be awake to receive during all PSMP-DTTs identified by a group-addressed STA_INFO record where the PSMP Group Address ID subfield matches the LSBs of any address within its dot11GroupAddressesTable.

9.16.2 Scheduled PSMP

A PSMP session exists while any periodic TS exists that was established by a TSPEC with the APSD field set to 0 and the Schedule field set to 1 (representing Scheduled PSMP). The creation of a PSMP session is described in 11.4.4b.

While one or more PSMP sessions exist with the same SP, the AP shall periodically initiate a PSMP sequence by transmitting a PSMP frame using the SP indicated to the STA in response to the received TSPEC. Under S-PSMP rules, the AP shall not transmit a PSMP frame containing a STA_INFO record addressed to a STA unless the transmission occurs within a SP of that STA. The PSMP-DTT and PSMP-UTT allocated to a STA shall occur within a SP of that STA.

NOTE—An AP can simultaneously maintain multiple PSMP sessions with distinct SIs. The SIs of an AP’s PSMP sessions are multiples of the SI granularity. It is possible that an AP can combine the schedule of multiple PSMP sessions into a single PSMP frame if the start times of the PSMP sessions coincide. For example, the schedule carried by a PSMP frame related to a PSMP session at 20 ms and 30 ms SIs can be combined into a single PSMP frame once every 3 SIs of PSMP session at 20 ms or once every 2 SIs of the PSMP session at 30 ms.

The start time of a PSMP sequence should be aligned with the start time of the SP.

9.16.3 Unscheduled PSMP

An HT AP may start an unscheduled PSMP sequence that includes STAs that are PSMP-capable at any time that these STAs are awake.

NOTE—A STA in power save is awake as defined in 11.2.1.4 (U-APSD, S-APSD), as defined in 11.2.1.5 (PS-poll), or during a DTIM period.

U-APSD STAs can signal the queue size or TXOP duration required to transmit its queued data to the AP in the QoS Control field of the trigger frame. This information can be used by the AP to estimate the duration of the PSMP-UTT so that the STA can transmit the queued data.

All the behavior defined in 11.2.1.4, 11.2.1.5, and 11.2.1.9 applies to unscheduled PSMP with the following exceptions:

— PSMP allows the STA to sleep during PSMP-DTTs and PSMP-UTTs in which it has no interest.
— In addition to the EOSP mechanism, the AP may indicate the end of a SP through the transmission of a PSMP frame with the More PSMP field set to 0 or by transmission of a CF-End frame when a PSMP frame was expected.

9.17 Sounding PPDUs

A sounding PPDU is a PPDU for which the SOUNDING parameter of the corresponding RXVECTOR or TXVECTOR has the value SOUNDING. Sounding PPDUs are transmitted by STAs to enable the receiving STAs to estimate the channel between the transmitting STA and the receiving STA.

A STA transmits sounding PPDUs when it operates in the following roles:

— MFB requester (see 9.18.2)
— Beamformee responding to a training request, calibration initiator, or responder involved in implicit transmit beamforming (see 9.19.2.2, 9.19.2.3, and 9.19.2.4)
— Beamformer involved in explicit transmit beamforming (see 9.19.3)
— ASEL transmitter and ASEL sounding-capable transmitter involved in ASEL (see 9.20.2)

A STA receives sounding PPDUs when it operates in the following roles:

— MFB responder (see 9.18.2)
— Beamformer sending a training request, calibration initiator, or responder involved in implicit transmit beamforming (see 9.19.2.2, 9.19.2.3, and 9.19.2.4)
— Beamformee involved in explicit transmit beamforming (see 9.19.3)
— Transmit ASEL responder and ASEL receiver involved in ASEL (see 9.20.2)

When transmitting a sounding PPDU, the transmitting STA follows the rules stated below to determine the maximum number of space-time streams for which channel coefficients can be simultaneously estimated:

— When transmitting a sounding PPDU that
    — Contains a +HTC frame with the MRQ subfield set to 1, or
    — Is sent as a response to a +HTC frame with the TRQ field set to 1, or
    — Is sent during a calibration sounding exchange, or

  - — Is sent by a beamformer involved in explicit transmit beamforming, or
  - — Is sent in transmit or receive ASEL exchanges,
- — Then,
  - — If the sounding PPDU is not an NDP sounding PPDU, the NUM_EXTEN_SS parameter in the TXVECTOR shall not be set to a value greater than the limit indicated by the Channel Estimation Capability subfield in the Transmit Beamforming Capabilities field transmitted by the STA that is the intended receiver of the sounding PPDU.

    NOTE—The maximum number of space-time streams for which channel coefficients can be simultaneously estimated using the HT-LTFs corresponding to the data portion of the packet is limited by the Rx MCS Bitmask subfield of the Supported MCS Set field and by the the Rx STBC subfield of the HT Capabilities Info field. Both fields are part of the HT Capabilities element.
  - — If the sounding PPDU is an NDP, the number of spatial streams corresponding to the MCS parameter of the TXVECTOR shall not exceed the limit indicated by the Channel Estimation Capability subfield in the Transmit Beamforming Capabilities field transmitted from the STA that is the intended receiver of the NDP (see 9.21.2 for details on setting the MCS parameter).

If a STA sets the Receive Staggered Sounding Capable bit in the Transmit Beamforming Capabilities field to 1, the STA shall set the Channel Estimation Capability bit in the Transmit Beamforming Capabilities field to indicate a dimension that is greater than or equal to the dimension indicated by the Supported MCS Set field of the HT Capabilities element.

9.18 Link adaptation

9.18.1 Introduction

To fully exploit MIMO channel variations and transmit beamforming on a MIMO link, a STA can request that another STA provide MIMO channel sounding and MFB.

Link adaptation may be supported by immediate response or delayed response as described below. Unsolicited MFB is also possible.

- — *Immediate:* An immediate response occurs when the MFB responder transmits the response in the TXOP obtained by the TXOP holder. This approach allows the MFB requester to obtain the benefit of link adaptation within the same TXOP.
- — *Delayed:* A delayed response occurs when the MFB responder transmits the response in the role of a TXOP holder in response to an MRQ in a previous TXOP obtained by the MFB requester.
- — *Unsolicited:* An unsolicited response occurs when a STA sends MFB independent of any preceding MRQ.

9.18.2 Link adaptation using the HT Control field

A STA that supports link adaptation using the HT Control field shall set the MCS Feedback field of the HT Extended Capabilities field to Unsolicited or Both, depending on its specific MFB capability, in HT Capabilities elements that it transmits. MRQs shall not be sent to STAs that have not advertised support for link adaptation. A STA whose most recently transmitted MCS Feedback field of the HT Extended capabilities field of the HT Capabilities element is set to Unsolicited or Both may transmit unsolicited MFB in any frame that contains a +HTC field.

The MFB requester may set the MRQ subfield to 1 in the MAI subfield of the HT Control field of a +HTC frame to request a STA to provide MFB. In each MRQ, the MFB requester shall set the MSI subfield in the MAI subfield to a value in the range 0 to 6. How the MFB requester chooses the MSI value is implementation dependent.

NOTE—The MFB requester can use the MSI subfield as an MRQ sequence number, or it can implement any other encoding of the field.

The appearance of more than one instance of an HT Control field with the MRQ subfield set to 1 within a single PPDU shall be interpreted by the receiver as a single request for MFB.

An MFB requester shall transmit +HTC frames with the MRQ subfield set to 1 in one of the following ways:

— Within a sounding PPDU, or
— With the NDP Announcement subfield in the +HTC frame set to 1 and following the +HTC frame by an NDP transmission

The number of HT-LTFs sent in the sounding PPDU or in the NDP is determined by the total number of spatial dimensions to be sounded, including any extra spatial dimensions beyond those used by the data portion of the frame.

An MFB-capable STA (identified by the MCS Feedback field in Extended HT Capabilities Info field set to 3) shall support the following:

— MFB estimate computation and feedback on the receipt of MRQ (MRQ=1 in +HTC) in a sounding PPDU for which the RXVECTOR NUM_EXTEN_SS parameter contains 0 in the PHYRX-START.indication.
— MFB estimate computation and feedback on the receipt of MRQ (MRQ=1 in +HTC) in a staggered sounding PPDU if this STA declares support for receive staggered sounding by setting the Receive Staggered Sounding Capable subfield of the Transmit Beamforming Capabilities field to 1.
— MFB estimate computation and feedback on the receipt of NDP (see 9.21) if this STA declares support for receiving NDP sounding by setting the Receive NDP Capable subfield of the Transmit Beamforming Capabilities field to 1. The MFB requester shall set the MRQ subfield to 1 in the frame where the NDP Announcement subfield is set to 1.

On receipt of a +HTC frame with the MRQ subfield set to 1, an MFB responder initiates computation of the MCS estimate based on the associated sounding PPDU and labels the result of this computation with the MSI value. The MFB responder includes the received MSI value in the MFSI field of the corresponding response frame. In the case of a delayed response, this use of MSI and MFSI fields allows the MFB requester to correlate the MFB with the related MRQ.

The responder may send a response frame with any of the following combinations of MFB and MFSI:

— MFB = 127, MFSI = 7: no information is provided for the immediately preceding request or for any other pending request. This combination is used when the responder is required to include an HT Control field due to other protocols that use this field (i.e., the Reverse Direction Protocol) and when no MFB is available. It has no effect on the status of any pending MRQ.
— MFB = 127, MFSI in the range 0 to 6: the responder is not now providing, and will never provide, feedback for the request that had the MSI value that matches the MFSI value.
— MFB in the range 0 to 126, MFSI in the range 0 to 6: the responder is providing feedback for the request that had the MSI value that matches the MFSI value.
— MFB in the range 0 to 126, MFSI = 7: the responder is providing unsolicited feedback.

Hardware and buffer capability may limit the number of MCS estimate computations that a MFB responder is capable of computing simultaneously. When a new MRQ is received either from a different MFB requester or from the same MFB requester with a different MSI value, and the MFB responder is not able to complete the computation for MRQ, the MFB responder may either discard the new request or may abandon an existing request and initiate an MCS estimate computation for the new MRQ.

An MFB responder that discards or abandons the computation for an MRQ should indicate this action to the MFB requester by setting the MFB to the value 127 in the next transmission of a frame addressed to the MFB requester that includes the HT Control field. The value of the MFSI is set to the MSI value of the sounding frame for which the computation was abandoned.

NOTE—The MFB requester can advertise the maximum number of spatial streams that it can transmit in its HT Capabilities element. In order to do so, the MFB requester sets the Tx MCS Set Defined bit of the Supported MCS Set field to 1 and indicates the maximum number of streams in the Tx Maximum Number Spatial Streams Supported subfield of the Supported MCS Set field. If the Tx Rx MCS Set Not Equal bit is set to 0, the Tx MCS set is equal to the Rx MCS set, and the maximum number of transmit spatial streams is derived from the value of this field.

When computing the MCS estimate for an MFB requester whose Tx MCS Set Defined field is set to 1, the number of spatial streams corresponding to the recommended MCS shall not exceed the limit indicated by the Tx Maximum Number Spatial Streams Supported field. The MFB responder shall not recommend an MCS corresponding to UEQM unless the MFB requester supports such modulation, as indicated by the Tx Unequal Modulation Supported bit in the Supported MCS Set field.

If the MFB is in the same PPDU as a Noncompressed Beamforming frame or a Compressed Beamforming frame, the MFB responder should estimate the recommended MCS under the assumption that the MFB requester will use the steering matrices contained therein.

After the MCS estimate computation is completed, the MFB responder should include the MFB in the MFB field in the next transmission of a frame addressed to the MFB requester that includes an HT Control field. When the MFB requester sets the MRQ subfield to 1 and sets the MSI subfield to a value that matches the MSI subfield value of a previous request for which the responder has not yet provided feedback, the responder shall discard or abandon the computation for the MRQ that corresponds to the previous use of that MSI subfield value.

A STA may respond immediately to a current request for MFB with a frame containing an MFSI field value and MFB field value that correspond to a request that precedes the current request.

NOTE 1—If an HT STA includes the HT Control field in the initial frame of an immediate response exchange and the responding HT STA includes the HT Control field in the immediate response frame, the immediate response exchange effectively permits the exchange of HT Control field elements.

NOTE 2—If an MRQ is included in the last PPDU in a TXOP and there is not enough time for a response, the recipient can transmit the response MFB in a subsequent TXOP.

NOTE 3—Bidirectional request/responses are supported. In this case, a STA acts as the MFB requester for one direction of a duplex link and a MFB responder for the other direction and transmits both MRQ and MFB in the same HT data frame.

NOTE 4—A STA that sets the MCS Feedback field to 0 in the HT Extended Capabilities field of the HT Capability elements that it transmits does not respond to an MRQ.

If a beamformer transmits a PPDU with the TXVECTOR EXPANSION_MAT_TYPE set to either COMPRESSED_SV or NON_COMPRESSED_SV, it should use the recommended MCS associated with those matrices reported in a Noncompressed Beamforming frame or a Compressed Beamforming frame.

9.19 Transmit beamforming

9.19.1 General

In order for a beamformer to calculate an appropriate steering matrix for transmit spatial processing when transmitting to a specific beamformee, the beamformer needs to have an accurate estimate of the channel over which it is transmitting. Two methods of calculation are defined as follows:

— *Implicit feedback*: When using implicit feedback, the beamformer receives long training symbols transmitted by the beamformee, which allow the MIMO channel between the beamformee and beamformer to be estimated. If the channel is reciprocal, the beamformer can use the training symbols that it receives from the beamformee to make a channel estimate suitable for computing the transmit steering matrix. Generally, calibrated radios in MIMO systems can improve reciprocity. See 9.19.2.

— *Explicit feedback*: When using explicit feedback, the beamformee makes a direct estimate of the channel from training symbols sent to the beamformee by the beamformer. The beamformee may prepare CSI or steering feedback based on an observation of these training symbols. The beamformee quantizes the feedback and sends it to the beamformer. The beamformer can use the feedback as the basis for determining transmit steering vectors. See 9.19.3.

An HT STA shall not transmit a PPDU with the TXVECTOR EXPANSION_MAT parameter present if the MIB variable dot11BeamFormingOptionEnabled is set to FALSE.

9.19.2 Transmit beamforming with implicit feedback

9.19.2.1 General

Transmit beamforming with implicit feedback can operate in a unidirectional or bidirectional manner. In unidirectional implicit transmit beamforming, only the beamformer sends beamformed transmissions. In bidirectional implicit transmit beamforming, both STAs send beamformed transmissions, i.e., a STA may act as both beamformer and beamformee.

Calibration of receive/transmit chains should be done to improve performance of transmit beamforming using implicit feedback. Over-the-air calibration is described in 9.19.2.4. For implicit transmit beamforming, only the beamformer, which is sending the beamformed transmissions, needs to be calibrated.

A STA that advertises itself as being capable of being a beamformer and/or beamformee using implicit feedback shall support the requirements in Table 9-9.

Table 9-9—STA type requirements for transmit beamforming with implicit feedback

STA capability	Required support
Beamformer	Shall set the Implicit Transmit Beamforming Capable subfield to 1 of the Transmit Beamforming Capability field of the HT Capabilities element in HT Capabilities elements that it transmits. Shall set the Implicit Transmit Beamforming Receiving Capable subfield to 1 of the Transmit Beamforming Capability field of the HT Capabilities element. Shall be capable of receiving a sounding PPDU for which the SOUNDING parameter is SOUNDING and the NUM_EXTEN_SS is set to 0 in the RXVECTOR in the PHY-RXSTART.indication, independently of the values of the Receive Staggered Sounding Capable and Receive NDP Capable subfields. Shall set the Calibration subfield to 3 of the Transmit Beamforming Capability field of the HT Capabilities element to advertise full calibration support.
Beamformee	Shall set the Implicit Transmit Beamforming Receiving Capable subfield to 1 of the Transmit Beamforming Capability field of the HT Capabilities element in HT Capabilities elements that it transmits. Shall be capable of setting the SOUNDING parameter to SOUNDING and the NUM_EXTEN_SS to 0 in the TXVECTOR in the PHY-TXSTART.request when transmitting a sounding PPDU, as a response to TRQ=1, independently of the values of the Transmit Staggered Sounding Capable and Transmit NDP Capable subfields.

A STA that performs one of the roles related to transmit beamforming with implicit feedback shall support the associated capabilities shown in Table 9-10.

Table 9-10—Transmit beamforming support required with implicit feedback

Role	Required Support
Beamformee: A receiver of transmit beamformed PPDUs	Shall transmit sounding PPDUs as a response to TRQ=1.
Beamformer: A transmitter of beamformed PPDUs	Can receive sounding PPDUs. Can compute steering matrices from MIMO channel estimates obtained from long training symbols in sounding PPDUs received from the beamformee.
A responder in a calibration exchange	Can receive and transmit sounding PPDUs. Can respond with a CSI frame that contains channel measurement information obtained during reception of a sounding PPDU.
An initiator in a calibration exchange	Can receive and transmit sounding PPDUs. Can receive a CSI frame sent by a calibration responder.

When a beamformee transmits a sounding PPDU, the SOUNDING parameter in the TXVECTOR in the PHY-TXSTART.request shall be set to SOUNDING. If the beamformee is capable of implicit transmit beamforming and the beamformer is capable of receiving implicit transmit beamforming, the sounding PPDU from the beamformee may be steered.

A PPDU containing one or more +HTC MPDUs in which the TRQ field is set to 1 shall not be sent to a STA that sets the Implicit Transmit Beamforming Receiving Capable subfield of the Transmit Beamforming field of the HT Capabilities element to 0.

If a PPDU containing one or more +HTC MPDUs in which the TRQ field is set to 1 requires an immediate response, either the response from the beamformee shall be included in a sounding PPDU, or the NDP Announcement subfield of the HT Control field shall be set to 1 and the PPDU shall be followed by an NDP. If the PPDU in which the TRQ field is set to 1 does not require an immediate response, either the beamformee shall transmit a sounding PPDU in the next TXOP obtained by the beamformee, or the beamformee shall transmit a PPDU in the next TXOP obtained by the beamformee in which the NDP Announcement subfield of the HT Control field is set to 1 and that PPDU shall be followed by an NDP. The use of NDP as a sounding PPDU is described in 9.21.

NOTE—A STA that acts as a beamformer using implicit feedback expects to receive a sounding PPDU in response to a training request. The STA can compute steering matrices from the channel estimates obtained from the received sounding PPDU.

At the end of the TXOP, the final PPDU from the beamformer shall not have the TRQ field set to 1 in a frame that requests an immediate response if there is not enough time left in the TXOP for the beamformee to transmit the longest valid sounding PPDU with its response.

9.19.2.2 Unidirectional implicit transmit beamforming

Figure 9-31 shows an example of a PPDU exchange used in unidirectional implicit transmit beamforming using the Clause 20 PHY. In this example, sounding PPDUs are used that carry MPDUs (i.e., an example of implicit beamforming using NDPs is not shown here.) STA A is the beamformer that initiates the PPDU exchange, and STA B is the beamformee.

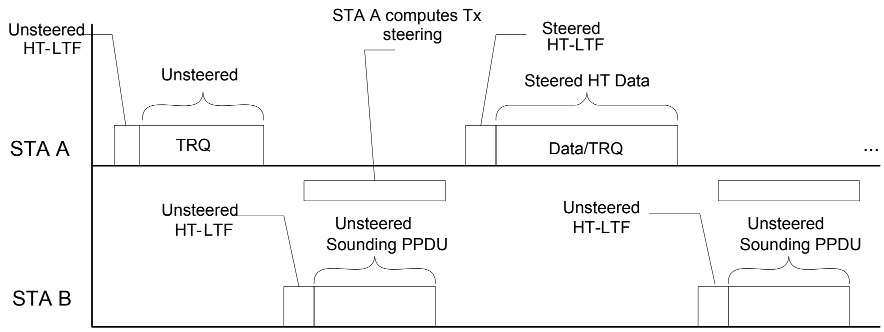


Figure 9-31—Example PPDU exchange for unidirectional implicit transmit beamforming

The PPDU exchange can be summarized as follows:

a) 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.

b) STA B sends a sounding PPDU in response to the training request from STA A.

c) On receiving the sounding PPDU, STA A uses the resulting channel estimate to compute steering matrices and uses these matrices to send a steered PPDU back to STA B.

d) The steered PPDU transmitted in step c) and subsequent steered PPDUs transmitted by STA A may include training requests (TRQ=1) in a +HTC MPDU. In response to each training request, STA B returns a sounding PPDU to STA A, which enables STA A to update its steering vectors. If the steering vectors resulting from step c) or subsequent sounding PPDUs are deemed stale due to delay, the sequence can be restarted by returning to step a).

Step d) in the above PPDU exchange represents steady-state unidirectional transmit beamforming operation.

During the PPDU exchange, neither the receiving nor the transmitting STA should switch antennas.

9.19.2.3 Bidirectional implicit transmit beamforming

Figure 9-32 shows an example of a PPDU exchange used in bidirectional implicit transmit beamforming, using the Clause 20 PHY. In this example, sounding PPDUs are used that carry MPDUs. STA A initiates the frame exchange, and STA A and STA B alternate in the roles of beamformer and beamformee.

The PPDU exchange can be summarized as follows:

a) 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.

b) STA B sends a sounding PPDU in response to the training request. In addition, this PPDU includes a training request in a +HTC MPDU to enable implicit transmit beamforming in the RD

c) On receiving the sounding PPDU, STA A uses the resulting channel estimate to compute steering matrices and uses these matrices to send a steered PPDU back to STA B. This steered PPDU is also a sounding PPDU in response to the training request from STA B.

NOTE—Steering matrices with nonorthonormal columns should not be used in transmitting sounding PPDUs for implicit feedback. In general, bidirectional implicit beamforming will not function as described here when the steering matrices have nonorthonormal columns. See 20.3.12.1.

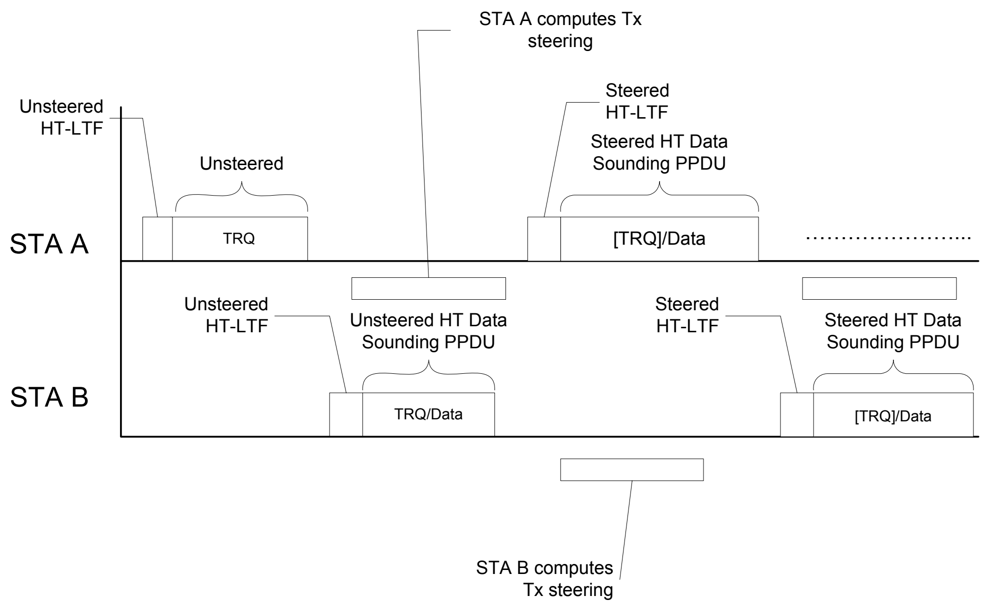


Figure 9-32—Example PPDU exchange for bidirectional implicit transmit beamforming

d) On receiving the sounding PPDU, STA B uses the resulting channel estimate to compute steering matrices and uses these matrices to send a steered PPDU back to STA A. The steered PPDU transmitted in step c) and subsequent steered PPDUs transmitted by STA A may include training requests in HTC. In response to each training request, STA B returns a sounding PPDU to STA A, which enables STA A to update its steering vectors. If the steering vectors resulting from step c) or subsequent sounding PPDUs are deemed stale due to delay, the sequence can be restarted by returning to step a).

e) The steered PPDU transmitted in step d) and subsequent steered PPDUs transmitted by STA B may include training requests in HTC. In response to each training request, STA A returns a sounding PPDU to STA B, which enables STA B to update its steering vectors. If the steering vectors resulting from step d) or subsequent sounding PPDUs are deemed stale due to delay, the sequence can be restarted by returning to step a).

Steps d) and e) in the above PPDU exchange represent steady-state bidirectional transmit beamforming operation.

During the PPDU exchange, neither the receiving nor the transmitting STA should switch antennas.

NOTE—The TRQ protocol used with the beamforming training process is not sufficient to permit STA B to transmit data frames in the RD. In the example shown in Figure 9-32, STA A would additionally have to follow the rules of the Reverse Direction Protocol (see 9.15).

9.19.2.4 Calibration

9.19.2.4.1 Introduction

Differences between transmit and receive chains in a STA degrade the inherent reciprocity of the over-the-air time division duplex channel and cause degradation of the performance of implicit beamforming. Calibration acts to remove or reduce differences between transmit and receive chains and enforce reciprocity in the observed baseband-to-baseband channels between two STAs.

A STA acting as a beamformer should be calibrated to maximize performance. A STA acting only as a beamformee does not need to be calibrated. If calibration is desired, it is performed using the over-the-air calibration procedure described below.

The calibration procedure involves the computation of correction matrices that effectively ensure that the observed channel matrices in the two directions of the link are transposes of each other and thus renders the resultant channel reciprocal. See 20.3.12.1 for a more detailed description. If it is able to do so, a STA should calibrate upon association.

NOTE—STAs with two or more transmit RF chains should be calibrated in order to engage in implicit transmit beamforming. STAs with any number of RF chains, including those with a single RF chain, can participate in a calibration exchange as a calibration responder.

9.19.2.4.2 Calibration capabilities

A STA that sets the Implicit Transmit Beamforming Capable subfield of the Transmit Beamforming Capabilities field to 1 shall support calibration and shall set the Calibration subfield of the Transmit Beamforming Capabilities field to 3 (indicating full support of calibration) in HT Capabilities elements that it transmits. A STA that does not set the Implicit Transmit Beamforming Capable subfield of the Transmit Beamforming Capabilities field to 1 may support calibration and shall set the Calibration subfield of the Transmit Beamforming Capabilities field to the value that indicates its calibration capability in the Transmit Beamforming Capabilities field in HT Capabilities elements that it transmits (see Table 7-43n), when the Transmit Beamforming Capabilities field exists.

A STA that is capable of initiating calibration (the Calibration subfield of the Transmit Beamforming Capabilities field is set to 3) shall set the CSI Max Number of Rows Beamformer Supported subfield to an appropriate value, even if the STA sets the Explicit Transmit Beamforming CSI Feedback subfield to a zero value.

In order to support calibration, a STA that advertises that it is capable of responding to a calibration request shall be capable of transmitting a CSI frame in which the value of the Grouping subfield of the MIMO Control field is 0 (no grouping) and the Coefficients Size subfield of the MIMO Control field is 3 (Nb = 8 bits) in response to a CSI feedback request indicated by the CSI/Steering subfield of the HT Control field set to 1 and the Calibration Position subfield of the HT Control field set to 3, independently of the advertised values of the Explicit Transmit Beamforming CSI Feedback subfield in the Transmit Beamforming Capabilities field in the HT Capabilities element. A STA that advertises that it is capable of initiating a calibration request shall be capable of receiving a CSI frame in which the value of the Grouping subfield of the MIMO Control field is set to 0 (no grouping) and the Coefficients Size subfield of the MIMO Control field is set to 3 (Nb = 8 bits) as a response to CSI feedback request indicated by the CSI/Steering subfield of the HT Control field set to 1 with the Calibration Position subfield set to 3, independently of the advertised values of the Explicit CSI Transmit Beamforming Capable subfield in the Transmit Beamforming Capabilities field in the HT Capabilities element.

A STA may initiate a calibration training frame exchange sequence with another STA if that STA supports calibration. A STA shall not initiate a calibration training frame exchange with another STA if that STA does not support calibration.

If the Receive NDP Capable field is set to 1, the value of the Calibration field is set to 1 or 3, and the device supports transmitting sounding PPDUs for which two or more channel dimensions can be estimated (two or more columns of the MIMO channel matrix), then transmission of NDPs shall be supported (and the Transmit NDP Capable bit shall be set to 1).

9.19.2.4.3 Sounding exchange for calibration

Figure 9-33 illustrates the calibration PPDU exchange using sounding PPDUs that contain an MPDU.

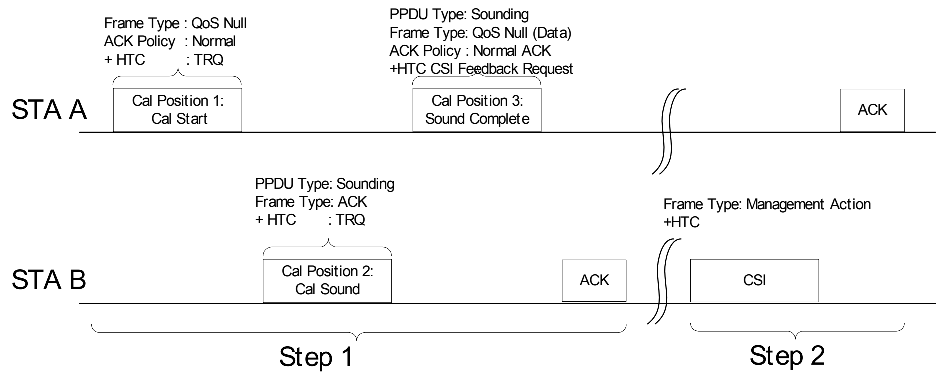


Figure 9-33—Calibration procedure with sounding PPDU containing an MPDU

The calibration procedure begins with a calibration sounding PPDU exchange sequence shown as Step 1 in Figure 9-33. The Calibration Sequence subfield in the HT Control field shall be incremented each time a new calibration procedure is started.

STA A (the calibration initiator) shall transmit a Calibration Start frame (Calibration Position subfield set to 1) with the TRQ field in the HT Control field set to 1. This frame initiates a calibration procedure. It shall be a QoS Null data frame with the ACK Policy field set to Normal ACK.

In response, STA B (the calibration responder) shall transmit a Calibration Sounding Response frame (Calibration Position subfield set to 2), a SIFS interval after the end of the Calibration Start frame, using a sounding PPDU. This step allows STA A to estimate the MIMO channel from STA B to STA A. In the Calibration Sounding Response frame, the Calibration Sequence subfield in HT Control field shall be set to the same value that is indicated in the Calibration Start frame. The Calibration Sounding Response frame shall have a frame type of ACK+HTC, and the TRQ field in the HT Control field in this frame shall be set to 1.

In response, STA A shall transmit a Calibration Sounding Complete frame (Calibration Position subfield set to 3) that contains the CSI/Steering subfield of the HT Control field set to 1, a SIFS interval after the end of the Calibration Sounding Response frame, using a sounding PPDU. This step allows STA B to estimate the MIMO channel from STA A to STA B. In this Calibration Sounding Complete frame, the Calibration Sequence subfield in the HT Control field shall be set to the same value that is indicated in the Calibration Sounding Response frame. The Calibration Sounding Complete frame shall be a QoS Null+HTC with the ACK Policy field set to Normal ACK.

A frame in which the Calibration Position subfield is set to 2 or 3 shall be transmitted in a sounding PPDU (a PPDU for which the SOUNDING parameter is set to SOUNDING). The number of Long Training fields (LTFs) used to obtain MIMO channel estimation that are sent in the sounding PPDU shall be determined by the number of transmit chains (N_{TX}) used in sending these LTFs at the STA transmitting the sounding PPDU. The transmit chains used at the calibration initiator are those for which calibration is required.

The calibration responder may train up to maximum available transmit chains to maximize the quality of the resulting calibration, although the number of space-time streams for data symbols shall be determined by the rule described in 9.6.

When transmitting a sounding PPDU during Step 1 of a calibration procedure, if the Receive Staggered Capability subfield in the Transmit Beamforming Capability field of the HT Capabilities element transmitted by the intended receiver is zero, then,

- — If the sounding PPDU is not an NDP, the number of antennas used by the sender shall be less than or equal to the maximum number of space-time streams indicated by the Rx MCS Bitmask subfield of the Supported MCS Set field and the Rx STBC subfield of the HT Capabilities element transmitted by the intended receiver.
- — If the sounding PPDU is an NDP, the number of antennas used by the sender shall be less than or equal to the number indicated by the Channel Estimation Capability subfield in the Transmit Beamforming Capability field of the HT Capabilities element transmitted by the intended receiver.

Sounding packets in which the Calibration Position subfield is set to 2 or 3 shall use the spatial mapping matrices defined in 20.3.13.2. The calibration responder shall not remove the spatial mapping from the CSI to be fed back to the initiator of the frame exchange.

NOTE—The calibration initiator of this frame exchange is responsible for accounting for the spatial mapping in both its local channel estimate as well as in the quantized CSI fed back to it.

The row order in the CSI feedback matrix transmitted from STA B shall correspond to the association of the rows of the spatial mapping matrix (see Equation (20-75)) to its transmit antennas. For example, the receive antenna at STA B associated with row i in the CSI feedback matrix in each subcarrier is the same as its transmit antenna associated with row i in the spatial mapping matrix used for transmitting the sounding response with Calibration Position set to 2.

Figure 9-34 and Figure 9-35 illustrate the calibration PPDU exchange using NDPs.

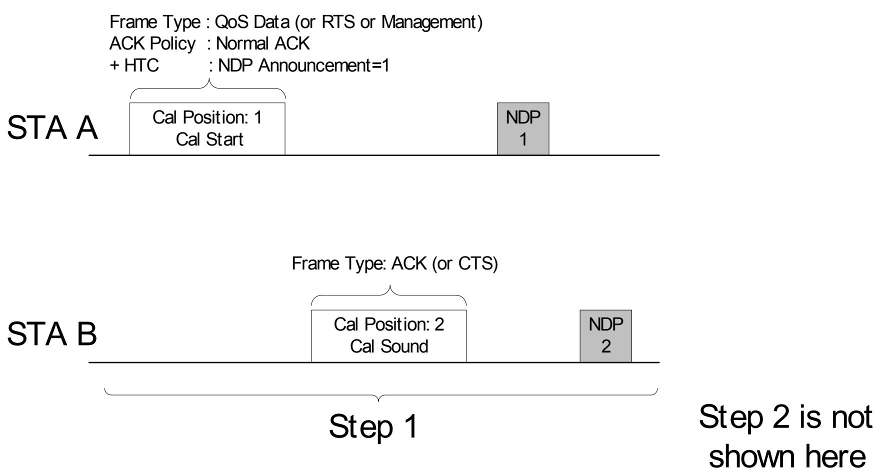


Figure 9-34—Calibration procedure with NDP

The calibration procedure begins with a calibration sounding PPDU exchange sequence, shown as Step 1 in Figure 9-34 and Figure 9-35, when STA B supports transmitting sounding PPDUs for which only one channel dimension can be estimated (i.e., a single column of the MIMO channel matrix). The Calibration Sequence subfield in the HT Control field shall be incremented each time a new calibration procedure is started.

NDP transmission within a calibration procedure follows the rules defined in 9.21.1. STA A transmits a Calibration Start frame (i.e., with the Calibration Position subfield set to 1) with the NDP Announcement subfield set to 1 and CSI/Steering subfield of the HT Control field set to 1. Only the current TXOP holder may set both the Calibration Position and NDP Announcement subfields to 1. This frame initiates a calibration procedure.

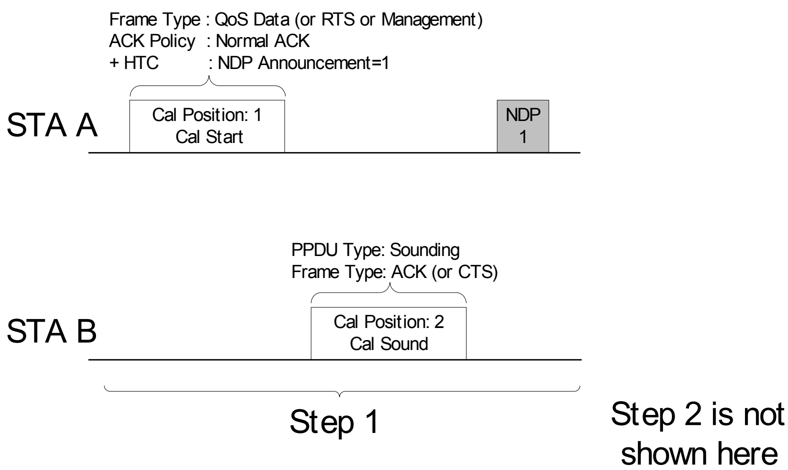


Figure 9-35—Calibration procedure with NDP when STA B supports transmitting sounding PPDUs for which only one channel dimension can be estimated (i.e., a single column of the MIMO channel matrix)

STA B shall transmit a Calibration Sounding Response frame (i.e., with the Calibration Position subfield set to 2) after a SIFS interval after the received Calibration Start frame. If STA B supports transmitting sounding PPDUs for which only one channel dimension can be estimated (i.e., a single column of the MIMO channel matrix), this Calibration Sounding Response frame is sent with the SOUNDING parameter of the TXVECTOR set to SOUNDING (see Figure 9-35).

As determined by NDP rules a) or b) in 9.21.1, STA A sends the first NDP as a sounding PPDU a SIFS after receiving the Calibration Sounding Response frame. This step allows STA B to estimate the MIMO channel from STA A to STA B. In the Calibration Sounding Response frame, the Calibration Sequence subfield in HT Control field shall be set to the same value that is contained in the Calibration Start frame. The Calibration Sounding Response frame shall contain an HT Control field, and the type and subtype of the frame are determined by the Calibration Start frame.

As determined by NDP rule d), STA B might transmit a second NDP as a sounding PPDU a SIFS interval after receiving the first NDP. This second NDP allows STA A to estimate the channel from STA B to STA A.

NOTE—STA B does not transmit an NDP when it supports transmitting sounding PPDUs for which only one channel dimension can be estimated (see Figure 9-35).

Otherwise (i.e., if STA B supports transmitting sounding PPDUs for which only one channel dimension can be estimated (single column of the MIMO channel matrix)), the transmission of the sounding PPDU in Calibration Position 2 allows STA A to estimate the channel from STA B to STA A.

NDP sounding PPDUs shall use the spatial mapping matrices defined in 20.3.13.2. The calibration responder shall not remove the spatial mapping from the CSI to be fed back to the initiator of the frame exchange.

NOTE—The calibration initiator of this frame exchange is responsible for accounting for the spatial mapping in both its local channel estimate as well as in the quantized CSI fed back to it.

9.19.2.4.4 CSI reporting for calibration

The remaining message exchange in the calibration procedure is not time critical.

The calibration initiator should not transmit any frames that are part of the calibration sequence shown in Step 1 in Figure 9-33 if either of the response frames from the calibration responder (the frames shown as

Calibration Position 2 and ACK in Step 1) is not received correctly within an ACKTimeout interval (as defined in 9.2.8) after the PHY-TXEND.confirm. If the calibration initiator aborts the calibration sequence, it can restart the calibration sequence with a value of the Calibration Sequence subfield in the Calibration Control subfield of the HT Control field that is different (i.e., incremented) from the value used in the aborted sequence. Within a non-NDP calibration sequence, the calibration responder should not transmit any further frames that are part of the calibration sequence shown in Step 1 if the frame having Calibration Position 3 is not received correctly within an ACKTimeout interval (as defined in 9.2.8) after the PHY-TXEND.confirm.

When the MIMO channel measurements become available at STA B, STA B shall send one or more CSI frames that contain the CSI report (Step 2 in Figure 9-33). This CSI report shall have full precision, i.e, Ng=1 (no grouping) and Nb=3 (8 bits). In these CSI frames, the Calibration Sequence subfields in HT Control fields shall be set to the same value that is indicated in the Calibration Sounding Complete frame. These CSI frames shall have a frame type of Management Action +HTC.

STA B should finish transmission of the first CSI frame within aMaxCSIMatricesReportDelay (in milliseconds) after the reception of the frame containing the CSI feedback request or NDP announcement.

NOTE—If necessary, the CSI Report field can be split into up to 8 segments as specified in Table 7-25c.

A STA that has started but not completed the calibration procedure and that receives some other request that requires the buffering of CSI (such as another calibration initiation frame, MFB request, CSI feedback request for link adaptation, or feedback request for explicit Transmit Beamforming) may ignore the other request.

From the beginning of Step 1 of the calibration procedure and continuing through the end of Step 2 of the calibration procedure, neither the receiving nor the transmitting STA should switch antennas.

9.19.3 Explicit feedback beamforming

In this subclause, the terms *beamformer* and *beamformee* refer to STAs that are involved in explicit feedback beamforming.

A beamformer uses the feedback response that it receives from the beamformee to calculate a beamforming feedback matrix for transmit beamforming. This feedback response may have one of three formats:

— *CSI*: The beamformee sends the MIMO channel coefficients to the beamformer.

— *Noncompressed beamforming*: The beamformee sends calculated beamforming feedback matrices to the beamformer.

— *Compressed beamforming*: The beamformee sends compressed beamforming feedback matrices to the beamformer.

The supported formats shall be advertised in the beamformee's HT Capabilities element.

NOTE—A beamformer can discard the feedback response if the TSF time when the PHY_CCA.indication(IDLE) primitive corresponding to the feedback response frame's arrival minus the value from the Sounding Timestamp field in the feedback response frame is greater than the coherence time interval of the propagation channel.

A beamformee's responding capabilities shall be advertised in HT Capabilities elements contained in Beacon, Probe Request, Probe Response, Association Request, Association Response, Action, and Action No Ack frames that are transmitted by the beamformee. Devices that are capable of acting as a beamformee shall advertise one of the following response capabilities in the Explicit Transmit Beamforming CSI Feedback subfield of the Transmit Beamforming Capability field:

— *Immediate*: The beamformee is capable of sending a feedback response a SIFS after receiving a sounding PPDU and/or is capable of sending a feedback response aggregated in a PPDU that contains a MAC response within the beamformer's TXOP.
— *Delayed*: The beamformee is not capable of sending the feedback response within the beamformer's TXOP, but it is capable of sending the feedback response in a TXOP that it obtains.
— *Immediate and Delayed*: The beamformee is capable of sending a feedback response a SIFS after receiving a sounding PPDU, sending a feedback response aggregated in a PPDU that contains a MAC response within the beamformer's TXOP, or sending the feedback response in a TXOP that it obtains.

The sounding frame types supported by the beamformee, staggered and/or NDP, are advertised in the HT Capabilities element in frames that are transmitted by the beamformee.

A STA that sets any of the Explicit Transmit Beamforming CSI Feedback Capable, Explicit Noncompressed Beamforming Feedback Capable, or Explicit Compressed Beamforming Feedback Capable fields to 1 shall transmit explicit feedback based on the receipt of a +HTC sounding PPDU in which the CSI/Steering subfield has a nonzero value and that does not contain Extension HT-LTFs (HT-ELTFs). This requirement is independent of the values of the Receive Staggered Sounding Capable and the Receive NDP Capable fields.

A beamformer shall set the SOUNDING parameter of the TXVECTOR to SOUNDING in the PHY-TXSTART.request primitive corresponding to each packet that is used for sounding.

A beamformer shall set the response type format indicated in the CSI/Steering subfield of the HT Control field of any sounding frame excluding the NDP and of any PPDU with the NDP Sounding Announcement field set to 1 to one of the nonzero values (CSI, Compressed Beamforming, or Noncompressed Beamforming) that corresponds to a type that is supported by the beamformee.

The receipt of a PHY-RXSTART.indication with the RXVECTOR SOUNDING parameter value set to SOUNDING indicates a sounding packet. A non-NDP request for feedback is a sounding PPDU with a +HTC MPDU that contains a nonzero value of the CSI/Steering subfield and that has the NDP Announcement subfield set to 0.

An NDP request for feedback is the combination of a +HTC MPDU that contains a nonzero value of the CSI/Steering subfield and that has the NDP Announcement subfield set to 1 and the NDP that follows.

A beamformee that transmits a feedback frame in response to a sounding PPDU sent by a beamformer shall transmit a frame of the type (CSI, Compressed Beamforming, or Noncompressed Beamforming) indicated in the CSI/Steering subfield of the HT Control field transmitted by the beamformer.

A beamformee that sets the Explicit Transmit Beamforming CSI Feedback field of its HT Capabilities element to either 2 or 3 shall transmit Explicit CSI feedback after SIFS or later in the 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 9-11. A beamformee that sets the Explicit Noncompressed Beamforming Feedback Capable field of its HT Capabilities element to either 2 or 3 shall transmit Explicit Noncompressed Beamforming feedback after SIFS or later in the 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 9-11.

A beamformee that sets the Explicit Compressed Feedback Capable field of its HT Capabilities element to either 2 or 3 shall transmit Explicit Compressed Beamforming feedback after SIFS or later in the 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 9-11.

Table 9-11—Rules for beamformee immediate feedback transmission responding to non-NDP sounding

Type of response	Rule
CTS response	If the transmission of a CTS is required in response to the non-NDP request for feedback, the transmission of the feedback response frame shall be delayed until the beamformee's next transmission within the TXOP. This feedback response frame may be aggregated in an A-MPDU with an ACK or BlockAck frame.
Acknowledgment response	If the transmission of an ACK or BlockAck control response frame is required in response to the non-NDP request for feedback, both the feedback response frame and the control response frame may be aggregated in an A-MPDU.
No control response	If the transmission of a control response frame is not required in response to the non-NDP request for feedback, the feedback response frame shall be sent a SIFS after the reception of the sounding PPDU containing the request for feedback.
Later aggregation of feedback and acknowledgment	If the immediate-feedback-capable beamformee cannot transmit an aggregated or immediate CSI/Steering response in a SIFS time after the end of the received sounding packet and the beamformee is subsequently required to transmit an ACK or BlockAck response in the same TXOP, it may transmit the feedback response in an A-MPDU with the ACK or BlockAck frame.

A beamformee that sets the Explicit Transmit Beamforming CSI Feedback field of its HT Capabilities element to either 2 or 3 shall transmit the Explicit CSI feedback after SIFS or later in the beamformer's TXOP as a response to an NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 9-12.

Table 9-12—Rules for beamformee immediate feedback transmission responding to NDP sounding

Type of response	Rule
Control response	If the transmission of a control response frame is required in response to the NDP request for feedback, the control response frame is transmitted a SIFS after reception of the PPDU that elicited the control response, and the feedback response frame may be transmitted a SIFS after the reception of the NDP. — If the feedback response frame is not transmitted a SIFS after the reception of the NDP and the beamformee is subsequently required to transmit an ACK or BlockAck response in the same TXOP, then the feedback response may be aggregated with the ACK or BlockAck frame. — If the feedback response frame is not transmitted a SIFS after the reception of the NDP and is not transmitted as part of an aggregated ACK or BlockAck response in the same TXOP, then the feedback response frame is delayed until the beamformee's next transmission within the TXOP.
No control response	If the transmission of a control response frame is not required in response to the NDP request for feedback, the feedback response frame may be sent a SIFS after the reception of the NDP. — If the feedback response frame is not transmitted a SIFS after the reception of the NDP and the beamformee is subsequently required to transmit an ACK or BlockAck response in the same TXOP, then the feedback response may be aggregated with the ACK or BlockAck frame. — If the feedback response frame is not transmitted a SIFS after the reception of the NDP and is not transmitted as part of an aggregated ACK or BlockAck response in the same TXOP, then the feedback response frame is delayed until the beamformee's next transmission within the TXOP.

A beamformee that sets the Explicit Noncompressed Beamforming Feedback Capable field of its HT Capabilities element to either 2 or 3 shall transmit the Explicit Noncompressed Beamforming feedback after SIFS or later in the beamformer's TXOP as a response to an NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 9-12.

A beamformee that sets the Explicit Compressed Beamforming Feedback Capable field of its HT Capabilities element to either 2 or 3 shall transmit the Explicit Compressed Beamforming feedback after SIFS or later in the beamformer's TXOP as a response to an NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 9-12.

When the beamformee sets the Explicit Transmit Beamforming CSI Feedback field of its HT Capabilities element to either 2 or 3 and the beamformer has transmitted an NDP or an non-NDP Explicit Beamforming CSI feedback request in a frame that does not require immediate control response, the beamformer shall not transmit the next packet to the beamformee until PIFS after transmitting the sounding request.

When the beamformee sets the Explicit Noncompressed Beamforming Feedback Capable field of its HT Capabilities element to either 2 or 3 and the beamformer has transmitted an NDP or an non-NDP Explicit Noncompressed Beamforming feedback request in a frame that does not require immediate control response, the beamformer shall not transmit the next packet to the beamformee until PIFS after the sounding request.

When the beamformee sets the Explicit Compressed Beamforming Feedback Capable field of its HT Capabilities element to either 2 or 3 and the beamformer has transmitted an NDP or an non-NDP Explicit Compressed Beamforming feedback request in a frame that does not require immediate control response, the beamformer shall not transmit the next packet to the beamformee until PIFS after transmitting the sounding request.

A beamformee shall not transmit a CSI, Compressed Beamforming, or Noncompressed Beamforming frame except in response to a request for feedback.

NOTE—Error recovery in a TXOP is not affected by sounding. A beamformer that is a TXOP holder and that fails to receive an expected response to a sounding PPDU can continue transmission as specified in 9.9.1.4.

A beamformee transmitting a feedback response after SIFS or later in the beamformer's TXOP shall use an Action No Ack frame or an Action No Ack +HTC frame (defined in 7.2.3.13).

A beamformee transmitting delayed feedback response shall use an Action frame or an Action +HTC frame to send this information within a separate TXOP.

If necessary, the CSI Report field, Noncompressed Beamforming Report field, or Compressed Beamforming Report field may be split into up to 8 frames. The length of each segment shall be equal number of octets for all segments except the last, which may be smaller.

NOTE—A STA that has been granted an RDG can act as a beamformer during the RDG time period, provided that the RD rules are obeyed.

A beamformee that advertises itself as delayed-feedback-capable shall not transmit an immediate feedback response unless it also advertises itself as immediate-feedback-capable.

A beamformer may use the following worst-case parameters to estimate the duration of the expected frame that contains the feedback response: Basic MCS, HT-Mixed Format, Supported Grouping.

An Explicit Feedback Request may be combined with an MRQ. If the response contains a beamforming feedback matrix, the returned MCS shall be derived from the same information that was used to generate this particular beamforming feedback matrix. If the response contains channel coefficients, the returned MCS shall be derived from an analysis of the sounding frame that was used to generate the channel coefficients. The MFB field set to 127 (meaning no feedback) may be used when the beamformee is unable to generate the MCS in time for inclusion in the response transmission frame. A CSI-capable STA may be incapable of generating MFB.

Explicit feedback shall be calculated only from a sounding PPDU.

9.20 Antenna selection (ASEL)

9.20.1 Introduction

ASEL is a time-variant mapping of the signals at the RF chains onto a set of antenna elements when the number of RF chains is smaller than the number of antenna elements at a STA and/or AP. The mapping can be chosen based on instantaneous or averaged CSI. ASEL requires the training of the full size channel associated with all antenna elements, which is obtained by transmitting or receiving sounding PPDUs over all antennas. These sounding PPDUs should be sent within a single TXOP. To avoid channel distortions, these sounding PPDUs shall be transmitted consecutively. The training information is exchanged using the HT Control field. When both transmitter and receiver have ASEL capabilities, training of transmit and receive antennas can be done one after another. ASEL supports up to eight antennas and up to four RF chains.

9.20.2 Procedure

A STA shall not initiate an ASEL training frame exchange sequence with another STA unless that STA supports ASEL, as determined by the ASEL Capability field (see 7.3.2.56.7).

A STA that is capable of supporting ASEL should set each subfield of the ASEL Capability field of the HT Capabilities element to 1 depending on its capabilities in HT Capabilities elements that it transmits (See 7.3.2.56.7).

A STA that sets the Explicit CSI Feedback Based Tx ASEL Capable subfield of the ASEL Capability field (see 7.3.2.56.7) to 1 shall set the CSI Max Number of Rows Beamformer Supported subfield of the Transmit Beamforming Capabilities field to an appropriate value, even if the STA sets the Explicit Transmit Beamforming CSI Feedback subfield to a zero value.

The frame exchange sequence for transmit ASEL is shown in Figure 9-36, where the term *ASEL transmitter* identifies the STA that is conducting transmit ASEL, and the term *transmit ASEL responder* identifies the STA that provides ASEL feedback. The frame exchange comprises the following steps:

a) (Optional) A transmit ASEL responder may initiate the transmit ASEL training by sending a +HTC frame with the ASEL Command subfield set to Transmit Antenna Selection Sounding Request (TXASSR).

b) The ASEL transmitter sends out consecutive sounding PPDUs separated by SIFS in a TXOP of which it is the TXOP holder with no ACK over different antenna sets, each PPDU containing a +HTC frame with the ASEL Command subfield set to Transmit Antenna Selection Sounding Indication (TXASSI or TXASSI-CSI). Each sounding PPDU is transmitted over one antenna set.

   If the ASEL transmitter allows antenna indices feedback (by setting the ASEL Command subfield to TXASSI), the antenna sets from which the sounding PPDUs are transmitted shall be disjoint. If the ASEL transmitter uses NDP sounding PPDUs for the ASEL sounding, the spatial mapping matrix Q_k shall be set equal to the identity matrix starting with the first NDP. If the ASEL transmitter uses non-NDP sounding PPDUs for the ASEL sounding, the spatial mapping matrix Q_k shall be an FFT matrix. An FFT matrix of size N is defined as a square matrix of dimension NxN with entries w_{im}, i=$0,..N-1$, $m=0,..N-1$ where $w_{im} = \frac{1}{\sqrt{N}} \times \exp\left(-j2\pi\frac{im}{N}\right)$.

The ASEL transmitter shall not include TXASSI-CSI in the command field of the sounding frame if the last received value of the Explicit CSI Feedback Capable subfield of the ASEL Capability field (see 7.3.2.56.7) from the receiver was zero.

NOTE—For example, in the case of sounding over all disjointed antenna sets, the number of consecutive sounding PPDUs equals the smallest integer that is greater than or equal to the number of antennas divided by the number of RF chains. These sounding PPDUs should be sent within a single TXOP.

c) The transmit ASEL responder estimates the subchannel corresponding to each sounding PPDU.

d) If the ASEL Command subfield in the sounding frames is set to TXASSI-CSI, after receiving all the sounding PPDUs, the transmit ASEL responder shall respond with the full size CSI in a subsequent TXOP. If the ASEL Command subfield in the sounding frames is set to TXASSI, after receiving all the sounding PPDUs, the transmit ASEL responder may either respond with the full size CSI in a subsequent TXOP, or conduct ASEL computation and provide the selected antenna indices in a subsequent TXOP.

   1) CSI is transported using the MIMO CSI Matrices frame defined in 7.4.10.6 contained within either an Action No Ack or Action frame. Multiple CSI frames may be required to provide the complete feedback, in which case the value of the Sounding Timestamp field within each of these CSI frames shall correspond to the arrival time of the sounding frame that was used to generate the feedback information contained in the frame.

   2) Antenna indices feedback is carried in the Antenna Selection Indices Feedback frame, defined in 7.4.10.9. One octet of the Antenna Selection Indices field is used to carry the selected antenna indices feedback.

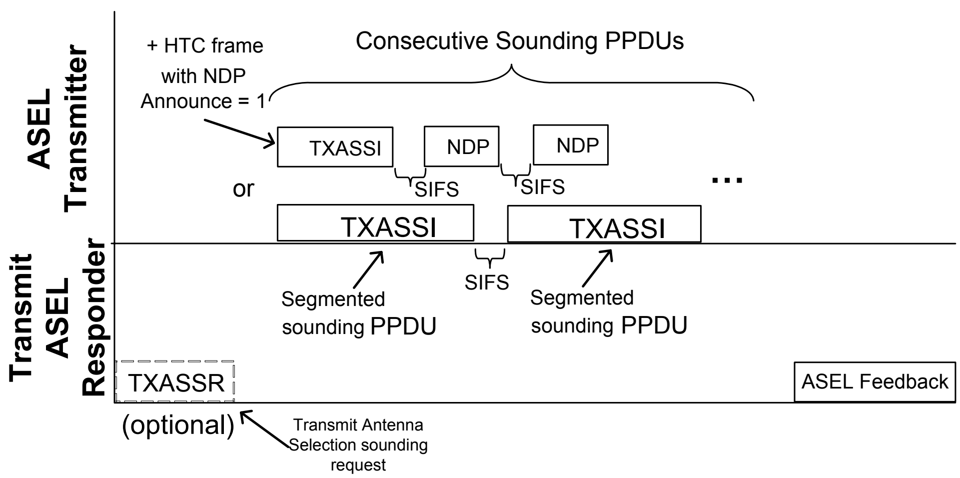


Figure 9-36—Transmit ASEL

If the transmit ASEL responder does not correctly receive all the sounding PPDUs but has correctly received at least one of the preceding sounding PPDUs, it shall send a +HTC frame with the MAI subfield set to the value ASELI (see Table 7-6a), the ASEL Command subfield set to No Feedback Due to ASEL Training Failure or Stale Feedback to indicate the failure of the ASEL training process, and the ASEL Data subfield set to either of the following:

— The integer value corresponding to the number in sequence of the first sounding PPDU that was not properly received, where 0 corresponds to the first sounding PPDU in the ASEL training sequence or

— Zero

A transmit ASEL responder that determines that the ASEL feedback is stale shall notify the ASEL transmitter by transmitting a +HTC MPDU with the MAI subfield set to ASELI, the ASEL Command subfield set to No Feedback Due to ASEL Training Failure or Stale Feedback, and the ASEL Data subfield set to 0.

If, in response to the transmission of a sequence of sounding PPDUs, the ASEL transmitter receives a +HTC MPDU with the MAI subfield set to ASELI, the ASEL Command subfield set to No Feedback Due to ASEL Training Failure or Stale Feedback, and the ASEL Data subfield set to a nonzero value to indicate a failed ASEL training frame sequence, the ASEL transmitter may perform any of the following actions:

— Do nothing.
— Restart the failed ASEL training frame sequence from the point of failure by transmitting a +HTC MPDU with the MAI subfield set to ASELI, the ASEL Command subfield set to TXASSR, and the ASEL Data subfield set to a nonzero value to correspond to the command Transmit Antenna Selection Sounding Resumption (a Resumption MPDU), where the ASEL Data subfield value is the order number (from the original training frame sequence) of the first sounding PPDU transmitted in the restarted ASEL training frame sequence and where 0 corresponds to the first sounding PPDU in the original ASEL training sequence.
— Execute a new ASEL training frame sequence by transmitting a +HTC MPDU with the MAI subfield set to ASELI, the ASEL Command subfield set to TXASSI or TXASSI-CSI, and the ASEL Data subfield set to a nonzero value.

If a transmit ASEL responder receives a +HTC MPDU with the MAI subfield set to ASELI, the ASEL Command subfield set to TXASSR, and the ASEL Data subfield set to a nonzero value to correspond to the command Transmit Antenna Selection Sounding Resumption (a Resumption MPDU), the transmit ASEL responder shall respond to the training sequence according to the original command value (i.e., TXASSI or TXASSI-CSI) and shall assume a total number of sounding PPDUs that corresponds to the number of sounding PPDUs from the original command frame. The number of sounding frames that follow the Resumption MPDU is equal to the number of sounding PPDUs from the original command frame minus the order number transmitted in the ASEL Data subfield of the Resumption MPDU.

The frame exchange sequence for receive ASEL is shown in Figure 9-37, where the term *ASEL receiver* identifies the STA that is conducting receive ASEL, and the term *ASEL sounding-capable transmitter* identifies the STA sending the consecutive sounding PPDUs used for receive ASEL calculations. The frame exchange comprises the following steps:

— The ASEL receiver transmits a +HTC frame with the MAI subfield set to ASELI, the ASEL Command subfield set to Receive Antenna Selection Request (RXASSR), and the ASEL Data subfield set to the number of sounding PPDUs required.

  NOTE— For example, in the case of sounding over all disjointed antenna sets, the number of total consecutive sounding PPDUs or NDPs equals the smallest integer that is greater than or equal to the number of antennas divided by the number of RF chains.

— The ASEL sounding-capable transmitter responds with the corresponding number of sounding PPDUs in its subsequent TXOP. These PPDUs are separated by SIFS. When using non-NDP sounding, each PPDU contains a +HTC frame in which the MAI subfield is set to ASELI, the ASEL Command subfield is set to Receive Antenna Selection Sounding Indication (RXASSI), and the ASEL Data subfield is set to the remaining number of sounding PPDUs to be transmitted. When using NDP sounding, the PPDU that precedes the first NDP contains a +HTC frame in which the NDP Announce field is set to 1, the MAI subfield is set to ASELI, the ASEL Command subfield is set to RXASSI, and the ASEL Data subfield is set to the remaining number of sounding PPDUs to be transmitted.

The ASEL receiver uses different antenna sets to receive these sounding PPDUs, estimates CSI after receiving all these sounding PPDUs, and conducts the ASEL.

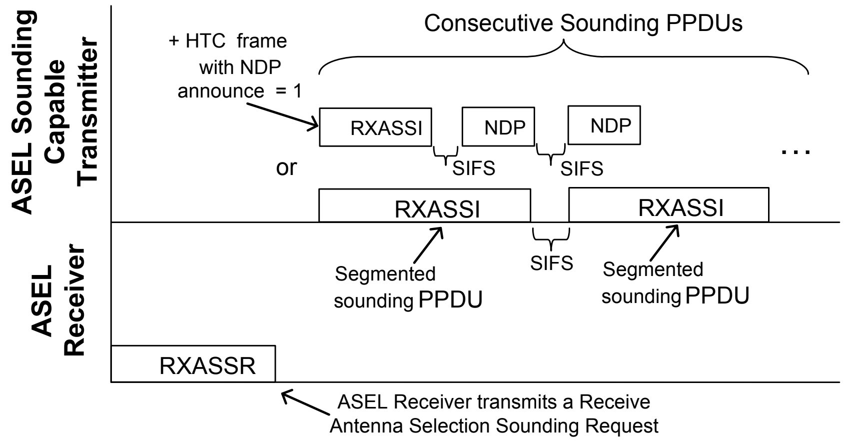


Figure 9-37—Receive ASEL

When transmitting the consecutive sounding PPDUs in transmit and receive ASEL exchanges (illustrated in Figure 9-36 and Figure 9-37), the transmitter shall not change the TXPWR_LEVEL parameter of the TXVECTOR.

When transmitting a sounding PPDU sent in transmit and receive ASEL exchanges (illustrated in Figure 9-36 and Figure 9-37), if the Receive Staggered Capability subfield of the Transmit Beamforming Capability field of the HT Capabilities element transmitted by the intended receiver is zero, then,

— If the sounding PPDU is not an NDP, the number of antennas used by the sender, as indicated by the ANTENNA_SET parameter in the TXVECTOR, shall be less than or equal to the maximum number of space-time streams indicated by the Rx MCS Bitmask subfield of the Supported MCS Set field and the Rx STBC subfield of the HT Capabilities element transmitted by the intended receiver.

— If the sounding PPDU is an NDP, the number of antennas used by the sender, as indicated by the ANTENNA_SET parameter in the TXVECTOR, shall be less than or equal to the number indicated by the Channel Estimation Capability subfield of the Transmit Beamforming Capability field of the HT Capabilities element transmitted by the intended receiver.

When both transmitter and receiver have ASEL capabilities, the following constraints apply:

— During a transmit ASEL frame exchange, the transmit ASEL responder shall use a subset of antennas that does not change during the reception of all of the sounding PPDUs of the ASEL sounding sequence.

— During a receive ASEL frame exchange, the ASEL sounding-capable transmitter shall use a subset of antennas that does not change during the transmission of all of the sounding PPDUs of the ASEL sounding sequence.

NOTE—When a receiver (either a transmit ASEL responder or an ASEL receiver) conducts ASEL computations (for either transmit or receive ASEL), if there is no transmit beamforming conducted at the same time, to achieve the best performance of ASEL, the receiver should assume that the first N_{STS} columns of the same spatial mapping matrix Q_k used for transmitting ASEL sounding PPDUs, where N_{STS} is the number of space-time streams, will be applied for the spatial mapping at the ASEL transmitter after the ASEL exchange as in Figure 9-36 and Figure 9-37. To achieve the best performance of ASEL, the ASEL transmitter should apply the first N_{STS} columns of the same Q_k for spatial mapping after the ASEL exchange as in Figure 9-36 and Figure 9-37.

9.21 Null data packet (NDP) sounding

9.21.1 NDP rules

Sounding may be accomplished using either staggered sounding PPDU or NDP, as described in 20.3.13. The MAC rules associated with sounding using NDP are described in 9.21.1 to 9.21.4.

An HT STA that has set the Receive NDP Capable field of its HT Capabilities element to 1 during association processes an NDP as a sounding packet if the destination of the sounding packet is determined to match itself as described in 9.21.3 and if the source of the sounding packet can be ascertained as described in 9.21.4.

An RXVECTOR LENGTH parameter set to 0 indicates that the PPDU is an NDP.

A STA that is a TXOP holder or an RD responder shall not set both the NDP Announcement and RDG/More PPDU subfields to 1 simultaneously. The Calibration Position subfield shall not be set to any value except 0 and 1 in any +HTC frame in a PPDU that is also an NDP announcement. The Calibration Position subfield shall be set to 0 in any +HTC frame in a PPDU that is an NDP announcement that also contains any +HTC frame with the MAI subfield set to ASELI. The Calibration Position subfield shall be set to 0 in all +HTC frames in a PPDU that is an NDP announcement and that contains any +HTC frame with the MRQ subfield set to 1. The TRQ field shall be set to 0 in all +HTC frames in a PPDU that is an NDP announcement.

An NDP sequence contains at least one non-NDP PPDU and at least one NDP PPDU. Only one PPDU in the NDP sequence may contain an NDP announcement. An NDP sequence begins with an NDP announcement. The NDP sequence ends at the end of the transmission of the last NDP PPDU that is announced by the NDP announcement. A STA that transmits the first PPDU of an NDP sequence is the NDP sequence owner. In the NDP sequence, only PPDUs carrying NDP and PPDUs carrying non-A-MPDU control frames may follow the NDP sequence's starting PPDU.

A STA shall transmit only one NDP per NDP announcement, unless the NDP announcement includes a value in the ASEL Data subfield of the ASEL Command subfield of the HTC Control field that is greater than one. Each PPDU in an NDP sequence shall start a SIFS interval after end of the previous PPDU.

The +HTC field of a CTS frame shall not contain the NDP Announcement subfield set to 1.

NOTE—A CTS frame cannot be used for NDP announcement: if the CTS frame is a response to an RTS frame, the optional NAV reset timeout that starts at the end of the RTS frame does not include the additional NDP and SIFS duration (see 9.2.5.4). Also, if the CTS were the first frame of an NDP sequence, it would not be possible to determine the destination address of the NDP.

A STA shall transmit an NDP as follows:

a) A SIFS interval after sending a PPDU that is an NDP announcement and that does not contain an MPDU that requires an immediate response.

b) A SIFS interval after successfully receiving a correctly formed and addressed immediate response to a PPDU that is an NDP announcement and that contains an MPDU that requires an immediate response.

c) A SIFS interval after transmitting an NDP if the NDP announcement contains an ASEL Command subfield set to TXASSI, TXASSI-CSI, or RXASSI and the ASEL Data subfield is set to value greater than zero and if the number of NDPs sent before this one is less than the value in the ASEL Data subfield + 1.

NOTE—The total number of sent NDPs is equal to the value of in the ASEL Data subfield + 1.

d) A SIFS interval after receiving an NDP from a STA whose NDP announcement contained one or more +HTC frames with the Calibration Position subfield set to 1, when the receiving STA supports transmitting sounding PPDUs for which more than one channel dimension can be estimated (i.e., more than one column of the MIMO channel matrix).

This rule enables the NDP receiver to know that it will receive an NDP and can determine the source and destination of the NDP. It enables the receiver and transmitter to know when the immediate response and NDP will be transmitted relative to the frame containing the NDP announcement indication.

A STA that has transmitted an NDP announcement in a frame that requires an immediate response and that does not receive the expected response shall terminate the NDP sequence at that point (i.e., the STA does not transmit an NDP in the current NDP sequence).

A STA that has received an NDP announcement in a +HTC with the Calibration Position set to 1 or 2, and that does not receive the NDP PPDU expected shall terminate the NDP sequence at that point (i.e., does not transmit an NDP in the current NDP sequence) and not transmit any further frames that are a part of this calibration sequence shown in Step 1 of Figure 9-34.

Feedback information generated from the reception of an NDP is transmitted using any of the feedback rules and signaling as appropriate, e.g., immediate or delayed.

9.21.2 Transmission of an NDP

A STA that transmits an NDP shall set the LENGTH, SOUNDING, STBC, MCS, and NUM_EXTEN_SS parameters of the TXVECTOR as specified in this subclause.

- LENGTH shall be set to 0.
- SOUNDING shall be set to SOUNDING.
- STBC shall be set to 0.
- MCS shall indicate two or more spatial streams.

The number of spatial streams sounded is indicated by the MCS parameter of the TXVECTOR and shall not exceed the limit indicated by the Channel Estimation Capability field in the Transmit Beamforming Capabilities field transmitted by the STA that is the intended receiver of the NDP. The MCS parameter may be set to any value, subject to the constraint of the previous sentence, regardless of the value of the Supported MCS Set field of the HT Capabilities field at either the transmitter or recipient of the NDP. A STA shall set the NUM_EXTEN_SS parameter of the TXVECTOR to 0 in the PHY-TXSTART.request primitive corresponding to an NDP transmission.

A STA shall not transmit an NDP announcement with a RA corresponding to another STA unless it has received an HT Capabilities element from the destination STA in which the Receive NDP Capable field is set to 1.

9.21.3 Determination of NDP destination

The destination of an NDP is determined at the NDP receiver by examining the NDP announcement as follows:

- The destination of the first NDP in the NDP sequence is equal to the RA of any MPDU within NDP announcement.
- If Calibration Position subfield is set to 1 in the NDP announcement at the NDP receiver, the destination of the second NDP is equal to the TA of that frame. Otherwise, the destination of the second and any subsequent NDPs is equal to the destination of the previous NDP.

See T.4 for an illustration of these rules.

9.21.4 Determination of NDP source

The source of an NDP is determined at the NDP receiver by examining the NDP sequences's starting PPDU as follows:

- If any MPDU within the NDP announcement contains two or more addresses, the source of the first NDP is equal to the TA of that frame.
- Otherwise (i.e., the NDP announcement contains one address), the source of the first NDP is equal to the RA of the MPDU to which the NDP announcement is a response.
- If the Calibration Position subfield is set to 1 in an MPDU in the NDP announcement, the source of the second NDP is equal to the RA of that MPDU. Otherwise, the source of the second and any subsequent NDPs is equal to the source of the previous NDP.

See T.4 for an illustration of these rules.

10. Layer management

10.3 MLME SAP interface

10.3.2 Scan

10.3.2.2 MLME-SCAN.confirm

10.3.2.2.2 Semantics of the service primitive

Change the second paragraph of 10.3.2.2.2 as follows:

Each BSSDescription consists of the ~~following~~ elements shown in the following table.~~:~~ The “IBSS adoption” column indicates whether

a) This parameter is adopted by a STA that is joining an IBSS.

b) This parameter is adopted by a STA that is a member of an IBSS that receives a beacon from a STA that is a member of the same IBSS and that has a timestamp value that is greater than the local TSF value (see 11.1.4).

Change the BSSDescription table in 10.3.2.2.2 as follows (note that not all table cells are shown here):

Name	Type	Valid range	Description	IBSS adoption
BSSID, SSID, BSSType, Beacon Period, DTIM Period, Timestamp	*The text in these table cells remains unchanged for these rows.*			Adopt
Local Time	Integer	N/A	The value of the STA’s TSF timer at the start of reception of the first octet of the timestamp field of the received frame (probe response or beacon) from the found BSS.	Do not adopt
PHY Parameter Set	*The text in these table cells remains unchanged for these rows.*			Adopt
CF Parameter Set	As defined in frame format	As defined in ~~frame format~~ 7.3.2.5	The parameter set for the CF periods, if found BSS supports CF mode.	Do not adopt
IBSS Parameter Set	*The text in these table cells remains unchanged for these rows.*			Adopt
CapabilityInformation	As defined in frame format	As defined in ~~frame format~~ 7.3.1.4	The advertised capabilities of the BSS.	Do not adopt
BSSBasic Rate Set	*The text in these table cells remains unchanged for these rows.*			Adopt
OperationalRate Set	Set of integers	1–127 inclusive (for each integer in the set)	The set of data rates that the STA desires to use for communication within the BSS. The STA must be able to receive at each of the data rates listed in the set. This set is a superset of the rates contained in the BSSBasicRateSet parameter.	Do not adopt

Name	Type	Valid range	Description	IBSS adoption
Country, IBSS DFS Recovery Interval	*The text in these table cells remains unchanged for these rows.*			Adopt
RSN	RSN information element	As defined in ~~frame format~~ 7.3.2.25	A description of the cipher suites and AKM suites supported in the BSS	Do not adopt
Load	As defined in frame format	As defined in ~~frame format~~ 7.3.2.28	The values from the BSS Load information element if such an element was present in the probe response or Beacon frame, else null.	Do not adopt
EDCAParameter Set, QoSCapability, AP Channel Report, BSS Average Access Delay, Antenna Information, BSS Available Admission Capacity, BSS AC Access Delay, Measurement Pilot Transmission Information, Mutliple BSSID, RRM Enabled Capabilities, RCPIMeasurement, RSNI-Measurement, Requested information elements, DESERegistered Location	*The text in these table cells remains unchanged for these rows.*			Adopt
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	The values from the HT Capabilities element if such an element was present in the Probe Response or Beacon frame, else null. The parameter may be present only if the MIB attribute dot11HighThroughput-OptionImplemented is TRUE.	Do not adopt
HT Operation	As defined in frame format	As defined in 7.3.2.57	The values from the HT Operation element if such an element was present in the Probe Response or Beacon frame, else null. The parameter may be present only if the MIB attribute dot11HighThroughput-OptionImplemented is TRUE.	Adopt
BSSMembershipSelectorSet	set of integers	A value from Table 7-26a for each member of the set	The BSS membership selectors that represent the set of features that shall be supported by all STAs to join this BSS.	Adopt

Name	Type	Valid range	Description	IBSS adoption
BSSBasicMCSSet	Set of integers	Each member of the set takes a value in the range 0 to 76, representing an MCS index value	The set of MCS values that shall be supported by all HT STAs to join this BSS. The STA that is creating the BSS shall be able to receive and transmit at each of the MCS values listed in the set.	Adopt
HTOperational MCSSet	Set of integers	Each member of the set takes a value in the range 0 to 76, representing an MCS index value	The set of MCS values that the STA desires to use for communication within the BSS. The STA must be able to receive at each of the data rates listed in the set. This set is a superset of the MCS values contained in the BSSBasicMCSSet parameter.	Do not adopt
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.	Do not adopt
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.	Do not adopt
Overlapping BSS Scan Parameters	As defined in frame format	As defined in 7.3.2.59	Specifies the parameters within the Overlapping BSS Scan Parameters element that are indicated by the MAC entity. This parameter may be present if the dot11FortyMHzOptionImplemented attribute is TRUE and shall not be present if the dot11FortyMHzOptionImplemented attribute is false.	Adopt

10.3.3 Synchronization

10.3.3.1 MLME-JOIN.request

10.3.3.1.2 Semantics of the service primitive

Change the primitive parameters in 10.3.3.1.2 as follows:

The primitive parameters are as follows:

MLME-JOIN.request(
SelectedBSS,
JoinFailureTimeout,
ProbeDelay,
OperationalRateSet,
<u>HTOperationalMCSSet,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.3.1.2:

Name	Type	Valid range	Description
HTOperational MCSSet	Set of integers	0–76, representing an MCS index value (for each member of the set)	The set of MCS values that the STA desires to use for communication within the BSS. The STA must be able to receive at each of the data rates listed in the set. This set is a superset of the MCS values contained in the BSSBasicMCSSet parameter.

10.3.3.1.4 Effect of receipt

Insert the following paragraphs at the end of 10.3.3.1.4:

If an MLME receives an MLME-JOIN.request with the SelectedBSS parameter containing a BSSBasicRateSet element that contains any unsupported rates, the MLME response in the resulting MLME-JOIN.confirm shall contain a ResultCode parameter that is not set to the value SUCCESS.

If the MLME of an HT STA receives an MLME-JOIN.request with the SelectedBSS parameter containing a BasicMCSSet element that contains any unsupported MCSs, the MLME response in the resulting MLME-JOIN.confirm shall contain a ResultCode parameter that is not set to the value SUCCESS.

10.3.6 Associate

10.3.6.1 MLME-ASSOCIATE.request

10.3.6.1.2 Semantics of the service primitive

Change the primitive parameters in 10.3.6.1.2 as follows:

The primitive parameters are as follows:

MLME-ASSOCIATE.request(
PeerSTAAddress,
AssociateFailureTimeout,
CapabilityInformation,
ListenInterval,
Supported Channels,
RSN,
QoSCapability,
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
<u>HT Capabilities,</u>
<u>Extended Capabilities,</u>
<u>20/40 BSS Coexistence,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.6.1.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot11HighThroughputOption-Implemented is TRUE and shall be absent otherwise.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.6.2 MLME-ASSOCIATE.confirm

10.3.6.2.2 Semantics of the service primitive

Change the primitive parameters of 10.3.6.2.2 as shown:

The primitive parameters are as follows:

MLME-ASSOCIATE.confirm(
ResultCode,
CapabilityInformation,
AssociationID,
SupportedRates,
EDCAParameterSet,
RCPI.request,
RSNI.request,
RCPI.response,
RSNI.response,
RRMEnabledCapabilities
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
<u>HT Capabilities,</u>
<u>Extended Capabilities,</u>
<u>20/40 BSS Coexistence,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.6.2.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are to be used by the peer MAC entity (AP). The parameter may be present if the MIB attribute dot11HighThroughputOptionImplemented is TRUE; otherwise, this parameter shall not be present.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.6.3 MLME-ASSOCIATE.indication

10.3.6.3.2 Semantics of the service primitive

Change the primitive parameters of 10.3.6.3.2 as shown:

The primitive parameters are as follows:

MLME-ASSOCIATE.indication(
PeerSTAAddress,
CapabilityInformation,
ListenInterval,
SSID,
SupportedRates,
RSN,
QoSCapability,
RCPI,
RSNI,
RRMEnabledCapabilities,
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
DSERegisteredLocation,
<u>HT Capabilities,</u>
<u>Extended Capabilities,</u>
<u>20/40 BSS Coexistence,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.6.3.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the peer MAC entity. The parameter may be present only if the MIB attribute dot11HighThroughput-OptionImplemented is TRUE.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.6.4 MLME-ASSOCIATE.response

10.3.6.4.2 Semantics of the service primitive

Change the primitive parameters in 10.3.6.4.2 as shown:

The primitive parameters are as follows:

MLME-ASSOCIATE.response(
PeerSTAAddress,
ResultCode,
CapabilityInformation,
AssociationID,
EDCAParameterSet,
RCPI,
RSNI,
RRMEnabledCapabilities,
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
DSERegisteredLocation,
<u>HTCapabilities,</u>
<u>Extended Capabilities,</u>
<u>20/40 BSS Coexistence,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.6.4.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the peer MAC entity. The parameter shall be present if the MIB attribute dot11HighThroughput-OptionImplemented is TRUE and shall be absent otherwise.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.7 Reassociate

10.3.7.1 MLME-REASSOCIATE.request

10.3.7.1.2 Semantics of the service primitive

Change the primitive parameters in 10.3.7.1.2 as follows:

The primitive parameters are as follows:

MLME-REASSOCIATE.request(
NewAPAddress,
ReassociateFailureTimeout,
CapabilityInformation,
ListenInterval,
Supported Channels,
RSN,
QoSCapability,
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.7.1.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot11HighThroughputOption-Implemented is TRUE and shall be absent otherwise.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.7.2 MLME-REASSOCIATE.confirm

10.3.7.2.2 Semantics of the service primitive

Change the primitive parameters in 10.3.7.2.2 as follows:

The primitive parameters are as follows:

MLME-REASSOCIATE.confirm(
ResultCode,
CapabilityInformation,
AssociationID,
SupportedRates,
EDCAParameterSet,
RCPI.request,
RSNI.request,
RCPI.response,
RSNI.response,
RRMEnabledCapabilities,
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.7.2.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are to be used by the peer MAC entity (AP). The parameter may be present only if the MIB attribute dot11HighThroughputOptionImplemented is TRUE.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.7.3 MLME-REASSOCIATE.indication

10.3.7.3.2 Semantics of the service primitive

Change the primitive parameters in 10.3.7.3.2 as follows:

The primitive parameters are as follows:

MLME-REASSOCIATE.indication(
PeerSTAAddress,
CurrentAPAddress,
CapabilityInformation,
ListenInterval,
SSID,
SupportedRates,
RSN,
QoSCapability,
RCPI,
RSNI,
RRMEnabledCapabilities,
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
DSERegisteredLocation,
<u>HT Capabilities,</u>
<u>Extended Capabilities,</u>
<u>20/40 BSS Coexistence,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.7.3.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the peer MAC entity. The parameter may be present only if the MIB attribute dot11HighThroughput-OptionImplemented is TRUE.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.7.4 MLME-REASSOCIATE.response

10.3.7.4.2 Semantics of the service primitive

Change the primitive parameter list of 10.3.7.4.2 as shown:

The primitive parameters are as follows:

MLME-REASSOCIATE.response(
PeerSTAAddress,
ResultCode,
CapabilityInformation,
AssociationID,
EDCAParameterSet,
RCPI,
RSNI,
RRMEnabledCapabilities,
Content of FT Authentication Information Elements,
SupportedRegulatoryClasses,
DSERegisteredLocation,
HTCapabilities,
Extended Capabilities,
20/40 BSS Coexistence,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.7.4.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the peer MAC entity. The parameter shall be present if the MIB attribute dot11HighThroughputOptionImplemented is TRUE and shall be absent otherwise.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.

10.3.10 Start

10.3.10.1 MLME-START.request

10.3.10.1.2 Semantics of the service primitive

Change the primitive parameters in 10.3.10.1.2 as follows:

The primitive parameters are as follows:

MLME-START.request(
SSID,
BSSType,
BeaconPeriod,
DTIMPeriod,
CF parameter set,
PHY parameter set,
IBSS parameter set,
ProbeDelay,
CapabilityInformation,
BSSBasicRateSet,
OperationalRateSet,
Country,
IBSS DFS Recovery Interval,
EDCAParameterSet,
DSERegisteredLocation,
HT Capabilities,
HT Operation,
BSSMembershipSelectorSet,
BSSBasicMCSSet,
HTOperationalMCSSet,
Extended Capabilities,
20/40 BSS Coexistence,
Overlapping BSS Scan Parameters,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row of the untitled table defining the primitive parameters in 10.3.10.1.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format HT Capabilities element	As defined in 7.3.2.56	The HT capabilities to be advertised for the BSS. The parameter shall be present if the MIB attribute dot11HighThroughputOption-Implemented is TRUE; otherwise, this parameter shall not be present.
HT Operation	As defined in frame format HT Operation element	As defined in 7.3.2.57	The additional HT capabilities to be advertised for the BSS. The parameter shall be present if BSSType = INFRASTRUCTURE and the MIB attribute dot11HighThroughputOptionImplemented is TRUE; otherwise, this parameter shall not be present.

Name	Type	Valid range	Description
BSSMembershipSelectorSet	Set of integers	A value from Table 7-26a for each member of the set	The BSS membership selectors that represent the set of features that shall be supported by all STAs to join this BSS. The STA that is creating the BSS shall be able to support each of the features represented by the set.
BSSBasicMCSSet	Set of integers	Each member of the set takes a value in the range 0 to 76, representing an MCS index value	The set of MCS values that shall be supported by all HT STAs to join this BSS. The STA that is creating the BSS shall be able to receive and transmit at each of the MCS values listed in the set. If the HT Operation parameter includes a value of 1 for either the Dual Beacon field or the Dual CTS Protection field, the BSSBasicMCSSet parameter shall include at least one integer value in the range 0 to 7.
HTOperationalMCSSet	Set of integers	Each member of the set takes a value in the range 0 to 76, representing an MCS index value	The set of MCS values that the STA desires to use for communication within the BSS. The STA must be able to receive at each of the data rates listed in the set. This set is a superset of the MCS values contained in the BSSBasicMCSSet parameter.
Extended Capabilities	As defined in frame format	As defined in 7.3.2.27	Specifies the parameters within the Extended Capabilities element that are supported by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
20/40 BSS Coexistence	As defined in frame format	As defined in 7.3.2.60	Specifies the parameters within the 20/40 BSS Coexistence element that are indicated by the MAC entity. The parameter shall be present if the MIB attribute dot112040BSSCoexistence-ManagementSupport is TRUE.
Overlapping BSS Scan Parameters	As defined in frame format	As defined in 7.3.2.59	Specifies the parameters within the Overlapping BSS Scan Parameters element that are indicated by the MAC entity. This parameter may be present if the dot11FortyMHzOptionImplemented attribute is TRUE and shall not be present if the dot11FortyMHzOptionImplemented attribute is false.

10.3.10.1.4 Effect of receipt

Insert the following paragraphs at the end of 10.3.10.1.4:

If an MLME receives an MLME-START.request with a BSSBasicRateSet parameter containing any unsupported rates, the MLME response in the resulting MLME-START.confirm shall contain a ResultCode parameter that is not set to the value SUCCESS.

If the MLME of an HT STA receives an MLME-START.request with a BasicMCSSet parameter containing any unsupported MCSs, the MLME response in the resulting MLME-START.confirm shall contain a ResultCode parameter that is not set to the value SUCCESS.

10.3.15 Channel switch

10.3.15.1 MLME-CHANNELSWITCH.request

10.3.15.1.2 Semantics of the service primitive

Change the parameter list in 10.3.15.1.2 follows:

The primitive parameters are as follows:

MLME-CHANNELSWITCH.request(
Mode,
Channel Number,
<u>Secondary Channel Offset,</u>
Channel Switch Count,
VendorSpecificInfo
)

Insert the following row before the Channel Switch Count row in the untitled table defining the primitive parameters in 10.3.15.1.2:

Name	Type	Valid range	Description
Secondary Channel Offset	Integer	As in Table 7-27a	Specifies the position of secondary channel in relation to the primary channel. The parameter shall be present if the MIB attribute dot11FortyMHzOperationImplemented is TRUE; otherwise, the parameter shall not be present.

Insert the following paragraph at the end of 10.3.15.1.2:

The Secondary Channel Offset parameter may be present for HT STAs.

10.3.15.3 MLME-CHANNELSWITCH.indication

10.3.15.3.2 Semantics of the service primitive

Change the parameter list in 10.3.15.3.2 as follows:

The primitive parameters are as follows:

MLME-CHANNELSWITCH.indication(
Peer MAC Address,
Mode,
Channel Number,
Secondary Channel Offset,
Channel Switch Count,
VendorSpecificInfo
)

Insert the following row before the Channel Switch Count row in the untitled table defining the primitive parameters in 10.3.15.3.2:

Name	Type	Valid range	Description
Secondary Channel Offset	Integer	As in Table 7-27a	Specifies the position of secondary channel in relation to the primary channel. The parameter may be present only if the MIB attribute dot11FortyMHzOperationImplemented is TRUE.

10.3.15.4 MLME-CHANNELSWITCH.response

10.3.15.4.2 Semantics of the service primitive

Change the parameter list in 10.3.15.4.2 as follows:

The primitive parameters are as follows:

MLME-CHANNELSWITCH.response(
Mode,
Channel Number,
Secondary Channel Offset,
Channel Switch Count,
VendorSpecificInfo
)

Insert the following line before the Channel Switch Count row in the untitled table defining the primitive parameters in 10.3.15.4.2:

Name	Type	Valid range	Description
Secondary Channel Offset	Integer	As in Table 7-27a	Specifies the position of secondary channel in relation to the primary channel. The parameter may be present only if the MIB attribute dot11FortyMHzOperationImplemented is TRUE.

10.3.24 TS management interface

10.3.24.5 MLME-DELTS.request

10.3.24.5.2 Semantics of the service primitive

Change the ReasonCode row in the untitled table describing primitive parameters in 10.3.24.5.2 as follows:

Name	Type	Valid range	Description
ReasonCode	Enumeration	STA_LEAVING, END_TS, UNKNOWN_TS, SERVICE_CHANGE_PRECLUDES_TS	Indicates the reason why the TS is being deleted.

10.3.24.7 MLME-DELTS.indication

10.3.24.7.2 Semantics of the service primitive

Change the ReasonCode row in the untitled table describing primitive parameters in 10.3.24.7.2 as follows:

Name	Type	Valid range	Description
ReasonCode	Enumeration	STA_LEAVING, END_TS, UNKNOWN_TS, TIMEOUT, SERVICE_CHANGE_PRECLUDES_TS	Indicates the reason why the TS is being deleted.

10.3.25 Management of direct links

10.3.25.2 MLME-DLS.confirm

10.3.25.2.2 Semantics of the service primitive

Change the parameter list in 10.3.25.2.2 as follows:

The primitive parameters are as follows:

MLME-DLS.confirm (
PeerMACAddress,
ResultCode,
CapabilityInformation,
DLSTimeoutValue,
SupportedRates,
HT Capabilities
)

Insert the following line at the end of the untitled table describing primitive parameters in 10.3.25.2.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the MAC entity. The parameter may be present only if the MIB attribute dot11HighThroughputOptionImplemented is TRUE.

10.3.25.3 MLME-DLS.indication

10.3.25.3.2 Semantics of the service primitive

Change the parameter list in 10.3.25.3.2 as follows:

The primitive parameters are as follows:

MLME-DLS.indication (
PeerMACAddress,
CapabilityInformation,
DLSTimeoutValue,
DLSResponseTimeout,
HT Capabilities
)

Insert the following line at the end of the untitled table describing primitive parameters in 10.3.25.3.2:

Name	Type	Valid range	Description
HT Capabilities	As defined in frame format	As defined in 7.3.2.56	Specifies the parameters within the HT Capabilities element that are supported by the MAC entity. The parameter may be present only if the MIB attribute dot11HighThroughputOptionImplemented is TRUE.

10.4 PLME SAP interface

10.4.3 PLME-CHARACTERISTICS.confirm

10.4.3.2 Semantics of the service primitive

Change the primitive parameters as shown:

The primitive parameters are as follows:

PLME-CHARACTERISTICS.confirm(
aSlotTime,
aSIFSTime,
aSignalExtension,
aCCATime,
aPHY-RX-START-Delay,
aRxTxTurnaroundTime,
aTxPLCPDelay,
aRxPLCPDelay,
aRxTxSwitchTime,
aTxRampOnTime,
aTxRampOffTime,
aTxRFDelay,
aRxRFDelay,
aAirPropagationTime,
aMACProcessingDelay,
aPreambleLength,
aRIFSTime,
aSymbolLength,
aSTFOneLength,
aSTFTwoLength,
aLTFOneLength,
aLTFTwoLength,
aPLCPHeaderLength,
aPLCPSigTwoLength,
aPLCPServiceLength,
aPLCPConvolutionalTailLength,
aMPDUDurationFactor,
aMPDUMaxLength,
aPSDUMaxLength,
aPPDUMaxTime,
aIUSTime,
aDTT2UTTTime,
aCWmin,
aCWmax,
aMaxCSIMatricesReportDelay
)

Change the last paragraph of the subclause as follows:

The values assigned to the parameters shall be as specified in the PLME SAP interface specification contained within each PHY subclass of this standard. The parameters aSignalExtension, aRIFSTime, aSymbolLength, aSTFOneLength, aSTFTwoLength, aLTFOneLength, aLTFTwoLength, aPLCPSigTwoLength, aPLCPServiceLength, aPLCPConvolutionalTailLength, aMPDUDurationFactor, aMPDUMaxLength, aPSDUMaxLength, aPPDUMaxTime, aIUSTime aDTT2UTTTime and aMaxCSI-MatricesReportDelay are not used by all PHYs defined within this standard.

Insert the following row before the aCCATime row in the untitled table defining the primitive parameters in 10.4.3.2:

Name	Type	Description
aSignalExtension	integer	Duration (in microseconds) of the signal extension (i.e., a period of no transmission) that is included at the end of certain PPDU formats; see 20.3.2 and 9.2.10a.

Insert the following rows before the aPLCPHeaderLength row in the untitled table defining the primitive parameters in 10.4.3.2:

Name	Type	Description
aRIFSTime	integer	Value of the reduced interframe space (in microseconds), which is the time by which multiple transmissions from a single transmitter may be separated, when no SIFS-separated response transmission is expected. See 9.2.3.0b.
aSymbolLength	integer	The current PHY's Symbol length (in microseconds). If the actual value of the length is not an integral number of μs, the value is rounded up to the next higher value.
aSTFOneLength	integer	Length of the non-HT-STF (L-STF) for HT-mixed format, and the HT-greenfield STF (HT-GF-STF) for HT-greenfield format (in microseconds)
aSTFTwoLength	integer	Length of the HT-STF (in microseconds)
aLTFOneLength	integer	Length of the First HT-LTF (in microseconds)
aLTFTwoLength	integer	Length of the Additional HT-LTFs (in microseconds)

Change the aPLCPHeaderLength row in the untitled table defining the primitive parameters in 10.4.3.2 as follows:

Name	Type	Description
aPLCPHeader-Length	integer	The current PHY's PLCP header length (in microseconds), excluding aPLCPSigTwoLength if present. If the actual value of the length of the modulated header is not an integral number of μs, the value is rounded up to the next higher value.

Insert the following rows before the aMPDUDurationFactor row in the untitled table defining the primitive parameters in 10.4.3.2:

Name	Type	Description
aPLCPSigTwo-Length	integer	Length of the HT SIGNAL field (HT-SIG) (in microseconds).
aPLCPServiceLength	integer	The length of the PLCP SERVICE field (in number of bits).
aPLCPConvolutionalTailLength	integer	The length of the sequence of convolutional code tail bits (in number of bits).

Insert the following rows before the aCWmin row in the untitled table defining the primitive parameters in 10.4.3.2:

Name	Type	Description
aPSDUMax-Length	integer	The maximum number of octets in a PSDU that can be conveyed by a PPDU.
aPPDUMaxTime	integer	The maximum duration of a PPDU in milliseconds.
aIUSTime	integer	The minimum time between the end of a PSMP-UTT and the start of the following PSMP-UTT in the same PSMP sequence.
aDTT2UTTTime	integer	The minimum time between the end of a PSMP-DTT and the start of the PSMP-UTT addressed to the same STA.

Insert the following row at the end of the untitled table defining the primitive parameters in 10.4.3.2:

Name	Type	Description
aMaxCSIMatriesReportDelay	integer	The maximum time (in milliseconds) between the reception of a frame containing a CSI Feedback Request or an NDP announcement and the transmission of the first CSI frame containing channel state information measured from the received Sounding Complete frame. See 9.19.2.4.4.

10.4.6 PLME-TXTIME.request

10.4.6.1 Function

Change 10.4.6.1 as follows:

This primitive is a request for the PHY to calculate the time that will be required to transmit onto the WM a PPDU containing a specified length ~~MPDU~~PSDU, and using a specified format, data rate, and signaling.

10.4.6.2 Semantics of the service primitive

Change 10.4.6.2 as follows:

This primitive provides the following parameters:

PLME-TXTIME.request(TXVECTOR)

The TXVECTOR represents a list of parameters that the MAC sublayer provides to the local PHY entity in order to transmit a~~n MPDU~~ PSDU, as further described in 12.3.4.4~~ and~~, 17.4 and 20.4 (which defines the local PHY entity).

10.4.6.3 When generated

Change 10.4.6.3 as follows:

This primitive is issued by the MAC sublayer to the PHY entity when the MAC sublayer needs to determine the time required to transmit a particular ~~MPDU~~PSDU.

11. MLME

11.1 Synchronization

11.1.2 Maintaining synchronization

11.1.2.1 Beacon generation in infrastructure networks

Insert the following paragraph at the end of 11.1.2.1:

An AP whose last transmitted values for the Tx STBC subfield and Rx STBC subfield of the HT Capabilities Info field of the HT Capabilities element are both nonzero may transmit an STBC Beacon frame and group-addressed traffic using the basic STBC MCS, as defined in 9.6.0c. An AP that transmits an STBC Beacon shall set the Dual Beacon field to 1 in transmitted HT Operation elements. The STBC Beacon field shall be set to 1 to identify an STBC Beacon frame. The TBTT for the STBC Beacon frame shall be offset by half of a beacon interval from the TBTT of the Beacon frame with the STBC Beacon field set to 0. Except for the setting of the STBC Beacon field, TIM field, and TSF field, all other fields inside the STBC Beacon frame shall be identical to the Beacon frame with the STBC Beacon field set to 0.

11.1.3 Acquiring synchronization, scanning

11.1.3.4 Synchronizing with a BSS

Change 11.1.3.4 as follows:

Upon receipt of an MLME-JOIN.request, a STA shall adopt the BSSID in the request. Upon receipt of a Beacon frame from the BSS, a STA shall adopt the channel synchronization information (applicable only if the STA contains an FH PHY), and TSF timer value of the parameters in the Beacon frame using the algorithm described in 11.1.2.4, and the MLME shall issue an MLME-JOIN.confirm indicating the operation was successful.

In addition to these synchronization parameters, a STA joining an infrastructure BSS will adopt each of the parameters found in the BSSDescription of the MLME-JOIN.request except Local time, Capability Information, ~~and~~ BSSBasicRateSet parameters, <u>and HT Capabilities element</u>. Local time is not adopted but is used as a local variable in adopting the TSF as described in 11.1.2.4. The Capability Information reflects the capabilities of the sender and is not adopted but may be used to determine local configuration or behavior. The BSSBasicRateSet parameter is not adopted but may determine if the STA can join the BSS. ~~A STA joining an IBSS will adopt the same parameters except the CF parameter set (since contention free period is not permitted in an IBSS).~~

If the JoinFailureTimeout timer expires prior to the receipt of a Beacon frame from the BSS, the MLME shall issue an MLME-JOIN.confirm indicating the operation was unsuccessful.

If the dot11MultiDomainCapabilityEnabled attribute is ~~true~~<u>TRUE</u>, a STA <u>that is joining an infrastructure BSS and</u> receiv<u>es</u>~~ing~~ a Beacon or Probe Response frame containing a Country information element shall adopt <u>all</u> the ~~all~~ parameters included in that Country information <u>element,</u> ~~element when joining a BSS~~ and the dot11RegDomainsSupportEntry shall be set to Other.

If a Hopping Pattern Parameters element is present in the Beacon or Probe Response frame, and if the dot11MultiDomainCapabilityEnabled attribute is ~~true~~<u>TRUE</u>, a STA <u>that is joining an infrastructure BSS</u> shall adopt the pattern parameters in the element and calculate the hopping patterns using one of the algorithms defined in 7.3.2.10 or 7.3.2.11. Using the appropriate pattern, set, and index values from the FH Parameter Set element, the STA shall adopt the values in use by the BSS when joining. The dot11RegDomainsSupportedValue shall be set to Other when the STA is operating using Country information element settings.

In addition to adopting the synchronization parameters as described in the first paragraph of this subclause, a STA joining an IBSS shall adopt each of the parameters found in the BSSDescription of the MLME-JOIN.request according to the rule found for that parameter in the "IBSS adoption" column of the matching row of the BSSDescription table found in 10.3.2.2.2. Parameters adopted by a STA when joining an IBSS shall not be changed by the STA except when adopting parameters following the reception of a Beacon frame with a later timestamp as described in 11.1.4.

In addition to the table entries in 10.3.2.2.2, if the dot11MultiDomainCapabilityEnabled attribute is TRUE, a STA that is joining an IBSS and receives a Beacon or Probe Response frame containing a Country information element shall adopt all the parameters included in that Country information element, and the dot11Reg-DomainsSupportEntry shall be set to Other.

In addition to the table entries in 10.3.2.2.2, if a Hopping Pattern Parameters element is present in the Beacon or Probe Response frame, and if the dot11MultiDomainCapabilityEnabled attribute is TRUE, a STA that is joining an IBSS shall adopt the pattern parameters in the element and calculate the hopping patterns using one of the algorithms defined in 7.3.2.10 or 7.3.2.11. Using the appropriate pattern, set, and index values from the FH Parameter Set element, the STA shall adopt the values in use by the IBSS when joining. The dot11RegDomainsSupportedValue shall be set to Other when the STA is operating using Country information element settings.

11.1.4 Adjusting STA timers

Change the third paragraph of 11.1.4 as follows:

All Beacon and Probe Response frames carry a Timestamp field. A STA receiving such a frame from another STA in an IBSS with the same SSID shall compare the Timestamp field with its own TSF time. If the Timestamp field of the received frame is later than its own TSF timer, the STA in the IBSS shall adopt each~~all~~ parameter~~s~~ contained in the Beacon frame according to the rule for that parameter found in the "IBSS adoption" column of the matching row of the BSSDescription table found in 10.3.2.2.2.~~, except the Capability bits, Supported Rates information element, and Extended Supported Rates information element.~~ Parameters adopted by a STA due to the receipt of a later timestamp shall not be changed by the STA except when adopting parameters due to a subsequently received Beacon frame with a later timestamp.

Insert the following subclause (11.1.6) after 11.1.5:

11.1.6 Supported rates and extended supported rates advertisement

A STA shall include rates from its OperationalRateSet parameter and BSS membership selectors from its BSSMembershipSelectorSet parameter in frames it transmits containing Supported Rates elements and Extended Supported Rates elements according to the rules described in this subclause.

For a STA supporting a combined total of eight or fewer data rates and BSS membership selectors, inclusion of the Extended Supported Rates element is optional in all of the frame types that include the Supported Rates element.

If the combined total of the number of rates in the OperationalRateSet parameter and the number of BSS membership selectors exceeds eight, then an Extended Supported Rate element shall be generated to specify the supported rates and BSS membership selectors that are not included in the Supported Rates element. If the BSSMembershipSelectorSet parameter contains at least one BSS membership selector, then at least one BSS membership selector value from the BSSMembershipSelectorSet parameter shall be included in the Supported Rates element.

NOTE—Inclusion of at least one BSS membership selector in the Supported Rates element ensures that a receiving STA that does not process the Extended Supported Rates element will still receive a BSS membership selector (which it considers to be a basic rate) that it does not support. Any values from the BSSMembershipSelectorSet parameter that are not transmitted in the Supported Rates element are transmitted in the Extended Supported Rates element.

11.2 Power management

11.2.1 Power management in an infrastructure network

Change 11.2.1 as follows:

STAs changing Power Management mode shall inform the AP of this fact using the Power Management bits within the Frame Control field of transmitted frames. The AP shall not arbitrarily transmit MSDUs or A-MSDUs to STAs operating in a PS mode, but shall buffer MSDUs and A-MSDUs and only transmit them at designated times.

The STAs that currently have buffered MSDUs or A-MSDUs within the AP are identified in a TIM, which shall be included as an element within all Beacon frames generated by the AP. A STA shall determine that an MSDU or A-MSDU is buffered for it by receiving and interpreting a TIM.

STAs operating in PS modes shall periodically listen for Beacon frames, as determined by the STA's ListenInterval and the ReceiveDTIMs parameter in the MLME-POWERMGT.request primitive.

In a BSS operating under the DCF, or during the CP of a BSS using the PCF, upon determining that an MSDU or A-MSDU is currently buffered in the AP, a STA operating in the *PS mode* shall transmit a short PS-Poll frame to the AP, which shall respond with the corresponding buffered MSDU or A-MSDU immediately, or acknowledge the PS-Poll and respond with the corresponding MSDU or A-MSDU at a later time. If the TIM indicating the buffered MSDU or A-MSDU is sent during a CFP, a CF-Pollable STA operating in the PS mode does not send a PS-Poll frame, but remains active until the buffered MSDU or A-MSDU is received (or the CFP ends). If any STA in its BSS is in PS mode, the AP shall buffer all ~~broadcast and multicast~~ group-addressed MSDUs and deliver them to all STAs immediately following the next Beacon frame containing a DTIM transmission.

A STA shall remain in its current Power Management mode until it informs the AP of a Power Management mode change via a frame exchange that includes an acknowledgment from the AP. Power Management mode shall not change during any single frame exchange sequence~~, as~~ (described in ~~9.12~~ Annex S).

A non-AP QoS STA may be in PS mode before the setup of DLS or Block Ack. Once DLS is set up with another non-AP QoS STA, the non-AP QoS STA suspends the PS mode and shall always be awake. When a STA enters normal (non-APSD) PS mode, any downlink Block Ack agreement without an associated schedule is suspended for the duration of this PS mode. MSDUs and A-MSDUs for TID without a schedule are sent using Normal Ack following a PS-poll as described in rest of this subclause. Uplink Block Acks, Block Acks for any TID with a schedule, and any Block Acks to APSD STA continue to operate normally.

11.2.1.1 STA Power Management modes

Change the second row of Table 11-1 as follows:

Table 11-1—Power Management modes

PS	STA listens to selected Beacon frames (based upon the ListenInterval parameter of the MLMEASSOCIATE.request primitive) and sends PS-Poll frames to the AP if the TIM element in the most recent Beacon frame indicates a directed MSDU or A-MSDU buffered for that STA. The AP shall transmit buffered directed MSDUs or A-MSDUs to a PS STA only in response to a PS-Poll from that STA, or during the CFP in the case of a CF-Pollable PS STA. In PS mode, a STA shall be in the Doze state and shall enter the Awake state to receive selected Beacon frames, to receive ~~broadcast and multicast~~ group-addressed transmissions following certain received Beacon frames, to transmit, and to await responses to transmitted PS-Poll frames or (for CF-Pollable STAs) to receive CF transmissions of buffered MSDUs or A-MSDUs.

11.2.1.2 AP TIM transmissions

Change 11.2.1.2 as follows:

The TIM shall identify the STAs for which traffic is pending and buffered in the AP. This information is coded in a *partial virtual bitmap*, as described in 7.3.2.6. In addition, the TIM contains an indication whether ~~broadcast/multicast~~group-addressed traffic is pending. Every STA is assigned an AID by the AP as part of the association process. AID 0 (zero) is reserved to indicate the presence of buffered ~~broadcast/multicast~~ group-addressed MSDUs. The AP shall identify those STAs for which it is prepared to deliver buffered MSDUs or A-MSDUs by setting bits in the TIM's partial virtual bitmap that correspond to the appropriate AIDs.

11.2.1.3 TIM types

Change the fourth paragraph of 11.2.1.3 as follows:

The third and fourth lines in Figure 11-4 depict the activity of two STAs operating with different power management requirements. Both STAs power-on their receivers when they need to listen for a TIM. This is indicated as a ramp-up of the receiver power prior to the TBTT. The first STA, for example, powers up its receiver and receives a TIM in the first Beacon frame; that TIM indicates the presence of a buffered MSDU or A-MSDU for the receiving STA. The receiving STA then generates a PS-Poll frame, which elicits the transmission of the buffered ~~data~~ MSDU or A-MSDU from the AP. ~~Broadcast and multicast~~Group-addressed MSDUs are sent by the AP subsequent to the transmission of a Beacon frame containing a DTIM. The DTIM is indicated by the DTIM Count field of the TIM element having a value of 0.

11.2.1.4 Power management with APSD

Change the fourth paragraph of 11.2.1.4 as follows:

If there is no unscheduled SP in progress, the unscheduled SP begins when the AP receives a trigger frame from a non-AP STA, which is a QoS data or QoS Null frame associated with an AC the STA has configured to be trigger-enabled. An A-MPDU that contains one or more trigger frames acts as a trigger frame. An unscheduled SP ends after the AP has attempted to transmit at least one MSDU, A-MSDU, or MMPDU associated with a delivery-enabled AC and destined for the non-AP STA, but no more than the number indicated in the Max SP Length field if the field has a nonzero value.

11.2.1.5 AP operation during the CP

Change the first paragraph of 11.2.1.5 as follows:

APs shall maintain a Power Management status for each currently associated STA that indicates in which Power Management mode the STA is currently operating. APs that implement and signal their support of APSD shall maintain an APSD and an access policy status for each currently associated non-AP STA that indicates whether the non-AP STA is presently using APSD and shall maintain the schedule (if any) for the non-AP STA. An AP shall, depending on the Power Management mode of the STA, temporarily buffer the MSDU, A-MSDU, or management frame destined to the STA. An AP implementing APSD shall, if a non-AP STA is using APSD and is in PS mode, temporarily buffer the MSDU, A-MSDU, or management frames destined to that non-AP STA. No MSDUs, A-MSDUs, or management frames addressed directly to STAs operating in the Active mode shall be buffered for power management reasons.

a) MSDUs, A-MSDUs, or management frames destined for PS STAs ~~STAs,~~ shall be temporarily buffered in the AP. MSDUs, A-MSDUs, or management frames ~~frames,~~ destined for PS STAs using APSD shall be temporarily buffered in the APSD-capable AP. The algorithm to manage this buffering is beyond the scope of this standard, with the exception that if the AP is QoS-enabled, it shall preserve the order of arrival of frames on a per-TID, per-STA basis.

b) MSDUs, A-MSDUs, or management frames destined for STAs in the Active mode ~~mode,~~ shall be directly transmitted to those STAs.

List items c), d), and e) remain unchanged.

f) Immediately after every DTIM, the AP shall transmit all buffered ~~broadcast/multicast~~group-addressed MSDUs. The More Data field of each ~~broadcast/multicast~~group-addressed frame shall be set to indicate the presence of further buffered ~~broadcast/multicast~~group-addressed MSDUs. If the AP is unable to transmit all of the buffered ~~broadcast/multicast~~group-addressed MSDUs before the primary or secondary TBTT following the DTIM, the AP shall indicate that it will continue to deliver the ~~broadcast/multicast~~group-addressed MSDUs by setting the bit for AID 0 (zero) in the ~~b~~Bit ~~m~~Map ~~c~~Control field of the TIM element of every Beacon frame, until all buffered ~~broadcast/multicast~~group-addressed frames have been transmitted. When the AP transmits an STBC DTIM or TIM Beacon frame, the AP shall retransmit all group-addressed frames that were transmitted following the non-STBC DTIM or TIM Beacon frame except that they are transmitted using the basic STBC MCS. It may be the case that a complete set of buffered group-addressed frames is sent over a period of time during which non-STBC and STBC transmissions are interleaved, but the transition from non-STBC group-addressed transmissions to STBC group-addressed transmissions shall be preceded by the transmission of an STBC Beacon frame and the transition from STBC group-addressed transmissions to non-STBC group-addressed transmissions shall be preceded by the transmission of a non-STBC Beacon frame.

g) A single buffered MSDU, A-MSDU, or management frame for a STA in the PS mode shall be forwarded to the STA after a PS-Poll has been received from that STA. For a non-AP STA ~~STAs~~ using U-APSD, the AP transmits one frame destined for the non-AP STA from any AC that is not delivery-enabled in response to PS-Poll from the non-AP STA. When all ACs associated with the non-AP STA are delivery-enabled, AP transmits one frame from the highest priority AC. The AP can respond with either an immediate ~~D~~data frame or with an ACK, while delaying the responding ~~D~~data frame.

For a STA in PS mode and not using U-APSD, the More Data field of the response ~~D~~data frame shall be set to indicate the presence of further buffered MSDUs, A-MSDUs, or management frames for the polling STA. For a non-AP STA using U-APSD, the More Data field shall be set to indicate the presence of further buffered MSDUs, A-MSDUs, or management frames that do not belong to delivery-enabled ACs. When all ACs associated with the non-AP STA are delivery-enabled, the More Data field shall be set to indicate the presence of further buffered MSDUs, A-MSDUs, or management frames belonging to delivery-enabled ACs. If there are buffered frames to transmit to the STA, the AP may set the More Data bit in a QoS +CF-Ack frame to 1, in response to a QoS data frame to indicate that it has one or more pending frames buffered for the PS STA identified by the RA ~~address~~ in the QoS +CF-Ack frame. An AP may also set the More Data bit in an ACK frame in response to a QoS data frame to indicate that it has one or more pending frames buffered for the PS STA identified by the RA ~~address~~ in the ACK frame, if that PS STA has set the More Data Ack subfield in the QoS Capability information element to 1.

Further PS-Poll frames from the same STA shall be acknowledged and ignored until the MSDU, A-MSDU, or management frame has either been successfully delivered or presumed failed due to maximum retries being exceeded. This prevents a retried PS-Poll from being treated as a new request to deliver a buffered frame.

h) At each scheduled APSD SP for a non-AP STA, the APSD-capable AP shall attempt to transmit at least one MSDU, A-MSDU, or MMPDU, associated with admitted TSPECs with the APSD and Schedule subfields both set to 1, that are destined for the non-AP STA. At each unscheduled SP for a non-AP STA, the AP shall attempt to transmit at least one MSDU, A-MSDU, or MMPDU, but no more than the value specified in the Max SP Length field in the QoS Capability element from delivery-enabled ACs, that are destined for the non-AP STA.

The More Data bit of the directed data or management frame associated with delivery-enabled ACs and destined for that non-AP STA indicates that more frames are buffered for the delivery-enabled ACs. The More Data bit set in MSDUs, A-MSDUs, or management frames associated with nondelivery-enabled ACs and destined for that non-AP STA indicates that more frames are buffered for the nondelivery-enabled ACs. For all frames except for the final frame of the SP, the EOSP subfield of the QoS Control field of the QoS data frame shall be set to 0 to indicate the continuation of the SP. An AP may also set the More Data bit to 1 in a QoS +CF-Ack frame in response to a QoS data frame to indicate that it has one or more pending frames buffered for the target STA identified by the RA ~~address~~ in the QoS +CF-Ack frame. If the QoS data frame is associated with a delivery-enabled AC, the More Data bit in the QoS +CF-Ack frame indicates more frames for all delivery-enabled ACs. If the QoS data frame is not associated with a delivery-enabled AC, the More Data bit in the QoS +CF-Ack frame indicates more frames for all ACs that are not delivery-enabled.

The AP considers APSD STA to be in Awake state after it has sent a QoS +CF-Ack frame, with the EOSP subfield in the QoS Control field set to 0, to the APSD STA. If necessary, the AP may generate an extra QoS Null frame, with the EOSP set to 1. When the AP has transmitted a directed frame to the non-AP STA with the EOSP subfield set to 1 during the SP except for retransmissions of that frame, the AP shall not transmit any more frames to that STA using this mechanism until the next SP. The AP shall set the EOSP subfield to 1 to indicate the end of the SP in APSD.

i) If the AP does not receive an acknowledgment to a directed MSDU, A-MSDU, or management frame sent to a non-AP STA in PS mode following receipt of a PS-Poll from that non-AP STA, it may retransmit the frame for at most the lesser of the maximum retry limit and the MIB attribute dot11QAPMissingAckRetryLimit times before the next Beacon frame, but it shall retransmit that frame at least once before the next Beacon frame, time permitting and subject to its appropriate lifetime limit. If an acknowledgment to the retransmission is not received, it may wait until after the next Beacon frame to further retransmit that frame subject to its appropriate lifetime limit.

j) If the AP does not receive an acknowledgment to a directed frame containing all or part of an MSDU or A-MSDU sent with the EOSP subfield set to 1, it shall retransmit that frame at least once within the same SP, subject to applicable retry or lifetime limit. The maximum number of retransmissions within the same SP is the lesser of the maximum retry limit and the MIB attribute dot11QAPMissingAckRetryLimit. If an acknowledgment to the retransmission of this last frame in the same SP is not received, it may wait until the next SP to further retransmit that frame, subject to its applicable retry or lifetime limit.

k) An AP can delete buffered frames for implementation-dependent reasons, including the use of an aging function and availability of buffers. The AP may base the aging function on the listen interval specified by the non-AP QoS STA in the (Re)Association Request frame.

l) When an AP is informed that a STA changes to the Active mode, then the AP shall send buffered MSDUs, A-MSDUs, and management frames (if any exist) to that STA without waiting for a

PS-Poll. When an AP is informed that an APSD-capable non-AP STA is not using APSD, then the AP shall send buffered MSDUs, A-MSDUs, and management frames (if any exist) to that non-AP STA according to the rules corresponding to the current PS mode of the non-AP STA.

11.2.1.6 AP operation during the CFP

Change 11.2.1.6 as follows:

APs shall maintain a Power Management status for each currently associated CF-Pollable STA that indicates in which Power Management mode the STA is currently operating. An AP shall, for STAs in PS mode, temporarily buffer ~~the~~any MSDU or A-MSDU destined to the STA.

a) MSDUs or A-MSDUs destined for PS STAs shall be temporarily buffered in the AP. The algorithm to manage this buffering is beyond the scope of this standard.

b) MSDUs or A-MSDUs destined to STAs in the Active mode shall be transmitted as defined in Clause 9.

c) Prior to every CFP, and at each beacon interval within the CFP, the AP shall assemble the partial virtual bitmap containing the buffer status per destination for STAs in the PS mode, set the bits in the partial virtual bitmap for STAs the PC is intending to poll during this CFP, and shall send this out in the TIM field of the DTIM. The bit for AID 0 (zero) in the ~~b~~Bit ~~m~~Map ~~c~~Control field of the TIM information element shall be set when ~~broadcast or multicast~~group-addressed traffic is buffered, according to 7.3.2.6.

d) All ~~broadcast and multicast MSDUs,~~ group-addressed MSDUs with the Order bit in the Frame Control field ~~clear,~~ clear shall be buffered if any associated STAs are in the PS mode, regardless of whether ~~or not~~ those STAs are CF-Pollable.

e) Immediately after every DTIM (Beacon frame with DTIM Count field of the TIM element equal to zero), the AP shall transmit all buffered ~~broadcast and multicast~~group-addressed frames. The More Data field shall be set in the headers of all but the final such frame to indicate the presence of further buffered ~~broadcast/multicast~~group-addressed MSDUs. If the AP is unable to transmit all of the buffered ~~broadcast/multicast~~group-addressed MSDUs before the non-STBC or STBC TBTT following the DTIM, the AP shall indicate that it will continue to deliver the ~~broadcast/multicast~~group-addressed MSDUs by setting the bit for AID 0 (zero) in the ~~b~~Bit ~~m~~Map ~~c~~Control field of the TIM element of every Beacon frame, until all buffered ~~broadcast/multicast~~group-addressed frames have been transmitted. When the AP transmits an STBC DTIM or TIM Beacon frame, the AP shall retransmit all group-addressed frames that were transmitted following the non-STBC DTIM or TIM Beacon frame except that they are transmitted using the basic STBC MCS. It may be the case that a complete set of buffered group-addressed frames is sent over a period of time during which non-STBC and STBC transmissions are interleaved, but the transition from non-STBC group-addressed transmissions to STBC group-addressed transmissions shall be preceded by the transmission of a STBC Beacon frame and the transition from STBC group-addressed transmissions to non-STBC group-addressed transmissions shall be preceded by the transmission of a non-STBC Beacon frame.

f) Buffered MSDUs, A-MSDUs, or MMPDUs for STAs in the PS mode shall be forwarded to the CF-Pollable STAs under control of the PC. Transmission of these buffered MSDUs or management frames as well as CF-Polls to STAs in the PS mode that were indicated in the DTIM in accordance with paragraph c) of this subclause shall begin immediately after transmission of buffered ~~broadcast and multicast~~group-addressed frames (if any), and shall occur in order by increasing AID of CF-Pollable STAs. A CF-Pollable STA for which the TIM element of the most recent Beacon frame indicated buffered MSDUs or management frames shall be in the Awake state at least until the receipt of a directed frame from the AP in which the Frame Control field does not indicate the existence of more buffered MSDUs, A-MSDUs, or management frames. After acknowledging the last of the buffered MSDUs, A-MSDUs, or management frames, the CF-Pollable STA operating in the PS mode may enter the Doze state until the next DTIM is expected.

g) An AP shall have an aging function to delete pending traffic buffered for an excessive time period. The exact specification of the aging function is beyond the scope of this standard.

h) When an AP detects that a CF-Pollable STA has changed from the PS mode to the Active mode, then the AP shall queue any buffered frames addressed to that STA for transmission to that CF-Pollable STA as directed by the AP's PC.

11.2.1.7 Receive operation for STAs in PS mode during the CP

Change 11.2.1.7 as follows:

STAs in PS mode shall operate as follows to receive an MSDU, A-MSDU, or management frame from the AP when no PC is operating and during the CP when a PC is operating.

a) STAs shall wake up early enough to be able to receive the first Beacon frame scheduled for transmission after the time corresponding to the last TBTT plus the STA's current ListenInterval.

b) When a STA detects that the bit corresponding to its AID is set in the TIM, the STA shall issue a PS-Poll to retrieve the buffered MSDU, A-MSDU, or management frame. The PS-Poll shall be transmitted after a random delay uniformly distributed between zero and aCWmin slots following a DIFS.

c) The STA shall remain in the Awake state until it receives the data or management frame in response to its poll or it receives another Beacon frame whose TIM indicates that the AP does not have any MSDUs, A-MSDUs, or management frames buffered for this STA. If the bit corresponding to the STA's AID is set in the subsequent TIM, the STA shall issue another PS-Poll to retrieve the buffered MSDU, A-MSDU, or management frame(s). When a non-AP STA that is using U-APSD and has all ACs delivery-enabled detects that the bit corresponding to its AID is set in the TIM, the non-AP STA shall issue a trigger frame or a PS-Poll frame to retrieve the buffered MSDU, A-MSDU or management frames.

d) If the More Data field in the received MSDU, A-MSDU, or management frame indicates that more traffic for that STA is buffered, the STA, at its convenience, shall Poll until no more MSDUs, A-MSDUs, or management frames are buffered for that STA.

e) When ReceiveDTIMs is true, the STA shall wake up early enough to be able to receive either every non-STBC DTIM or every STBC DTIM sent by the AP of the BSS. A STA that stays awake to receive ~~broadcast/multicast~~group-addressed MSDUs shall elect to receive all group-addressed non-STBC transmissions or all group-addressed STBC transmissions and shall remain awake until the More Data field of the appropriate type (non-STBC or STBC) of ~~broadcast/multicast~~group-addressed MSDUs indicates there are no further buffered ~~broadcast/multicast~~group-addressed MSDUs of that type or until a TIM is received indicating there are no more buffered ~~broadcast/multicast~~group-addressed MSDUs of that type. If a non-AP STA receives a QoS +CF-Ack frame from its AP with the More Data bit set to 1, then the STA shall operate exactly as if it received a TIM with its AID bit set. If a non-AP STA has set the More Data Ack subfield in QoS Capability information element to 1, then if it receives an ACK frame from its AP with the More Data bit set to 1, the STA shall operate exactly as if it received a TIM with its AID bit set. For example, a STA that is using the PS-Poll delivery method shall issue a PS-Poll frame to retrieve a buffered frame. See also 9.2.7.

11.2.1.8 Receive operation for STAs in PS mode during the CFP

Change 11.2.1.8 as follows:

STAs in PS mode that are associated as CF-Pollable shall operate as follows in a BSS with an active PC to receive MSDUs or management frames from the AP during the CFP:

a) STAs shall enter the Awake state so as to receive the Beacon frame (which contains a DTIM) at the start of each CFP.

b) To receive ~~broadcast/multicast~~group-addressed MSDUs, the STA shall wake up early enough to be able to receive either every non-STBC DTIM or every STBC DTIM that may be sent during the CFP. A STA receiving ~~broadcast/multicast~~group-addressed MSDUs shall elect to receive all group-addressed non-STBC transmissions or all group-addressed STBC transmissions and shall remain awake until the More Data field of the appropriate type (non-STBC or STBC) of ~~broadcast/multicast~~group-addressed MSDUs indicates there are no further buffered ~~broadcast/multicast MSDUs,~~ group-addressed MSDUs of that type or until a TIM is received indicating there are no more ~~broadcast/multicast~~group-addressed MSDUs of that type buffered. See also 9.2.7.

c) When a STA detects that the bit corresponding to its AID is set in the DTIM at the start of the CFP (or in a subsequent TIM during the CFP), the STA shall remain in the Awake state for at least that portion of the CFP through the time that the STA receives a directed MSDU, A-MSDU, or management frame from the AP with the More Data field in the Frame Control field indicating that no further traffic is buffered.

d) If the More Data field in the Frame Control field of the last MSDU, A-MSDU, or management frame received from the AP indicates that more traffic for the STA is buffered, then, when the CFP ends, the STA may remain in the Awake state and transmit PS-Poll frames during the CP to request the delivery of additional buffered MSDU, A-MSDU, or management frames, or may enter the Doze state during the CP (except at TBTTs for DTIMs expected during the CP), awaiting the start of the next CFP.

11.2.1.9 Receive operation for non-AP STAs using APSD

Change the first paragraph of 11.2.1.9 as follows:

A non-AP STA using APSD shall operate as follows to receive an MSDU, A-MSDU, or management frame from the AP:

Change list item b) of 11.2.1.9 as follows:

b) If the non-AP STA is initiating an unscheduled SP, the non-AP STA wakes up and transmits a trigger frame to the AP. When one or more ACs are not delivery-enabled, the non-AP STA may retrieve MSDUs, A-MSDUs, and MMPDUs belonging to those ACs by sending PS-Poll frames to the AP.

Insert the following subclause (11.2.1.12) after subclause 11.2.1.11:

11.2.1.12 PSMP power management

An AP transmits a PSMP frame containing a schedule only for STAs that are awake.

NOTE—A STA in power save mode is awake as defined in 11.2.1.4 (U-APSD, S-APSD), in 11.2.1.5 (PS-poll), or during a DTIM period.

The AP may signal the end of the SP for all awake associated PSMP-capable STAs by setting the More PSMP field to 0 or by sending CF-End frame instead of the next PSMP frame.

NOTE 1—The AP can also signal the end of an SP on a per-STA basis using the EOSP field set to 1 in the QoS Control field, as defined in 7.1.3.5.2 and 11.2.1.5. This field remains set to 1 for any retransmissions of the same frame, and no more new frames are sent to this particular STA in the current SP.

NOTE 2—If a STA is awake at the start of a scheduled PSMP session, the operation of the More Data field in the Frame Control field and the TIM element are defined by the S-APSD rules in 11.2.1.4, 11.2.1.5, and 11.2.1.9.

A STA shall wake up at the start of the next PSMP frame if the More PSMP field is set to 1 in the current PSMP frame, unless the STA has been permitted to return to sleep through the reception of a frame addressed to it with the EOSP field set to 1 or the maximum SP interval has elapsed.

A PPDU containing MPDUs addressed to a STA shall not start after expiry of the STA's PSMP-DTT. A STA completes the reception of any PPDU that starts before the end of the PSMP-DTT. If no frames addressed to a STA begin within a PSMP-DTT, it can assume that no frame addressed to it will arrive during this PSMP sequence.

The STA shall be awake to receive at the start of the PSMP-DTT determined from a STA_INFO field that has the STA_INFO Type subfield set to 2 and the AID field matching the STA's AID where the PSMP-DTT Duration subfield is not set to 0.

11.2.2 Power management in an IBSS

11.2.2.1 Basic approach

Delete the first paragraph and change the second through the seventh paragraphs of 11.2.2.1 as follows:

~~The basic approach is similar to the infrastructure case in that the STAs are synchronized, and multicast MSDUs and those MSDUs that are to be transmitted to a power-conserving STA are first announced during a period when all STAs are awake. The announcement is done via an ad hoc ATIM sent in an ATIM Window. A STA in the PS mode shall listen for these announcements to determine if it needs to remain in the awake state. The presence of the ATIM window in the IBSS indicates if the STA may use PS Mode. To maintain correct information on the power save state of other stations in an IBSS, a station needs to remain awake during the ATIM window. At other times the STA may enter the Doze state except as indicated in the following procedures~~

The basic approach is similar to the infrastructure case in that the STAs are synchronized, and ~~multicast~~group-addressed MSDUs and ~~those~~ the MSDUs or A-MSDUs that are to be transmitted to a power-conserving STA are first announced during a period when all STAs are awake. The announcement is done via an ad hoc ATIM sent in an ATIM Window. A STA in the PS mode shall listen for these announcements to determine if it needs to remain in the Awake state. The presence of the ATIM window in the IBSS indicates if the STA may use PS ~~M~~mode. To maintain correct information on the power save state of other STAs in an IBSS, a STA needs to remain awake during the ATIM window. At other times the STA may enter the Doze state except as indicated in the following procedures.

When an MSDU or A-MSDU is to be transmitted to a destination STA that is in a PS mode, the transmitting STA first transmits an ATIM frame during the ATIM Window, in which all the STAs including those operating in a PS mode are awake. The ATIM Window is defined as a specific period of time, defined by the value of the ATIM Window parameter in the IBSS Parameter Set supplied to the MLME-START.request primitive, following a TBTT, during which only Beacon or ATIM frames shall be transmitted. ATIM transmission times are randomized, after a Beacon frame is either transmitted or received by the STA, using the backoff procedure with the CW equal to aCWmin. Directed ATIMs shall be acknowledged. If a STA transmitting a directed ATIM does not receive an acknowledgment, the STA shall execute the backoff procedure for retransmission of the ATIM. ~~Multicast~~Group-addressed ATIMs shall not be acknowledged.

If a STA receives a directed ATIM frame during the ATIM Window, it shall acknowledge the directed ATIM and stay awake for the entire beacon interval waiting for the announced MSDU(s) or A-MSDU(s) to be received. If a STA does not receive an ATIM, it may enter the Doze state at the end of the ATIM Window. Transmissions of MSDUs announced by ATIMs are randomized after the ATIM Window, using the backoff procedure described in Clause 9.

It is possible that an ATIM may be received from more than one STA, and that a STA that receives an ATIM may receive more than a single MSDU or A-MSDU from the transmitting STA. ATIM frames are only addressed to the destination STA of the MSDU or A-MSDU.

An ATIM for a ~~broadcast or multicast~~group-addressed MSDU shall have a destination address identical to that of the MSDU.

After the ATIM interval, only ~~those~~ directed MSDUs or A-MSDUs that have been successfully announced with an acknowledged ~~ATIM,~~ ATIM and ~~broadcast/multicast~~group-addressed MSDUs that have been announced with an ~~ATIM,~~ ATIM shall be transmitted to STAs in the PS mode. Transmission of these frames shall be done using the normal DCF access procedure.

11.2.2.3 STA power state transitions

Change the first paragraph of 11.2.2.3 as follows:

A STA may enter PS mode if and only if the value of the ATIM Window in use within the IBSS is greater than zero. A STA shall set the Power Management subfield in the Frame Control field of data MPDUs containing all or part of MSDUs or A-MSDUs that it transmits using the rules in 7.1.3.1.6.

11.2.2.4 ATIM and frame transmission

Change 11.2.2.4 as follows:

If power management is in use within an IBSS, all STAs shall buffer MSDUs and A-MSDUs for STAs that are known to be in PS mode. The algorithm used for the estimation of the power management state of STAs within the IBSS is outside the scope of this standard. MSDUs and A-MSDUs may be sent to STAs in Active mode at any valid time.

a) Following the reception or transmission of the Beacon frame, during the ATIM Window, the STA shall transmit a directed ATIM management frame to each STA for which it has one or more buffered ~~unicast~~individually addressed MSDUs and A-MSDUs. If the STA has one or more buffered ~~multicast~~group-addressed MSDUs, with the Strictly Ordered bit clear, it shall transmit an appropriately addressed ~~multicast~~group-addressed ATIM frame. A STA transmitting an ATIM management frame shall remain awake for the entire current beacon interval.

b) All STAs shall use the backoff procedure defined in 9.2.5.2 for transmission of the first ATIM following the Beacon frame. All remaining ATIMs shall be transmitted using the conventional DCF access procedure.

c) ATIM management frames shall only be transmitted during the ATIM Window.

d) A STA shall transmit no frame types other than RTS, CTS, and ACK control frames and Beacon and ATIM management frames during the ATIM Window.

e) Directed ATIM management frames shall be acknowledged. If no acknowledgment is received, the ATIM shall be retransmitted using the conventional DCF access procedure. ~~Multicast~~Group-addressed ATIM management frames shall not be acknowledged.

f) If a STA is unable to transmit an ATIM during the ATIM Window, for example, due to contention with other STAs, the STA shall retain the buffered MSDU(s) and A-MSDU(s) and attempt to transmit the ATIM during the next ATIM Window.

g) Immediately following the ATIM Window, a STA shall begin transmission of buffered ~~broadcast/multicast~~group-addressed frames for which an ATIM was previously transmitted. Following the transmission of any ~~broadcast/multicast~~group-addressed frames, any MSDUs and management frames addressed to STAs for which an acknowledgment for a previously transmitted ATIM frame was received shall be transmitted. All STAs shall use the backoff procedure defined in 9.2.5.2 for transmission of the first frame following the ATIM Window. All remaining frames shall be transmitted using the conventional DCF access procedure.

h) A buffered MSDU may be transmitted using fragmentation. If an MSDU has been partially transmitted when the next Beacon frame is sent, the STA shall retain the buffered MSDU and announce the remaining fragments by transmitting an ATIM during the next ATIM Window.

i) If a STA is unable to transmit a buffered MSDU during the beacon interval in which it was announced, for example, due to contention with other STAs, the STA shall retain the buffered MSDU or A-MSDU and announce the MSDU or A-MSDU again by transmitting an ATIM during the next ATIM Window.

j) Following the transmission of all buffered MSDUs or A-MSDUs, a STA may transmit MSDUs or A-MSDUs without announcement to STAs that are known to be in the Awake state for the current beacon interval due to an appropriate ATIM management or Beacon frame having been transmitted or received.

k) A STA may discard frames buffered for later transmission to power-saving STAs if the STA determines that the frame has been buffered for an excessive amount of time or if other conditions internal to the STA implementation make it desirable to discard buffered frames (e.g., buffer starvation). In no case shall a frame be discarded that has been buffered for less than dot11BeaconPeriod. The algorithm to manage this buffering is beyond the scope of this standard.

Insert the following subclause (11.2.3) after 11.2.2.4:

11.2.3 SM power save

A STA consumes power on all active receive chains, even though they are not necessarily required for the actual frame exchange. The SM Power Save feature allows a STA to operate with only one active receive chain for a significant portion of time.

The STA controls which receive chains are active through the PHY-RXCONFIG.request primitive specifying a PHYCONFIG_VECTOR parameter ACTIVE_RXCHAIN_SET that indicates which of its receive chains should be active.

In dynamic SM power save mode, a STA enables its multiple receive chains when it receives the start of a frame sequence addressed to it. Such a frame sequence shall start with a single-spatial stream individually addressed frame that requires an immediate response and that is addressed to the STA in dynamic SM power save mode. An RTS/CTS sequence may be used for this purpose. The receiver shall be capable of receiving a PPDU that is sent using an MCS that indicates more than one spatial stream a SIFS after the end of its response frame transmission. The receiver switches to the multiple receive chain mode when it receives the RTS addressed to it and switches back immediately when the frame sequence ends.

NOTE—A STA in dynamic SM power save mode cannot distinguish between an RTS/CTS sequence that precedes a MIMO transmission and any other RTS/CTS and, therefore, always enables its multiple receive chains when it receives an RTS addressed to itself.

The receiver can determine the end of the frame 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 9.2.1) indicates that the medium is idle at the TxPIFS slot boundary (defined in 9.2.10).

A STA in static SM power save mode maintains only a single receive chain active.

An HT STA may use the SM Power Save Action frame to communicate its SM Power Save state. A non-AP HT STA may also use SM Power Save bits in the HT Capabilities element of its Association Request to achieve the same purpose. The latter allows the STA to use only a single receive chain immediately after association.

A STA that has one or more DLS links shall notify all STAs with which it has a DLS link of any change in SM power save mode before operating in that mode.

Changes to the number of active receive chains are made only after the SM Power Save Mode indication has been successfully delivered (i.e., by acknowledgment of a frame carrying the HT Capabilities element or by acknowledgment of a SM Power Save frame). The SM Power Save Mode indication shall be transmitted using a individually addressed frame.

11.3 STA authentication and association

Change list item a)2)vii) as follows:

a) Class 1 frames (permitted from within States 1, 2, and 3):
   2) Management frames
      vii) Within an IBSS, all Action frames<u> and all Action No Ack frames</u>

Change list item c)2)i) as follows:

c) Class 3 frames (if and only if associated; allowed only from within State 3):
   2) Management frames
      i) Within an infrastructure BSS, all Action<u> and Action No Ack</u> frames except the following frames:
         A) Public Action

11.3.2 Association, reassociation, and disassociation

11.3.2.2 AP association procedures

Insert the following list items (b2 and b3) after item b1) in 11.3.2.2 as follows:

b2) An AP shall refuse an association request from a STA that does not support all the rates in the BSSBasicRateSet parameter.

b3) An AP shall refuse an association request from an HT STA that does not support all the MCSs in the BSSBasicMCSSet parameter.

11.3.2.4 AP reassociation procedures

Insert the following list items (b2 and b3) after item b1) in 11.3.2.4 as follows:

b2) An AP shall refuse a reassociation request from a STA that does not support all the rates in the BSSBasicRateSet parameter.

b3) An AP shall refuse a reassociation request from an HT STA that does not support all the MCSs in the BSSBasicMCSSet parameter.

11.4 TS operation

Insert the following subclause (11.4.4b) after 11.4.4a:

11.4.4b PSMP management

A STA may attempt to create a scheduled PSMP session with its AP only if the AP has the S-PSMP Support field in the Extended Capabilities element set to 1.

The TSPEC reserves resources within the AP and modifies the AP's scheduling behavior. The parameters in the TSPEC can be grouped into two categories: PSMP scheduling and PSMP reservation. The scheduling parameters are used by the AP to schedule a suitable SI. The reservation parameters are used by the AP to reserve time in the PSMP-UTT and PSMP-DTT.

The service start time and SI specifies the PSMP schedule in the response's Schedule element. All other parameters result in a reservation for the PSMP-UTT and PSMP-DTT within the scheduled PSMP sequence.

An AP shall terminate the PSMP session only when the last TS associated with the particular PSMP session is terminated.

Once created, a PSMP session can be extended by another TSPEC setup. A STA that has an established PSMP session may issue an additional TSPEC request with the following:

- The Aggregation field set to 1
- The Scheduled field set to 1 and APSD field set to 0 (S-PSMP)
- The Minimum Service Interval and Maximum Service Interval fields both set to the Service Interval field value from the Schedule element specified when the PSMP session was established

The AP shall return an identical Schedule element for all TSPEC response frames related to the same PSMP session.

NOTE—A STA that does not have an established PSMP session might send a TSPEC request specifying S-PSMP session with the same SI. The AP is free to choose between aggregating this request with an existing PSMP session of the same SI or creating a new PSMP session.

The parameters of a TS already associated with the PSMP session can be changed; however, the SI shall not be changed. The start time of existing STAs in the PSMP schedule shall not be changed by the addition of a TSPEC from a new STA.

A TSPEC that reserves resources for a STA under scheduled PSMP shall have the APSD and Scheduled fields set to indicate Scheduled PSMP as defined in Table 7-41.

The non-AP STA SME decides that a PSMP session needs to be established. How it makes this decision and how it selects the related TSPEC parameters are beyond the scope of this standard.

The Minimum Service Interval field of the TSPEC element of an ADDTS request frame shall be a multiple of the SI granularity indicated by the AP in its Extended Capabilities element.

11.4.7 TS deletion

Insert reason code 31 into Table 11-3:

Table 11-3—Encoding of ReasonCode to Reason Code field value for DELTS

ReasonCode	Reason Code field
SERVICE_CHANGE_PRECLUDES_TS	31

Change the fourth paragraph of 11.4.7 as follows:

An HC should not delete a TSPEC without a request from the SME except due to inactivity (see 11.4.8)<u> or an HC service change that precludes the HC from continuing to meet the requirements of the TSPEC</u>.

11.5 Block Ack operation

11.5.1 Setup and modification of the Block Ack parameters

11.5.1.1 Procedure at the originator

Insert the following list item and note at the beginning of the lettered list of the first paragraph of 11.5.1.1, and renumber the remaining list items accordingly:

a) If the initiating STA is an HT STA, is a member of an IBSS, and has no other existing Block Ack agreement with the recipient STA, then the initiating STA shall transmit a Probe Request frame to the recipient STA and shall not transmit an ADDBA Request frame unless it receives a Probe Response frame from the recipient within dot11ADDBAFailureTimeout.

NOTE—When the Block Ack agreement is being established between a non-AP STA and its AP, then the originator and the recipient have exchanged capability information during the association exchange that allows them to determine whether the other STA is an HT STA. If the STA is establishing a Block Ack agreement with another STA through DLS, then the DLS setup procedure includes the exchange of capability information that allows both STAs to determine whether the other STA is an HT STA.

b) ~~a)~~ Check ....

c) ~~b)~~ If ....

d) ~~c)~~ If ....

e) ~~d)~~ If ....

Insert the following subclause (11.5.1.3) after 11.5.1.2:

11.5.1.3 Procedure common to both originator and recipient

Once a Block Ack agreement has been successfully established between two STAs, the type of agreement thus established is dependent on the capabilities of the STAs and the contents of the ADDBA frames used to establish this agreement as defined in Table 11-4a.

Table 11-4a—Types of Block Ack agreement based on capabilities and ADDBA conditions

Capabilities condition	ADDBA condition	Type of Block Ack agreement
One or both of the STA are non-HT.	Block Ack Policy subfield set to 1	Immediate
	Block Ack Policy subfield set to 0	Delayed
Both STAs are HT STAs.	Block Ack Policy subfield set to 1	HT-Immediate
Both STAs are HT STAs, and both of the STAs set the HT-Delayed Block Ack subfield of the HT Capabilities element to 1.	Block Ack Policy subfield set to 0	HT-Delayed
Both STAs are HT STAs, and at least one of the STAs sets the HT-Delayed Block Ack subfield of the HT Capabilities element to 0.	Block Ack Policy subfield set to 0	Delayed

11.6 Higher layer timer synchronization

11.6.2 Procedure at the STA

Change the second paragraph of 11.6.2 as follows:

In order to determine whether to provide an MLME-HL-SYNC.indication primitive for a particular data frame, a MAC that supports MLME-HL-SYNC primitives compares the Address 1 field in a data frame's MAC header against a list of group addresses previously registered by an MLME-HL-SYNC.request primitive. If the MAC and the transmitter of the Sync frame are collocated within the same STA, the MLME-HL-SYNC.indication primitive shall occur when the last symbol of the PPDU carrying a matching data frame is transmitted. Otherwise, the indication shall occur when the last symbol of the PPDU carrying the matching data frame is received. In both cases, the MLME-HL-SYNC.indication primitive provided is simultaneous (within implementation dependent delay bounds) with the indication provided to other STAs within the BSS for the same data frame.

Change list items a) to d) and insert list item e) in 11.7 as follows:

11.7 DLS operation

a) A STA, STA-1, that intends to exchange frames directly with another non-AP STA, STA-2, invokes DLS and sends a DLS Request frame to the AP (step 1a in Figure 11-15). This request contains the rate set, capabilities of STA-1, and the MAC addresses of STA-1 and STA-2. If STA-1 is an HT STA, this request also contains the HT capabilities of STA-1.

b) If STA-2 is associated in the BSS, direct streams are allowed in the policy of the BSS, and STA-2 is indeed a QoS STA, then the AP forwards the DLS Request frame, independently of whether the AP is capable of decoding all of the fields in the body of the frame, to the recipient, STA-2 (step 1b in Figure 11-15).

c) If STA-2 accepts the direct stream, it sends a DLS Response frame to the AP (step 2a in Figure 11-15), which contains the rate set, (extended) capabilities of STA-2, and the MAC addresses of STA-1 and STA-2. If STA-2 is an HT STA, this response also contains an HT capabilities element representing the HT capabilities of STA-2.

d) The AP forwards the DLS Response frame to STA-1 (step 2b in Figure 11-15), independently of whether the AP is capable of decoding all of the fields in the body of the frame.

e) ~~after which~~ If the DLS Response frame contained a status code of SUCCESSFUL, the direct link becomes active and frames can be sent from STA-1 to STA-2 and from STA-2 to STA-1.

11.7.1 DLS procedures

11.7.1.2 Setup procedure at the AP

Change the last item of the dashed list after the first paragraph in 11.7.1.2 as follows:

— Send the DLS Request frame, with all fields having the same value as the DLS Request frame received by the AP, to the destination STA (step 1b in Figure 11-15), independently of whether the AP is capable of decoding all of the fields in the body of the frame.

Change 11.7.2 as follows:

11.7.2 Data transfer after setup

For each active direct link, a STA shall record the MAC and PHY features, rates, and MCSs that are supported by the other STA participating in the direct link, according to the Supported Rates, Extended

Supported Rates, Capability Information, and HT Capabilities fields within the DLS Request and DLS Response frames that were used to establish the direct link.

A STA transmitting frames within a direct link shall not transmit frames using features, rates, or MCSs that are not supported by the other STA in the direct link. After establishing protection as required by 9.13 or 9.2.5.5a, STAs may use features, rates, or MCSs that are supported by both of the STAs in the direct link, even when the AP does not support those features, except for transmission of a 40 MHz mask PPDU, which is governed by the rules found in 11.14.4.

~~Both the STAs may use direct link for data transfers using any of the access mechanisms defined in this standard.~~ STAs participating in a direct link may ~~also~~ set up Block Ack if needed. ~~If needed, t~~The STAs may set up TSs with the HC to ensure they have enough bandwidth or use polled TXOPs for data transfer. A protective mechanism (such as transmitting using HCCA, RTS/CTS, or the mechanism described in 9.13) should be used to reduce the probability of other STAs interfering with the direct-link transmissions.

11.9 DFS procedures

11.9.2 Quieting channels for testing

Change the fourth paragraph of 11.9.2 as follows:

Control of the channel is lost at the start of a quiet interval, and the NAV is set by all the STAs in the BSS ~~or IBSS~~ for the length of the quiet interval. Transmission by any STA in the BSS of any MPDU and any associated acknowledgment within either the primary channel or the secondary channel (if present) of the BSS shall be complete before the start of the quiet interval. If, before starting transmission of an MPDU, there is not enough time remaining to allow the transmission to complete before the quiet interval starts, the STA shall defer the transmission by selecting a random backoff time, using the present CW (without advancing to the next value in the series). The short retry counter and long retry counter for the MSDU or A-MSDU are not affected.

11.9.6 Requesting and reporting of measurements

Change the fourth paragraph of 11.9.6 as follows:

A STA that successfully requests another STA to perform a measurement on another channel should not transmit MSDUs, A-MSDUs, or MMPDUs to that STA during the interval defined for the measurement plus any required channel switch intervals. In determining this period, a STA shall assume that any required channel switches take less than dot11ChannelSwitchTime per switch.

11.9.7 Selecting and advertising a new channel

11.9.7.2 Selecting and advertising a new channel in an IBSS

Change the first paragraph of 11.9.7.2 as follows:

DFS in an IBSS is complicated by the following:

- There is no central AP function for collating measurements or coordinating a channel switch. If STAs make independent decisions to switch channel in the presence of radar, there is a danger that all STAs will announce a switch to differing channels if several of them detect the radar.
- There is no association protocol that can be used to
  - Exchange supported channel information and
  - Determine membership of the IBSS at a given instant for requesting measurements.

— Beaconing is a shared process; therefore, it cannot be guaranteed that a STA that has something to send (e.g., a channel switch message) will be the next STA to transmit a Beacon frame.
— A 20/40 MHz IBSS cannot be changed to a 20 MHz IBSS, and a 20 MHz IBSS cannot be changed to a 20/40 MHz IBSS.

Insert the following subclause (11.9.7.3) after 11.9.7.2:

11.9.7.3 HT-greenfield transmissions in regulatory classes with behavior limits set of 16

The requirements described in this subclause apply only when an HT STA is operating in a regulatory class for which the behavior limits set listed in Annex J includes the value 16; i.e., the regulatory class is subject to DFS with 50–100 µs radar pulses.

A non-HT OBSS scan operation is a passive or active scan of the primary channel and of the secondary channel if it is within a 20/40 MHz BSS that a STA currently uses or intends to use. During a non-HT OBSS scan operation, the channel scan duration is a minimum of dot11OBSSScanPassiveTotalPerChannel TU when scanning passively and a minimum of dot11OBSSScanActiveTotalPerChannel TU when scanning actively.

Before an HT STA starts a BSS with the OBSS Non-HT STAs Present field of the HT Operation element set to 0, the HT STA shall perform a non-HT OBSS scan in order to search for any existing non-HT OBSSs.

When an HT STA detects there are one or more non-HT OBSSs and if the HT STA starts a BSS on that channel, then the HT STA shall set the OBSS Non-HT STAs Present field of the HT Operation element to 1; otherwise, the HT STA may set the OBSS Non-HT STAs Present field of the HT Operation element to 0.

NOTE—Detection of a non-HT OBSS can be achieved by the reception of a Beacon or Probe Response frame that does not contain an HT Capabilities element or HT Operation element.

An HT AP shall not transmit a PPDU with the FORMAT parameter of the TXVECTOR set to HT_GF if the OBSS Non-HT STAs Present field of the HT Operation element is set to 1 in the most recently transmitted management frame that contained that element.

An HT non-AP STA shall not transmit a PPDU with the FORMAT parameter of the TXVECTOR set to HT_GF if the most recent frame received from its AP containing an HT Operation element has the OBSS Non-HT STAs Present field set to 1.

NOTE—This requirement applies also to PPDUs transmitted on a direct link between two non-AP STAs.

When moving the BSS to a new channel or set of channels and before completing a non-HT OBSS scan of the new channel or set of channels, an HT AP shall set the OBSS Non-HT STAs Present field of the HT Operation element to 1. After the HT AP completes one non-HT OBSS scan of the new channel or set of channels and if the HT AP has detected that there are zero non-HT OBSSs, then the HT AP may set the OBSS Non-HT STAs Present field of the HT Operation element to 0.

Insert the following subclauses (11.14 through 11.18) after 11.13:

11.14 20/40 MHz BSS operation

11.14.1 Rules for operation in 20/40 MHz BSS

The rules described in 11.14.1 through 11.14.12 are applicable to STAs that are either a STA 5G or a STA 2G4.

An FC HT STA that transmits a frame containing an Extended Capabilities element shall set the 20/40 BSS Coexistence Management Support field of this element to 1.

An HT STA 2G4 that is a member of an IBSS and that transmits a frame containing an HT Operation element or Secondary Channel Offset element shall set the Secondary Channel Offset field of this element to SCN.

11.14.2 Basic 20/40 MHz BSS functionality

An HT AP declares its channel width capability (20 MHz only or 20/40 MHz) in the Supported Channel Width Set subfield of the HT Capabilities element.

An HT AP shall set the STA Channel Width field to 1 in frames in which it has set the Secondary Channel Offset field to SCA or SCB. An HT AP shall set the STA Channel Width field to 0 in frames in which it has set the Secondary Channel Offset field to SCN.

A non-AP HT STA declares its channel width capability (non-FC HT STA or FC HT STA) in the Supported Channel Width Set subfield in the HT Capabilities element.

NOTE 1—A 20/40 MHz BSS can include any mixture of FC HT STAs, non-FC HT STAs, and non-HT STAs. Protection requirements for mixed networks are defined in 9.13.

NOTE 2—A non-AP HT STA can switch between FC HT STA and non-FC HT STA operation by disassociation followed by association or reassociation.

An HT STA shall not indicate support for 40 MHz unless it supports reception and transmission of 40 MHz PPDUs using all MCSs within the BasicMCSSet and all MCSs that are mandatory for the attached PHY.

An HT STA shall not transmit a 20 MHz PPDU containing one or more data MPDUs using the secondary channel of a 20/40 MHz BSSs. The Notify Channel Width Action frame may be used by a non-AP STA to notify another STA that the STA wishes to receive frames in the indicated channel width.

An HT STA that is a member of an IBSS adopts the value of the Secondary Channel Offset field in received frames according to the rules in 11.1.4 and shall not transmit a value for the Secondary Channel Offset field that differs from the most recently adopted value.

11.14.3 Channel selection methods for 20/40 MHz operation

11.14.3.1 General

For an HT STA, the following MIB attributes shall be set to TRUE: dot11RegulatoryClassesImplemented, dot11RegulatoryClassesRequired, and dot11ExtendedChannelSwitchEnabled.

An AP operating a 20/40 MHz BSS, on detecting an OBSS whose primary channel is the AP’s secondary channel, switches to 20 MHz BSS operation and may subsequently move to a different channel or pair of channels. An IBSS DFS owner (IDO) STA operating a 20/40 MHz IBSS, on detecting an OBSS whose primary channel is the IDO STA’s secondary channel, may choose to move to a different pair of channels.

11.14.3.2 Scanning requirements for a 20/40 MHz BSS

Before an AP or IDO STA starts a 20/40 MHz BSS, it shall perform a minimum of dot11BSSWidthChannel-TransitionDelayFactor OBSS scans (see 11.14.5) to search for existing BSSs.

If the AP or IDO STA starts a 20/40 MHz BSS in the 5 GHz band and the BSS occupies the same two channels as any existing 20/40 MHz BSSs, then the AP or IDO STA shall ensure that the primary channel of the new BSS is identical to the primary channel of the existing 20/40 MHz BSSs and that the secondary channel of the new 20/40 MHz BSS is identical to the secondary channel of the existing 20/40 MHz BSSs, unless the AP discovers that on these two channels are existing 20/40 MHz BSSs with different primary and secondary channels.

If an AP or IDO STA starts a 20/40 MHz BSS in the 5 GHz band, the selected secondary channel should correspond to a channel on which no beacons are detected during the dot11BSSWidthChannelTransition-DelayFactor OBSS scan time performed by the AP or IDO STA, unless there are beacons detected on both the selected primary and secondary channels.

NOTE—The 20/40 MHz channel sets and their corresponding behavior limits (i.e., choice of primary and secondary channels) permissible in each regulatory class are defined in Annex J and Annex I, respectively.

An HT AP or an IDO STA that is also an HT STA should not start a 20 MHz BSS in the 5 GHz band on a channel that is the secondary channel of a 20/40 MHz BSS.

The AP or IDO STA may continue to periodically scan after the BSS has been started. Information obtained during such scans is used as described within this subclause and within 11.14.12.

After starting a 20 MHz BSS, an FC HT AP 2G4 shall perform a minimum of dot11BSSWidthChannelTransitionDelayFactor OBSS scans, either by itself or through its associated STAs before making a transition from a 20 MHz BSS to a 20/40 MHz BSS. When the AP performs the scanning and the secondary channel for the 20/40 MHz BSS has been selected, then the scan shall be performed over the set of channels that are allowed operating channels within the current operational regulatory domain and whose center frequency falls within the *affected frequency range* given by Equation (11-3). When the AP performs the scanning without an intended secondary channel for the 20/40 MHz BSS or when the AP's associated STA(s) perform the scanning, then the scan shall be performed on all channels in the frequency band.

NOTE—An FC HT AP can change from operating a 20 MHz BSS to a 20/40 MHz BSS while maintaining associations by making a change to the transmitted value of the Secondary Channel Offset field.

$$\textit{affected frequency range} = \left[\frac{f_P + f_S}{2} - 25\text{ MHz}, \frac{f_P + f_S}{2} + 25\text{ MHz}\right] \tag{11-3}$$

where
- f_P is the center frequency of channel P
- f_S is the center frequency of channel S

An FC HT AP 2G4 shall maintain a local boolean variable *20/40 Operation Permitted* that can have either the value TRUE or FALSE. The initial value of *20/40 Operation Permitted* shall be FALSE. The value of *20/40 Operation Permitted* is recomputed according to Equation (11-4) whenever a BSS channel width trigger event is detected or whenever a period of time has elapsed with no BSS channel width triggers being detected and no overlap being reported, as defined in 11.14.12.

$$\begin{aligned}\textit{20/40 Operation Permitted} = &(P == OP_i \text{ for all values of } i) \text{ AND}\\ &(P == OT_i \text{ for all values of } i) \text{ AND}\\ &(S == OS_i \text{ for all values of } i)\end{aligned} \tag{11-4}$$

where
- P is the operating or intended primary channel of the 20/40 MHz BSS
- S is the operating or intended secondary channel of the 20/40 MHz BSS
- OP_i is member i of the set of channels that are members of the channel set C and that are the primary operating channel of at least one 20/40 MHz BSS that was detected within the AP's BSA during the previous dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTriggerScanInterval seconds

OS_i is member *i* of the set of channels that are members of the channel set C and that are the secondary operating channel of at least one 20/40 MHz BSS that was detected within the AP's BSA during the previous dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTriggerScanInterval seconds

OT_i is member *i* of the set that comprises all channels that are members of the channel set C that were listed at least once in the Channel List fields of 20/40 BSS Intolerant Channel Report elements received during the previous dot11BSSWidthChannelTransitionDelayFactor × dot11BSS-WidthTriggerScanInterval seconds and all channels that are members of the channel set C and that are the primary operating channel of at least one 20 MHz BSS that was detected within the AP's BSA during the previous dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTrigger-ScanInterval seconds

C is the set of all channels that are allowed operating channels within the current operational regulatory domain and whose center frequency falls within the *affected frequency range* given by Equation (11-3)

and where the use of "==" in the above expressions means that the value on the left side of the "==" is to be tested for equality with the value on the right side of the "==" yielding a boolean value of TRUE if the two sides are equal and FALSE if the two sides are unequal. If either side of the equality is the empty set or has a NULL value, then the expression is defined to have a boolean value of TRUE.

An FC HT AP 2G4 shall not start a 20/40 MHz BSS in the 2.4 GHz band if the value of the local variable *20/40 Operation Permitted* is FALSE (see Equation (11-4)).

An FC HT AP 2G4 may transmit a frame containing a Secondary Channel Offset field set to a value of SCA or SCB only if *20/40 Operation Permitted* is TRUE.

In addition to information obtained by the FC HT AP 2G4 through its own scanning, an FC HT AP 2G4 shall use 20/40 BSS Intolerant Channel Report element information from received 20/40 BSS Coexistence Management frames with a value for the Address 1 field that matches the FC HT AP 2G4 using either individual or group addressing, but with no qualification of the Address 3 value, when determining if *20/40 Operation Permitted* is TRUE or FALSE. The information from the Channel List fields of received 20/40 BSS Intolerant Channel Report elements is used in generating the *OT* set for Equation (11-4).

After initial establishment of the 20/40 MHz BSS, if the value of *20/40 Operation Permitted* becomes FALSE, the FC HT AP 2G4 reverts to 20 MHz BSS operation (see 11.14.12). The FC HT AP 2G4 can subsequently move the BSS to a pair of channels where the value of *20/40 Operation Permitted* evaluates to TRUE.

11.14.3.3 Channel management at the AP and in an IBSS

While operating a 20/40 MHz BSS, an IDO STA or an AP may decide to move its BSS, and an AP may decide to switch the BSS to 20 MHz operation either alone or in combination with a channel move. These channel move or BSS width switch operations can occur if, for example, another BSS starts to operate in either or both of the primary or secondary channels, or if radar is detected in either or both of the primary or secondary channels, or for other reasons that are beyond the scope of this standard. Specifically, the AP or IDO STA may move its BSS to a different pair of channels, and the AP may separately, or in combination with the channel switch, change from a 20/40 MHz BSS to a 20 MHz BSS using either the primary channel of the previous channel pair or any other available 20 MHz channel. While operating a 20 MHz BSS, an IDO STA or an AP may decide to move its BSS, and an AP may decide to switch the BSS to a 20/40 MHz BSS, either alone or in combination with a channel move.

If an AP or IDO STA uses one or more Extended Channel Switch Announcement frames without also using Beacon and Probe Response frames to announce a change of regulatory class and/or a change in channel(s) and if the new regulatory class supports either of the behavior limits 13 or 14 as identified in the appropriate table of Annex J (i.e., Table J.1, Table J.2, or Table J.3), then the BSS width (20 MHz BSS or 20/40 MHz BSS) immediately after the switch shall be the same as the BSS width immediately before the transmission of the first Extended Channel Switch Announcement frame that announced the change. The AP or IDO STA may subsequently perform a BSS width change.

NOTE—If an AP or IDO STA uses one or more Extended Channel Switch Announcement frames without also using Beacon and Probe Response frames to announce a change of regulatory class and/or a change in channel(s), then the AP or IDO STA cannot change from 20 MHz BSS operation to 20/40 MHz BSS operation as part of that change, even if the new regulatory class supports 20/40 MHz BSS operation, because Extended Channel Switch Announcement frames do not convey secondary channel information (i.e., information regarding whether a secondary channel, if permitted in the regulatory class, is to be used).

When switching a 20/40 MHz BSS to 20 MHz BSS mode, the AP may recalculate the TS bandwidth budget and may delete one or more active TSs by invoking the MLME-DELTS.request primitive with a ReasonCode value of SERVICE_CHANGE_PRECLUDES_TS.

An AP switches between 20/40 MHz BSS and 20 MHz BSS as follows:

— By changing the value of the Secondary Channel Offset field of the HT Operation element in the Beacon frame, and/or
— By changing the value of the Secondary Channel Offset field of the Secondary Channel Offset element, and/or
— Through the New Regulatory Class field of transmitted Extended Channel Switch Announcement elements.

In order to maintain existing associations and/or minimize disruption to communications with other STAs while making a channel width change or while performing a channel pair relocation, an AP may inform HT STAs within its BSS that it is making the change by including an Extended Channel Switch Announcement element in Beacon, Probe Response, and Extended Channel Switch Announcement frame transmissions until the intended channel switch time. An IDO STA may inform HT STAs within its BSS that it is performing a channel pair relocation by including an Extended Channel Switch Announcement element in Beacon, Probe Response, and Extended Channel Switch Announcement frame transmissions until the intended channel switch time. The New Channel Number field of the Extended Channel Switch Announcement element represents the new channel (when the BSS after relocation/width change will be a 20 MHz BSS) or the primary channel of the new pair of channels (when the BSS after relocation/width change will be a 20/40 MHz BSS). When changing to a new pair of channels, the New Regulatory Class field specifies the position of the secondary channel relative to the new primary channel, i.e., either above or below.

When transmitting HT Operation elements, Channel Switch Announcement elements, and/or Extended Channel Switch Announcement elements, the AP moving the BSS or changing its channel width selects a combination of operating parameters from any single row of any one of the tables in Annex J that is appropriate for the current operating domain of the AP. Similarly, when transmitting HT Operation elements, Channel Switch Announcement elements, and/or Extended Channel Switch Announcement elements, the IDO STA moving the BSS selects a combination of operating parameters from any single row of any one of the tables in Annex J that is appropriate for the current operating domain of the IDO STA. The AP or IDO STA selects one channel number from the "Channel set" column of the selected row. The AP or IDO STA includes the selected information in subsequently transmitted frames that contain any combination of the following four elements:

— HT Operation element
— Channel Switch Announcement element
— Extended Channel Switch Announcement element
— Secondary Channel Offset element

The AP or IDO STA shall set the Secondary Channel Offset field of transmitted HT Operation elements and transmitted Secondary Channel Offset elements to SCA if the Behavior Limit parameter of the selected row contains the value 13. The AP or IDO STA shall set the Secondary Channel Offset field of transmitted HT Operation elements and transmitted Secondary Channel Offset elements to SCB if the Behavior Limit parameter of the selected row contains the value 14. The AP or IDO STA shall set the Secondary Channel Offset field of transmitted HT Operation elements and transmitted Secondary Channel Offset elements to SCN if the Behavior Limit parameter of the selected row contains neither the value 13 nor the value 14.

The AP or IDO STA shall set the New Channel Number field of transmitted Channel Switch Announcement elements and Extended Channel Switch Announcement elements to the value of the selected channel from the selected row.

The AP or IDO STA shall set the New Regulatory Class field of transmitted Extended Channel Switch Announcement elements to the value of the "Regulatory class" column of the selected row.

Movement of a 20/40 MHz BSS from one channel pair to a different channel pair and changing between 20 MHz and 20/40 MHz operation should be scheduled so that all STAs in the BSS, including STAs in power save mode, have the opportunity to receive at least one Extended Channel Switch Announcement element or Channel Switch Announcement element before the switch.

When the Extended Channel Switch Announcement element and Extended Channel Switch Announcement frame are transmitted in bands where dot11SpectrumManagementRequired is TRUE, the Channel Switch Announcement element and Channel Switch Announcement frame may also be transmitted. A STA that announces a channel switch using both the Extended Channel Switch Announcement element and the Channel Switch Announcement element shall set the New Channel Number field of both elements to the same value. An HT STA that receives a channel switch announcement through both the Extended Channel Switch Announcement element and the Channel Switch Announcement element shall ignore the received Channel Switch Announcement element.

For 20 MHz operation when the new regulatory class signifies 40 MHz channel spacing, the 20 MHz channel is the primary channel of the 40 MHz channel.

11.14.4 40 MHz PPDU transmission restrictions

11.14.4.1 Fields used to determine 40 MHz PPDU transmission restrictions

Several fields from various frames are used to convey information between STAs regarding the support for 40 MHz PPDU transmission and reception and regarding any current prohibition against the transmission and reception of 40 MHz PPDUs.

The rules defined in 11.14.4.2, 11.14.4.3, and 11.14.4.4 describe the behavior that accompanies those fields.

The fields that are used to determine the status of the transmission and reception of 40 MHz PPDUs are as follows:

— The Supported Channel Width Set subfield of the HT Capabilities element
— The Secondary Channel Offset field of the HT Operation element
— The STA Channel Width field of the HT Operation element
— The Channel Width field of the Notify Channel Width action frame
— The Extended Channel Switch Announcement element

The Supported Channel Width Set subfield is used to indicate whether the transmitting STA is capable of transmitting and receiving 40 MHz PPDUs.

NOTE—The Supported Channel Width Set subfield transmitted by an AP is constant for the lifetime of its BSS as it is a parameter of the MLME-START.request primitive.

In addition to the restrictions on transmission of 40 MHz mask PPDUs found in 11.14.4.1 through 11.14.4.4, if a STA operating in the 2.4 GHz industrial, scientific, and medical (ISM) band has no means of determining the presence of non-IEEE 802.11 communication devices operating in the area, then the STA shall not transmit any 40 MHz mask PPDUs.

In addition to the restrictions on transmission of 40 MHz mask PPDUs found in 11.14.4.1 through 11.14.4.4, if a STA operating in the 2.4 GHz ISM band has a means of determining the presence of non-IEEE 802.11 communication devices operating in the area and determines either that no non-IEEE 802.11 communication device is operating in the area or that non-IEEE 802.11 communication devices are operating in the area but the STA implements a coexistence mechanism for these non-IEEE 802.11 communication devices, then the STA may transmit 40 MHz mask PPDUs; otherwise, the STA shall not transmit any 40 MHz mask PPDUs.

11.14.4.2 Infrastructure non-AP STA restrictions

A STA that is associated with an AP shall not transmit a value for the Supported Channel Width Set subfield that differs from a previously transmitted value during its current association.

The Secondary Channel Offset field is used to indicate whether the BSS is occupying a 40 MHz wide pair of channels and, when a secondary channel exists, whether it is above or below the primary channel in frequency. The Extended Channel Switch Announcement action frame and the Extended Channel Switch Announcement element can each be used to indicate a transition from 20/40 MHz BSS operation to 20 MHz BSS operation and vice versa and to indicate whether a secondary channel, when it exists, is above or below the primary channel in frequency.

An FC HT STA shall maintain a local boolean variable *40MHzRegulatoryClass* as described here. The initial value of *40MHzRegulatoryClass* shall be FALSE. The value of *40MHzRegulatoryClass* is recomputed according to the rules in this subclause at every TBTT and following the reception of a frame transmitted by the AP associated with the STA when that frame contains either of the following fields:

— Current Regulatory Class field
— New Regulatory Class field

The local boolean variable *40MHzRegulatoryClass* becomes TRUE upon reception of a frame transmitted by the associated AP if the frame contained a Current Regulatory Class field with a value that corresponds to a regulatory class that corresponds to a channel spacing value of 40 MHz, as specified in Annex J.

The local boolean variable *40MHzRegulatoryClass* becomes FALSE upon reception of a frame transmitted by the associated AP if the frame contained a Current Regulatory Class field with a value that corresponds to a regulatory class that does not correspond to a channel spacing value of 40 MHz.

The local boolean variable *40MHzRegulatoryClass* becomes TRUE at the *n*th TBTT following reception of a frame transmitted by the associated AP that contains an Extended Channel Switch Announcement element with a value of *n* in the Channel Switch Count field and a value in the New Regulatory Class field that corresponds to a regulatory class that corresponds to a channel spacing value of 40 MHz provided that the frame is the most recently received frame meeting the above conditions.

The local boolean variable *40MHzRegulatoryClass* becomes FALSE at the *n*th TBTT following reception of a frame transmitted by the associated AP that contains an Extended Channel Switch Announcement element with a value of *n* in the Channel Switch Count field and a value in the New Regulatory Class field that corresponds to a regulatory class that does not correspond to a channel spacing value of 40 MHz provided that the frame is the most recently received frame meeting the above conditions.

A STA can choose to dynamically constrain its operating channel width to 20 MHz while being a member of a 20/40 MHz BSS. Transitions to and from this constrained state are indicated using the transmission of a frame that carries the Channel Width field. A Channel Width field value of 0 indicates that the transmitting STA is not currently able to receive 40 MHz PPDUs, beginning at the end of the transmission of the frame that contained the Channel Width field.

A STA shall not transmit a frame containing a STA Channel Width field or a Channel Width field set to 1 if the value of its most recently transmitted Supported Channel Width Set subfield is 0.

A STA that is associated with an infrastructure BSS (STA1) shall not transmit a 40 MHz PPDU containing one or more frames addressed to another STA (STA2) unless the following three conditions are true:

— The Supported Channel Width Set subfield of the HT Capabilities element of both STAs is set to 1
— The Secondary Channel Offset field of the most recently received HT Operation element sent by the AP of the BSS has a value of SCA or SCB
— The local boolean variable *40MHzRegulatoryClass* is TRUE.

If the above three conditions are met, STA1 should not transmit a 40 MHz PPDU containing one or more frames addressed to STA2 unless the following two conditions are true:

— Either STA1 has not received a Notify Channel Width action frame that was transmitted by STA2, or the Channel Width field of the most recently received Notify Channel Width action frame at STA1 that was transmitted by STA2 is nonzero.
— If STA2 is an AP, the STA Channel Width field of the most recently received HT Operation element that was transmitted by STA2 is set to 1.

11.14.4.3 AP restrictions

An AP shall not transmit a 40 MHz PPDU containing one or more frames addressed to another STA unless the following three conditions are true:

— The Supported Channel Width Set subfield of the HT Capabilities element of the AP and the STA are set to a nonzero value.
— The Secondary Channel Offset field of the AP's most recently transmitted HT Operation element has a value of SCA or SCB
— The local boolean variable *40MHzRegulatoryClass* is TRUE.

If the above three conditions are met, the AP should not transmit a 40 MHz PPDU containing frames addressed to another STA unless either the AP has not received a Notify Channel Width action frame that was transmitted by the STA or the Channel Width field of the most recently received Notify Channel Width action frame at the AP that was transmitted by the STA is nonzero.

An AP shall not transmit a 40 MHz PPDU containing one or more frames with a group address in the Address 1 field unless the following three conditions are true:

— The Supported Channel Width Set subfield of the HT Capabilities element of the AP is set to 1
— The Secondary Channel Offset field of the AP's most recently transmitted HT Operation element has a value of SCA or SCB
— The local boolean variable *40MHzRegulatoryClass* is TRUE.

If the above three conditions are met, the AP should not transmit a 40 MHz PPDU containing one or more frames with a group address in the Address 1 field if the most recently received Notify Channel Width action frame for any of the STAs associated with the AP has the Channel Width field set to 0.

11.14.4.4 Restrictions on non-AP STAs that are not infrastructure BSS members

An HT STA 2G4 that is not a member of an infrastructure BSS shall not transmit a 40 MHz mask PPDU.

An HT STA 5G that is not associated with an infrastructure BSS (STA1) shall not transmit a 40 MHz PPDU containing frames addressed to another STA (STA2) unless the following three conditions are true:

- The Supported Channel Width Set subfield of the HT Capabilities element of both STAs is set to 1
- The Secondary Channel Offset field of the most recently received HT Operation element sent by STA2 has a value of SCA or SCB
- The Secondary Channel Offset field of the most recently transmitted HT Operation element sent by STA1 has a value of SCA or SCB

If the above three conditions are met, STA1 should not transmit a 40 MHz PPDU containing one or more frames addressed to STA2 unless STA1 has not received a STA Channel Width field that was transmitted by STA2 or the value of the most recently received STA Channel Width field at STA1 that was transmitted by STA2 is nonzero.

An HT STA 5G that is not associated with an infrastructure BSS (STA1) shall not transmit a 40 MHz PPDU containing one or more frames with a group address in the Address 1 field unless the following two conditions are true:

- The Supported Channel Width Set subfield of the HT Capabilities element most recently transmitted by STA1 is set to 1.
- The Secondary Channel Offset field of the HT Operation element most recently transmitted by STA1 has a value of SCA or SCB.

If the above two conditions are met, STA1 should not transmit a 40 MHz PPDU containing one or more frames with a group address in the Address 1 field unless the most recently received STA Channel Width field for each other known member of the BSS of which STA1 is a member is set to 1.

11.14.5 Scanning requirements for 40-MHz-capable STA

An OBSS scan operation is a passive or active scan of a set of channels that are potentially affected by 20/40 MHz BSS operation. Each channel in the set may be scanned more than once during a single OBSS scan operation. OBSS scans are performed by STAs that are FC HT STA 2G4. STAs that are FC HT STA 5G are not required to perform OBSS scan operations.

NOTE—STAs that perform OBSS scans report discovered BSSs and received 20/40 BSS coexistence information to their associated AP (see 11.14.12).

During an individual scan within an OBSS scan operation, the mininum per-channel scan duration is dot11OBSSScanPassiveDwell TU (when scanning passively) or dot11OBSSScanActiveDwell TU (when scanning actively). During an OBSS scan operation, each channel in the set is scanned at least once per dot11BSSWidthTriggerScanInterval seconds, and the minimum total scan time (i.e., the sum of the scan durations) per channel within a single OBSS scan operation is dot11OBSSScanPassiveTotalPerChannel TU for a passive scan and dot11OBSSScanActiveTotalPerChannel TU for an active scan.

NOTE—The values provided in the previous paragraph indicate the minimum requirements. For some combinations of parameter values, it is necessary to exceed the minimum values of some parameters in order to meet the minimum value constraints of all parameters.

When an AP transmits an Overlapping BSS Scan Parameters element, the value of each of the fields of the element shall be set to the value of the MIB variable from the transmitting AP's MIB according to the mapping between the frame fields and MIB variables as defined in 7.3.2.59.

Upon receipt of a frame containing an Overlapping BSS Scan Parameters element from the AP with which an FC HT STA 2G4 is associated, the MLME of the receiving FC HT STA 2G4 shall update each of the values of the MIB variables used during OBSS scanning operations according to the mapping between the frame fields and MIB variables as defined in 7.3.2.59.

An FC HT AP 2G4 may transmit frames containing an Overlapping BSS Scan Parameters element to any or all associated STAs in order to provide OBSS scan parameter values that are different from the default values.

An FC HT STA 2G4 that is associated with an FC HT AP 2G4 shall perform at least one OBSS scan every dot11BSSWidthTriggerScanInterval seconds, unless the FC HT STA 2G4 satisfies the conditions described in 11.14.6.

11.14.6 Exemption from OBSS scanning

An FC HT STA 2G4 shall maintain a local variable *ActivityFraction*. The value of *ActivityFraction* is defined by Equation (11-5).

$$ActivityFraction = \frac{T_{ACTIVE}}{T_{MEASURE\text{-}ACTIVE}} \tag{11-5}$$

where

T_{ACTIVE}	is the total duration of transmitted MSDUs and received individually addressed MSDUs during the previous $T_{MEASURE\text{-}ACTIVE}$ seconds
$T_{MEASURE\text{-}ACTIVE}$	is dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTriggerScan-Interval seconds.

An FC HT STA 2G4 may transmit to its associated AP a 20/40 BSS Coexistence Management frame with the Scanning Exemption Request field in the 20/40 Coexistence element set to 1.

If the last 20/40 BSS Coexistence Management frame received by an FC HT STA 2G4 in an individually addressed frame from its associated AP has the Scanning Exemption Grant field set to 1, the STA is exempted from scanning whenever the value of its local variable *ActivityFraction* is less than dot11OBSSScanActivityThreshold/10000.

An FC HT AP 2G4 shall not transmit a 20/40 BSS Coexistence Management frame with the Scanning Exemption Grant field set to 1 addressed to an FC HT STA if the following condition is true:

— The FC HT STA has transmitted one or more channel report elements and is the only STA in the BSS that has indicated one or more channels on which a STA has found conditions that disallow the use of a 20/40 MHz BSS.

If there is more than one FC HT STA in the BSS that has indicated conditions that disallow the use of 20/40 MHz BSS on a specific channel, then the following apply:

— If all the FC HT STAs that have indicated unavailability of a channel have also requested to be exempt from scanning, the AP shall disallow at least one of the FC HT STA to be exempt from scanning.

— If, from the group of FC HT STAs that have indicated unavailability of a channel, there is at least one FC HT STA that has not requested to be exempt from scanning, the AP may allow all the STAs that have requested to be exempt from scanning to be exempted from scanning.

11.14.7 Communicating 20/40 BSS coexistence information

In addition to the 20/40 BSS Coexistence Management frame, a STA can include the 20/40 BSS Coexistence element in transmitted Beacon, Probe Request, Probe Response, (Re)Association Request, and (Re)Association Response frames.

11.14.8 Support of DSSS/CCK in 40 MHz

Transmission and reception of PPDUs using DSSS/CCK by FC HT STAs is managed using the DSSS/CCK Mode in 40 MHz subfield of the HT Capabilities Info field (see 7.3.2.56.2).

An HT STA declares its capability to use DSSS/CCK rates while it has a 40 MHz operating channel width through the DSSS/CCK Mode in 40 MHz subfield of its (Re)Association Request frames.

If the DSSS/CCK Mode in 40 MHz subfield is set to 1 in Beacon and Probe Response frames, an associated HT STA in a 20/40 MHz BSS may generate DSSS/CCK transmissions. If the subfield is set to 0, then the following apply:

— Associated HT STAs shall not generate DSSS/CCK transmissions.
— The AP shall not include an ERP Information element in its Beacon and Probe Response frames.
— The AP shall not include DSSS/CCK rates in the Supported Rates element.
— The AP shall refuse association requests from a STA that includes only DSSS/CCK rates in its Supported Rates and Extended Supported Rates elements.

11.14.9 STA CCA sensing in a 20/40 MHz BSS

A STA may transmit a 20 MHz mask PPDU in the primary channel following the rules in 9.9.1.

A STA transmitting a 40 MHz mask PPDU that begins a TXOP using EDCA as described in 9.9.1.3 or that is using a PIFS as permitted in 9.2.3.2 shall sense CCA on both the 20 MHz primary channel and the 20 MHz secondary channel before the 40 MHz mask PPDU transmission starts.

Unless explicitly stated otherwise, a STA may treat a PHY-CCA.indication that is BUSY as though it were IDLE in the following cases:

— If the channel-list parameter is present and equal to {secondary} and the STA is transmitting a 20 MHz mask PPDU on the primary channel, or
— If the channel-list parameter is present and equal to {primary} and the STA is transmitting a 20 MHz mask PPDU on the secondary channel.

NOTE—Transmission of PPDUs on the secondary channel is also subject to constraints in 11.14.2.

At the specific slot boundaries (defined in 9.2.10) determined by the STA based on the 20 MHz primary channel CCA, when the transmission begins a TXOP using EDCA (as described in 9.9.1.3), the STA may transmit a pending 40 MHz mask PPDU only if the secondary channel has also been idle during the times the primary channel CCA is performed (defined in 9.2.10) during an interval of a PIFS for the 5 GHz band and DIFS for the 2.4 GHz band immediately preceding the expiration of the backoff counter. If a STA was unable to transmit a 40 MHz mask PPDU because the secondary channel was occupied during this interval, it may take one of the following steps:

a) Transmit a 20 MHz mask PPDU on the primary channel.
b) Restart the channel access attempt. In this case, the STA shall invoke the backoff procedure as specified in 9.9.1 as though the medium is busy as indicated by either physical or virtual CS and the backoff timer has a value of zero.

NOTE—As a result of this rule, the STA selects a new random number using the current value of CW[AC], and the retry counters are not updated.

When a TXOP is obtained for a 40 MHz PPDU, the STA may transmit 40 MHz PPDUs and/or 20 MHz PPDUs during the TXOP. When the TXOP is obtained by the exchange of 20 MHz PPDUs only in the primary channel, the STA shall not transmit 40 MHz PPDUs during the TXOP.

11.14.10 NAV assertion in 20/40 MHz BSS

An HT STA shall update its NAV using the Duration/ID field value in any frame received in a 20 MHz PPDU in the primary channel or received in a 40 MHz PPDU and that does not have an RA matching the STA MAC address.

NOTE—A STA need not set its NAV in response to 20 MHz frames received on the secondary channel or any other channel that is not the primary channel, even if it is capable of receiving those frames.

11.14.11 Signaling 40 MHz intolerance

An HT STA 2G4 shall set the Forty MHz Intolerant field to 1 in transmitted HT Capabilities elements if the value of the MIB attribute dot11FortyMHzIntolerant is TRUE; otherwise, the field shall be set to 0.

A STA 2G4 shall set the Forty MHz Intolerant field to 1 in transmitted 20/40 BSS Coexistence fields if the value of the MIB attribute dot11FortyMHzIntolerant is TRUE; otherwise, the field shall be set to 0. A STA 2G4 that is not an HT STA 2G4 shall include a 20/40 BSS Coexistence element in management frames in which the element may be present if the STA has a MIB attribute dot11FortyMHzIntolerant and the value of that MIB attribute is TRUE.

A STA 5G shall set the Forty MHz Intolerant field to 0 in transmitted HT Capabilities elements and 20/40 BSS Coexistence fields.

11.14.12 Switching between 40 MHz and 20 MHz

The following events are defined to be BSS channel width trigger events (TEs):

— **TE-A**: On any of the channels of the channel set defined in Clause 19, reception of a Beacon frame that does not contain an HT Capabilities element.

— **TE-B**: On any of the channels of the channel set defined in Clause 19, reception of a 20/40 BSS Coexistence Management, Beacon, Probe Request, or Probe Response frame that contains a value of 1 in a Forty MHz Intolerant field and that has the Address 1 field set to the receiving STA's address or to a group address value, with no further addressing qualifications.

— **TE-C**: Reception of a 20/40 BSS Coexistence Management frame with the 20 MHz BSS Width Request field set to 1 and with a value for the Address 1 field that matches the receiving STA using either individual or group addressing and with a value for the TA field that corresponds to the MAC address of a STA with which the receiver is associated.

— **TE-D**: Reception of a 20/40 BSS Coexistence Management frame containing at least one 20/40 BSS Intolerant Channel Report element with a nonzero length and with a value for the Address 1 field set to the receiving STA's address or to a group address value, but with no qualification of the Address 3 value.

An FC HT AP 2G4 shall reevaluate the value of the local variable *20/40 Operation Permitted* (see 11.14.3.2) when either of the following events occurs:

— A BSS channel width trigger event TE-A is detected.

— A BSS channel width trigger event TE-D is detected.

An FC HT AP 2G4 may reevaluate the value of the local variable *20/40 Operation Permitted* (see 11.14.3.2) when either of the following situations occurs:

- — No BSS channel width trigger events TE-A are detected for a period of time equal to dot11BSSWidth-ChannelTransitionDelayFactor × dot11BSSWidthTriggerScanInterval seconds.
- — No BSS channel width trigger events TE-D are detected for a period of time equal to dot11BSSWidth-ChannelTransitionDelayFactor × dot11BSSWidthTriggerScanInterval seconds.

An FC HT AP 2G4 that detects either BSS channel width trigger event TE-B or TE-C or that determines that the value of its variable *20/40 Operation Permitted* has changed from TRUE to FALSE shall set the Secondary Channel Offset field to SCN in transmitted HT Operation elements beginning at the next DTIM or next TBTT if no DTIMs are transmitted to indicate that no secondary channel is present (i.e., that the BSS operating width is 20 MHz).

An FC HT AP 2G4 shall not set the Secondary Channel Offset field to a value of SCA or SCB in transmitted HT Operation elements unless the following two conditions have been met:

- — A period of dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTriggerScanInterval seconds have elapsed during which no BSS channel width trigger events TE-B or TE-C are detected.
- — The value of the local variable *20/40 Operation Permitted* (see 11.14.3.2) is TRUE.

To request an update of the status of the 20 MHz BSS Width Request field, an FC HT AP 2G4 can transmit a 20/40 BSS Coexistence Management frame with a value of 1 in the Information Request field as described in 11.16.

An FC HT STA 2G4 that is associated with an FC HT AP 2G4 shall maintain a record of detected BSS channel width trigger events as follows:

- — For each detected BSS channel width trigger event TE-A:
  - — If a DS Parameter Set field is present in the received Beacon frame, the channel of the BSS channel width trigger event is the value of the Current Channel field of the DS Parameter Set field; otherwise, the channel of the BSS channel width trigger event is the channel on which the detecting STA received the Beacon frame.
  - — If a Supported Regulatory Classes element is present in the received Beacon frame, the regulatory class of the BSS channel width trigger event is the value of the Current Regulatory Class field of the Supported Regulatory Classes element of the received Beacon frame; otherwise, the regulatory class of the BSS channel width trigger event is “unknown.”
- — For each detected BSS channel width trigger event TE-A of a unique combination of regulatory class and channel, the FC HT STA 2G4 shall maintain a record containing two variables:
  - — The regulatory class of the BSS channel width trigger event
  - — The channel of the BSS channel width trigger event

NOTE—If a BSS channel width trigger event TE-A is detected for a regulatory class and channel combination for which no record exists, the STA creates such a record.

If a BSS channel width trigger event TE-A is detected for a regulatory class and channel combination for which a record already exists, the information in that record shall be updated with the information determined from the new trigger event.

For all BSS channel width trigger events TE-B, the FC HT STA 2G4 shall maintain a single record containing an indication of whether one or more trigger events TE-B have been detected.

At the completion of an OBSS scan operation (i.e., at the end of the period of time equal to dot11BSSWidthTriggerScanInterval) or when it receives a 20/40 BSS Coexistence Management frame from its associated AP that contains a value of 1 in the Information Request field, an FC HT STA 2G4 that is associated with an FC HT AP 2G4 shall create a 20/40 BSS Coexistence Management frame by including a value of zero for all fields of a 20/40 BSS Coexistence Management frame and then transferring information from the BSS channel width trigger event TE-A and TE-B records to the frame according to the following four steps:

- For each unique regulatory class that is stored in the set of BSS channel width trigger event TE-A records, the STA shall create a 20/40 BSS Intolerant Channel Report element for inclusion in the frame and include all of the unique channels associated with the regulatory class in the channel list of that element.
- The STA sets the Forty MHz Intolerant field of the 20/40 BSS Coexistence element based on the value of the dot11FortyMHzIntolerant MIB attribute (see 11.14.11).
- The STA shall set to 1 the 20 MHz BSS Width Request field of the 20/40 BSS Coexistence element for inclusion in the frame if a record for BSS channel width trigger event TE-B exists and indicates that at least one trigger event TE-B has been detected.
- The STA may set to 1 the Information Request field.

Upon completion of these four steps, the FC HT STA 2G4 shall delete all records for trigger events TE-A and TE-B. Subsequently detected trigger events cause the creation of new records as necessary to be used in subsequently generated 20/40 BSS Coexistence Management frames. Following the record deletion, the FC HT STA 2G4 shall transmit to its associated FC HT AP 2G4 the 20/40 BSS Coexistence Management frame if any of the following conditions is true:

- At least one 20/40 BSS Intolerant Channel Report element with the Length field set to a nonzero value is included.
- The Forty MHz Intolerant field is set to 1.
- The 20 MHz BSS Width Request field is set to 1.
- The Information Request field is set to 1.
- The frame was created in response to the reception of an Information Request field that was set to 1.

11.15 Phased coexistence operation (PCO)

11.15.1 General description of PCO

PCO is an optional coexistence mechanism in which a PCO active AP divides time into alternating 20 MHz and 40 MHz phases (see Figure 11-20). The PCO active AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of OBSSs on both 20 MHz halves of a 40 MHz channel.

A PCO active STA that does not know the current PCO phase shall transmit using a 20 MHz PPDU.

During the 40 MHz phase, a PCO active STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, with the following exceptions:

- Any CF-End frame shall be sent using only a 40 MHz HT PPDU.
- A PCO active AP may transmit 20 MHz group-addressed frames as defined in 9.6.0d.3.

A PCO active STA shall transmit management frames in 20 MHz or 40 MHz PPDUs according to 9.6.0d during the 40 MHz phase, except that Set PCO Phase frames shall be sent following the rules specified in 11.15.2.

During the 40 MHz phase, a PCO active STA can act as though the HT Protection field were set to no protection mode, as defined in 9.13.3.1.

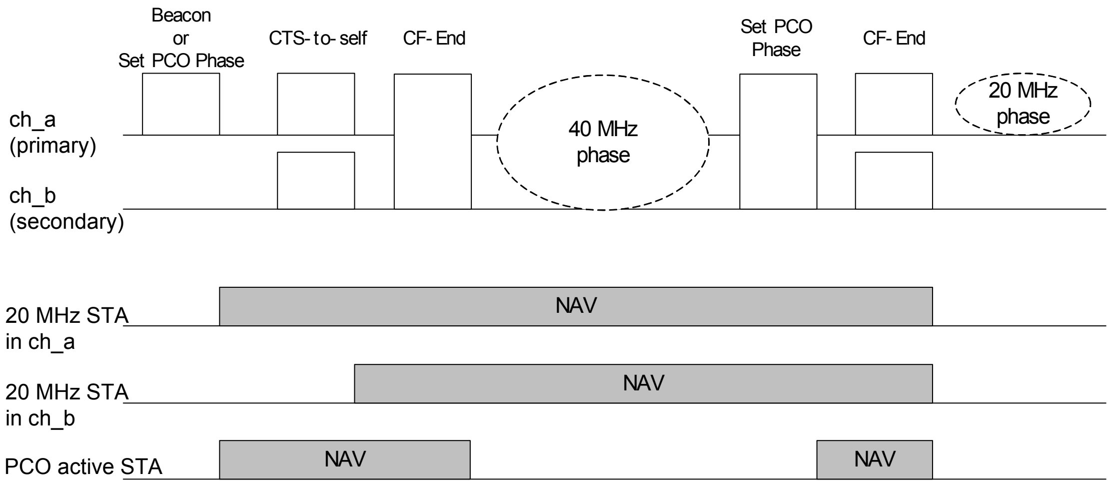


Figure 11-20—Phased coexistence operation (PCO)

During the 20 MHz phase, a PCO active STA shall not transmit frames using a 40 MHz (HT or non-HT duplicate) PPDU. The protection of a PCO active STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.

During the 20 MHz phase, a STA may transmit a 40 MHz mask PPDU that is not also a 40 MHz PPDU.

NOTE—This rule allows a STA to transmit 20 MHz PPDUs without requiring it to change to a 20 MHz transmit mask.

A PCO-capable AP may set the PCO Active field to 1 only if it is in a 20/40 MHz BSS.

NOTE—A non-PCO-capable 20/40 STA regards the PCO active BSS as a PCO inactive BSS. A non-PCO-capable 20/40 STA that associates with a PCO active BSS protects its transmissions as though the BSS were a PCO inactive BSS.

The value indicated by the PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO active STA shall be able to receive a PPDU using the new channel width no later than the value specified by the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

11.15.2 Operation at a PCO active AP

A PCO-capable AP activates PCO if it decides that PCO active BSS is more appropriate than either PCO inactive BSS or 20 MHz BSS in the current circumstances. The algorithm for making this decision is beyond the scope of this standard.[1]

A PCO active AP shall set the PCO Active field in the HT Operation element to 1.

When a PCO active AP detects that PCO is not providing a performance benefit, the PCO active AP may deactivate PCO and operate in either a PCO inactive BSS or 20 MHz BSS. A PCO-capable AP shall set the PCO Active field in the HT Operation element to 0 when PCO operation is disabled. Since the AP advertises the current mode in its Beacon and Probe Response frames, its associated STAs are informed of the mode change.

[1]A PCO-capable AP can consider the performance impact, e.g., throughput and jitter, caused by and given to STAs based on their capabilities, traffic types, or load to determine the BSS’s PCO mode. STAs under consideration may be not only associated STAs but also those that were detected in OBSSs.

Values of the PCO Transition Time field in the HT Extended Capabilities field from 1 to 3 indicate the maximum time the PCO active STA takes to switch between a 20 MHz channel width and a 40 MHz channel width. A PCO active AP may set the PCO Transition Time field to 0 when it requires the associated PCO active STAs to be able to receive 40 MHz frames and respond with 40 MHz frames during the 20 MHz phase.

The PCO active AP shall increase the value of the PCO Transition Time field if the PCO active AP accepts the association of a PCO-capable STA whose value of the PCO Transition Time field exceeds the one currently used by the PCO active AP. If the PCO active AP decides not to extend its transition time to meet the value of the requesting STA, the PCO active AP shall deny the association. The AP may choose to continue PCO when a non-PCO-capable 20/40 STA requests association, and in such cases, the PCO active AP shall be able to receive 40 MHz frames and respond using 40 MHz frames during the 20 MHz phase.

A PCO active AP that indicates a switch to the 40 MHz phase by a PCO Phase field in a Beacon frame or by a PCO Phase Control field in a Set PCO Phase frame and that transmits a nonzero value of the PCO Transition Time field shall wait for at least the transition time specified by the PCO Transition Time field before sending a CF-End frame in the 40 MHz channel to start the 40 MHz operating phase.

When switching to the 40 MHz phase, a PCO active AP indicates a NAV duration either in the CF Parameter Set element of a Beacon frame or in the Duration/ID field of a Set PCO Phase frame sent on the primary channel that shall protect up to the end of the intended 40 MHz phase plus a transition time. A PCO active AP may continue the CFP after the 40 MHz phase by setting a longer duration for the CFP. The value of the Duration/ID field in a CTS-to-self frame sent to protect a 40 MHz phase shall be set to protect up to the intended end of the 40 MHz phase plus a transition time. The CTS-to-self shall be sent in a non-HT duplicate PPDU. The transmission of the CTS-to-self shall be delayed until the secondary channel CCA has indicated idle for at least a PIFS interval. It need not sense the primary channel because it is already reserved by a Beacon frame or a Set PCO Phase frame.

If the PCO Transition Time field is nonzero, a PCO active AP shall start a timer with a timeout value equal to the time specified by the PCO Transition Time field after transmitting a Beacon frame or a Set PCO Phase frame. If this timer expires while attempting to reserve the secondary channel, the AP shall transmit a Set PCO Phase frame indicating a switch back to the 20 MHz phase and shall transmit a CF-End frame on the primary channel.

NOTE—If this timer expires while attempting to reserve the secondary channel, the AP abandons switching to the 40 MHz phase to avoid an unexpectedly long delay.

A PCO active AP may transmit a Set PCO Phase frame in a non-HT duplicate PPDU followed by a CF-End frame in a 40 MHz HT PPDU to reserve both the primary and secondary channels again for the 40 MHz phase or to extend the 40 MHz phase. The value of the Duration/ID field in a Set PCO Phase frame contained in a non-HT duplicate PPDU for this intent shall protect up to the end of the intended 40 MHz phase plus the transition time.

To start the 20 MHz phase, a PCO active AP shall send a Set PCO Phase frame in a 40 MHz HT PPDU or in a non-HT duplicate PPDU with the Duration/ID field set to cover the transition time. It may also send a CF-End frame in both primary and secondary channels following the Set PCO Phase frame, where a CF-End frame in the primary channel shall be sent out at least after the transition time. The Duration/ID field of the Set PCO Phase frame for this case shall cover the transition time plus the duration of a CF-End frame.

A PCO active AP may broadcast a Set PCO Phase frame to advertise the current PCO phase to PCO active STAs.

Although PCO improves throughput in some circumstances, PCO might also introduce jitter. To minimize the jitter, the maximum duration of 40 MHz phase and 20 MHz phase is dot11PCOFortyMaxDuration and dot11PCOTwentyMaxDuration, respectively. Also in order for the PCO active AP to give opportunities for each STA to send frames, the minimum duration of 40 MHz phase and 20 MHz phase is dot11PCOFortyMinDuration and dot11PCOTwentyMinDuration, respectively.

11.15.3 Operation at a PCO active non-AP STA

If the PCO field in the Association Request frame to a PCO active AP is set to 1 and the association succeeds, the STA shall operate in PCO mode. When requesting association, a PCO-capable STA shall set the PCO Transition Time field to 0 if the PCO active AP has set the PCO Transition Time field to 0. A PCO-capable STA may attempt to associate with a transition time that is larger than one currently advertised by the PCO active AP. If such an association fails, the PCO-capable non-AP STA may regard the BSS as a PCO inactive BSS and may attempt an association as a non-PCO-capable 20/40 STA.

NOTE—A STA that does not support the PCO transition time indicated by an AP can still attempt association with that AP. The AP will either refuse the association based on PCO transition time or respond by adjusting its PCO transition time to suit the STA.

A PCO active non-AP STA may transmit a Probe Request frame to the associated PCO active AP to determine the current PCO phase. A PCO active STA associated with a PCO active AP shall switch its operating phase from 20 MHz channel width to 40 MHz channel width when it receives from its AP a Beacon frame or a Probe Response frame that contains the PCO Phase field set to 1 or a Set PCO Phase frame with the PCO Phase Control field set to 1. The value of the CFP DurRemaining field in the CF Parameter Set element of a Beacon frame or the value of the Duration/ID field of a Set PCO Phase frame shall be interpreted as the duration of the PCO 40 MHz phase.

A PCO active STA associated with a PCO active AP shall switch its operating phase from 40 MHz channel width to 20 MHz channel width when it receives a Beacon frame or a Probe Response frame that contains the PCO Phase field set to 0 or a Set PCO Phase frame with the PCO Phase Control field set to 0. It also may switch from 40 MHz channel width to 20 MHz channel width based on the expiry of the value in the Duration/ID field of a Set PCO Phase frame that indicated a 40 MHz phase or based on the expiry of the value in the CFP DurRemaining field of the CF Parameter Set element of a Beacon frame that indicated a 40 MHz phase.

A PCO active STA shall halt PCO operation if it receives an HT Operation element from its AP with the PCO Active field set to 0.

NOTE—An HT STA can change its PCO capabilities by disassociating followed by associating or reassociating with an AP.

11.16 20/40 BSS Coexistence Management frame usage

A STA that supports the 20/40 BSS Coexistence Management frame type shall set the 20/40 BSS Coexistence Management Support field to 1 in transmitted Extended Capabilities information elements.

A STA that supports the 20/40 BSS Coexistence Management frame type shall include an Extended Capabilities information element in transmitted Beacon, (Re)Association Request, (Re)Association Response, Probe Request, and Probe Response frames.

A STA shall not transmit to another STA a 20/40 BSS Coexistence Management frame with an individual address in the Address 1 field if the most recently received Extended Capabilities element from the recipient STA contained a value of 0 in the 20/40 BSS Coexistence Management Support field. A STA that transmits a 20/40 BSS Coexistence Management frame may set the Address 1 field to a group address.

NOTE—A 20/40 BSS Coexistence Management frame is a class 1 frame and, therefore, can be sent to a STA that supports reception of such frames and that is not a member of the same BSS as the transmitting STA. In such a case, the BSSID of the frame is set to the wildcard BSSID value, regardless of whether the Address 1 field contains a unicast or group address value.

A STA may transmit a 20/40 BSS Coexistence Management frame that contains a value of 1 for the Request Information field to another STA that supports the transmission of and reception of the 20/40 BSS Coexistence Management frame, except when the frame is a response to a 20/40 BSS Coexistence Management frame that contains a value of 1 for the Request Information field.

A STA that receives a 20/40 BSS Coexistence element with the Information Request field set to 1, a value for the Address 1 field that matches the receiving STA using an individual address, and a nonwildcard BSSID field that matches the STA's BSS shall immediately queue for transmission a 20/40 BSS Coexistence Management frame with the transmitting STA as the recipient.

11.17 RSNA A-MSDU procedures

When dot11RSNAEnabled is TRUE, a STA indicates support for payload protected A-MSDUs (PP A-MSDUs) or signaling and payload protected A-MSDUs (SPP A-MSDUs) during association or reassociation. On either association or reassociation, the associating STA and its peer STA both determine and maintain a record of whether an encrypted A-MSDU sent to its peer is to be a PP A-MSDU or an SPP A-MSDU based on the value of the SPP A-MSDU Capable and SPP A-MSDU Required subfields of the RSN Capabilities field of the RSN information element (see 7.3.2.25.3).

Table 11-13 defines behavior related to the transmission and reception of individually addressed A-MSDUs of a first HT STA (STA1) that has successfully negotiated an RSNA (re)association with a second HT STA (STA2). Reception and transmission of A-MSDUs using a non-RSN association is unaffected by the values of the SPP A-MSDU Capable and SPP A-MSDU Required subfields.

Table 11-13—A-MSDU STA behavior for RSN associations

STA1 state		STA2 state		STA1 action with respect to STA2
SPP A-MSDU capable	SPP A-MSDU required	SPP A-MSDU capable	SPP A-MSDU required	
0	0	X	0	May transmit PP A-MSDU. Shall not transmit SPP A-MSDU. Shall receive PP A-MSDU. Received SPP A-MSDU MIC will fail.
0	0	X	1	Shall not transmit PP A-MSDU. Shall not transmit SPP A-MSDU. Shall discard received (PP and SPP) A-MSDU.
0	1	X	X	Shall not transmit PP A-MSDU. Shall not transmit SPP A-MSDU. Shall discard received (PP and SPP) A-MSDU.
1	0	0	0	May transmit PP A-MSDU. Shall not transmit SPP A-MSDU. Shall receive PP A-MSDU. Received SPP A-MSDU MIC will fail.
1	0	0	1	Shall not transmit PP A-MSDU. Shall not transmit SPP A-MSDU. Shall discard received (PP and SPP) A-MSDU.
NOTE—X = Not significant.				

Table 11-13—A-MSDU STA behavior for RSN associations *(continued)*

STA1 state		STA2 state		STA1 action with respect to STA2
SPP A-MSDU capable	SPP A-MSDU required	SPP A-MSDU capable	SPP A-MSDU required	
1	X	1	X	Shall not transmit PP A-MSDU. May transmit SPP A-MSDU. Received PP A-MSDU MIC will fail. Shall receive SPP A-MSDU.
1	1	0	X	Shall not transmit PP A-MSDU. Shall not transmit SPP A-MSDU. Shall discard received (PP and SPP) A-MSDU.
NOTE—X = Not significant.				

NOTE—This subclause does not describe the operation of group-addressed A-MSDUs because the use of group-addressed A-MSDUs is not permitted, as defined in 9.7c.

11.18 Public Action frame addressing

A STA that is a member of a BSS that transmits a Public Action frame with a unicast value in the Address 1 field corresponding to a STA that is not a member of the same BSS as the transmitting STA shall set the BSSID field of the frame to the wildcard BSSID value.

A STA that is a member of a BSS that transmits a Public Action frame to a group address shall set the BSSID field of the frame to the wildcard BSSID value or to the transmitting STA's BSSID value.

A STA that is a member of a BSS that transmits a Public Action frame with a unicast value in the Address 1 field corresponding to a STA that is a member of the same BSS as the transmitting STA shall set the BSSID field of the frame to the transmitting STA's BSSID value.

A STA that is not a member of a BSS that transmits a Public Action frame shall set the BSSID field of the frame to the wildcard BSSID value.

12. PHY service specification

12.3 Detailed PHY service specifications

12.3.4 Basic service and options

12.3.4.2 PHY-SAP sublayer-to-sublayer service primitives

Insert the following row at the end of Table 12-2:

Table 12-2— PHY-SAP sublayer-to-sublayer service primitives

Primitive	Request	Indicate	Confirm
PHY-CONFIG	X		X

12.3.4.3 PHY-SAP service primitives parameters

Change the STATUS parameter row and insert the new row at the end of Table 12-3 as follows:

Table 12-3—PHY-SAP service primitive parameters

Parameter	Associated primitive	Value
STATUS	PHY-CCA.indication	(BUSY,[channel-list]), (IDLE)
PHYCONFIG_VECTOR	PHY-CONFIG	A set of parameters

12.3.4.4 Vector descriptions

Insert the following rows at the end of Table 12-4:

Table 12-4—Vector descriptions

Parameter	Associated vector	Value
ACTIVE_RXCHAIN_SET	PHYCONFIG_VECTOR	The ACTIVE_RXCHAIN_SET parameter indicates which receive chains of the available receive chains are active. The length of the field is 8 bits. A 1 in bit position *n* indicates that the receive chain numbered *n* is used. At most 4 bits out of 8 may be set to 1.
OPERATING_CHANNEL	PHYCONFIG_VECTOR	The operating channel the PHY is set to use.

Table 12-4—Vector descriptions *(continued)*

Parameter	Associated vector	Value
CHANNEL_OFFSET	PHYCONFIG_VECTOR	Enumerated type: CH_OFFSET_NONE indicates operation in 20 MHz HT STAs. CH_OFFSET_ABOVE indicates operation in 40 MHz with the secondary channel above the primary. CH_OFFSET_BELOW indicates operation in 40 MHz with the secondary channel below the primary.

Insert the following paragraph at the end of 12.3.4.4:

The Clause 20 PHY TXVECTOR and RXVECTOR contain additional parameters related to the operation of the Clause 20 PHY modes of operation as described in 20.2. In certain modes of operation, the DATARATE parameter is replaced by a MCS value. The mapping from Clause 20 MCS to data rate is defined in 20.6.

12.3.5 PHY-SAP detailed service specification

12.3.5.4 PHY-TXSTART.request

12.3.5.4.1 Function

Change 12.3.5.4.1 as follows:

This primitive is a request by the MAC sublayer to the local PHY entity to start the transmission of a~~n~~ ~~MPDU~~ PSDU.

12.3.5.4.2 Semantics of the service primitive

Change the second paragraph of 12.3.5.4.2 as follows:

The TXVECTOR represents a list of parameters that the MAC sublayer provides to the local PHY entity in order to transmit a~~n MPDU~~ PSDU. This vector contains both PLCP and PHY management parameters. The required PHY parameters are listed in 12.3.4.4.

12.3.5.4.3 When generated

Change 12.3.5.4.3 as follows:

This primitive will be issued by the MAC sublayer to the PHY entity when the MAC sublayer needs to begin the transmission of a~~n MPDU~~ PSDU.

12.3.5.6 PHY-TXEND.request

12.3.5.6.1 Function

Change 12.3.5.6.1 as follows:

This primitive is a request by the MAC sublayer to the local PHY entity that the current transmission of the ~~MPDU~~ PSDU be completed.

12.3.5.6.3 When generated

Change 12.3.5.6.3 as follows:

This primitive will be generated when the MAC sublayer has received the last PHY-DATA.confirm from the local PHY entity for the ~~MPDU~~PSDU currently being transferred.

12.3.5.7 PHY-TXEND.confirm

12.3.5.7.3 When generated

Change 12.3.5.7.3 as follows:

This primitive will be issued by the PHY to the MAC entity when the PHY has received a PHYTXEND.request immediately after transmitting the end of the last bit of the last data octet indicating that the symbol containing the last data octet has been transferred and any Signal Extension has expired.

12.3.5.10 PHY-CCA.indication

12.3.5.10.2 Semantics of the service primitive

Change the first two paragraphs of 12.3.5.10.2 as follows:

The primitive provides the following parameters:

PHY-CCA.indication (STATE, IP-REPORT, channel-list)

The STATE parameter can be one of two values: BUSY or IDLE. The parameter value is BUSY if the channel(s) assessment by the PHY determines that the channel is not available. Otherwise, the value of the parameter is IDLE.

Insert the following paragraph at the end of 12.3.5.10.2:

When STATE is IDLE or when, for the type of PHY in operation, CCA is determined by a single channel, the channel-list parameter is absent. Otherwise, it carries a set indicating which channels are busy, represented by the values {primary}, {primary, secondary}, and {secondary}.

12.3.5.10.3 When generated

Change 12.3.5.10.3 as follows

This primitive is generated within aCCATime of the occurrence of a change in the status of the channel(s) ~~changes~~ from channel idle to channel busy or from channel busy to channel idle. This includes the period of time when the PHY is receiving data. If the STA is not an HT STA, t~~T~~he PHY maintains the channel busy indication until the period indicated by the LENGTH field in a valid PLCP header has expired.

If the STA is an HT STA and the operating channel width is 20 MHz, the PHY maintains the channel busy indication until the period indicated by the LENGTH field has expired, where the LENGTH field is

— In a valid SIG field if the format of the PPDU is NON_HT
— In a valid HT-SIG field if the format of the PPDU is HT_MF or HT_GF

If the STA is an HT STA and the operating channel width is 40 MHz, the PHY maintains the channel busy indication until the period indicated by the LENGTH field has expired, where the LENGTH field is

— In a valid SIG field if the format of the PPDU is NON_HT and the PPDU is received in the primary channel
— In a valid HT-SIG field if the format of the PPDU is HT_MF or HT_GF provided that the PPDU is either a 20 MHz PPDU received in the primary channel or a 40 MHz PPDU

12.3.5.12 PHY-RXEND.indication

12.3.5.12.1 Function

Change 12.3.5.12.1 as follows:

This primitive is an indication by the PHY to the local MAC entity that the ~~MPDU~~PSDU currently being received is complete.

12.3.5.12.2 Semantics of the service primitive

Change the third item in the dashed list after the second paragraph in 12.3.5.12.2 as follows:

— *CarrierLost.* This value is used to indicate that during the reception of the incoming ~~MPDU~~PSDU, the carrier was lost and no further processing of the ~~MPDU~~PSDU can be accomplished.

Insert the following subclauses (12.3.5.13 through 12.3.5.14.4) after 12.3.5.12.4:

12.3.5.13 PHY-CONFIG.request

12.3.5.13.1 Function

This primitive is a request by the MAC sublayer to the local PHY entity to configure the PHY.

12.3.5.13.2 Semantics of the service primitive

The semantics of the primitives are as follows:

PHY-CONFIG.request (PHYCONFIG_VECTOR)

12.3.5.13.3 When generated

This primitive is generated by the MAC sublayer for the local PHY entity when it desires to change the configuration of the PHY.

12.3.5.13.4 Effect of receipt

The effect of receipt of this primitive by the PHY is to apply the parameters provided with the primitive and to configure the PHY for future operation.

12.3.5.14 PHY-CONFIG.confirm

12.3.5.14.1 Function

This primitive is issued by the PHY to the local MAC entity to confirm that the PHY has applied the parameters provided in the PHY-CONFIG.request primitive.

12.3.5.14.2 Semantics of the service primitive

The semantics of the primitives are as follows:

PHY-CONFIG.confirm

This primitive has no parameters.

12.3.5.14.3 When generated

This primitive is issued by the PHY to the MAC entity when the PHY has received and successfully applied the parameters in the PHY-CONFIG.request primitive.

12.3.5.14.4 Effect of receipt

The effect of the receipt of this primitive by the MAC is unspecified.

Insert the following clause (Clause 20) after Clause 19:

20. High Throughput (HT) PHY specification

20.1 Introduction

20.1.1 Introduction to the HT PHY

Clause 20 specifies the PHY entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system.

In addition to the requirements found in Clause 20, an HT STA shall be capable of transmitting and receiving frames that are compliant with the mandatory PHY specifications defined as follows:

- In Clause 17 when the HT STA is operating in a 20 MHz channel width in the 5 GHz band
- In Clause 18 and Clause 19 when the HT STA is operating in a 20 MHz channel width in the 2.4 GHz band

The HT PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to four spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using one to four spatial streams is defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (four spatial streams, 40 MHz bandwidth).

The HT PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction (FEC) coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. LDPC codes are added as an optional feature.

Other optional features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT-greenfield format, and STBC.

An HT non-AP STA shall support all equal modulation (EQM) rates for one spatial stream (MCSs 0 through 7) using 20 MHz channel width. An HT AP shall support all EQM rates for one and two spatial streams (MCSs 0 through 15) using 20 MHz channel width.

The maximum HT PSDU length is 65 535 octets.

20.1.2 Scope

The services provided to the MAC by the HT PHY consist of two protocol functions, defined as follows:

a) A PHY convergence function, which adapts the capabilities of the physical medium dependent (PMD) system to the PHY service. This function is supported by the physical layer convergence procedure (PLCP), which defines a method of mapping the PSDUs into a framing format (PPDU) suitable for sending and receiving PSDUs between two or more STAs using the associated PMD system.

b) A PMD system whose function defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the PPDU format, these STAs support a mixture of HT PHY and Clause 15, Clause 17, Clause 18, or Clause 19 PHYs.

20.1.3 HT PHY functions

The HT PHY contains three functional entities: the PHY convergence function (i.e., the PLCP), the PMD function, and the layer management function (i.e., the PLME). Each of these functions is described in detail in 20.3 through 20.5.

The HT PHY service is provided to the MAC through the PHY service primitives defined in Clause 12.

20.1.3.1 HT PLCP sublayer

In order to allow the MAC to operate with minimum dependence on the PMD sublayer, a PHY convergence sublayer is defined (i.e., the PLCP). The PLCP sublayer simplifies the PHY service interface to the MAC services.

20.1.3.2 HT PMD sublayer

The HT PMD sublayer provides a means to send and receive data between two or more STAs. This clause is concerned with the 2.4 GHz and 5 GHz frequency bands using HT OFDM modulation.

20.1.3.3 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

20.1.3.4 Service specification method

The models represented by figures and state diagrams are intended to be illustrations of the functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation; the actual method of implementation is left to the discretion of the HT-PHY-compliant developer. The service of a layer or sublayer is the set of capabilities that it offers to a user in the next higher layer (or sublayer). Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

20.1.4 PPDU formats

The structure of the PPDU transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH, CH_OFFSET, and MCS parameters as defined in Table 20-1. The effect of the CH_BANDWIDTH, CH_OFFSET, and MCS parameters on PPDU format is described in 20.2.3.

The FORMAT parameter determines the overall structure of the PPDU as follows:

— *Non-HT format* **(NON_HT):** Packets of this format are structured according to the Clause 17 (OFDM) or Clause 19 (ERP) specification. Support for non-HT format is mandatory.

— *HT-mixed format* **(HT_MF):** Packets of this format contain a preamble compatible with Clause 17 and Clause 19 receivers. The non-HT-STF (L-STF), the non-HT-LTF (L-LTF), and the non-HT SIGNAL field (L-SIG) are defined so they can be decoded by non-HT Clause 17 and Clause 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT-mixed format is mandatory.

— *HT-greenfield format* **(HT_GF):** HT packets of this format do not contain a non-HT compatible part. Support for HT-greenfield format is optional. An HT STA that does not support the reception of an HT-greenfield format packet shall be able to detect that an HT-greenfield format packet is an HT transmission (as opposed to a non-HT transmission). In this case, the receiver shall decode the HT-SIG and determine whether the HT-SIG cyclic redundancy check (CRC) passes.

20.2 HT PHY service interface

20.2.1 Introduction

The PHY interfaces to the MAC through the TXVECTOR, RXVECTOR, and PHYCONFIG_VECTOR. The TXVECTOR supplies the PHY with per-packet transmit parameters. Using the RXVECTOR, the PHY informs the MAC of the received packet parameters. Using the PHYCONFIG_VECTOR, the MAC configures the PHY for operation, independent of frame transmission or reception.

This interface is an extension of the generic PHY service interface defined in 12.3.4.

20.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 20-1 are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request service primitive and/or as part of the RXVECTOR parameter list in the PHY-RXSTART.indication service primitive.

Table 20-1—TXVECTOR and RXVECTOR parameters

Parameter	Condition	Value	TXVECTOR (See NOTE 1)	RXVECTOR (See NOTE 1)
FORMAT		Determines the format of the PPDU. Enumerated type: NON_HT indicates Clause 15, Clause 17, Clause 18, or Clause 19 PPDU formats or non-HT duplicated PPDU format. In this case, the modulation is determined by the NON_HT_MODULATION parameter. HT_MF indicates HT-mixed format. HT_GF indicates HT-greenfield format.	Y	Y
NON_HT_MODULATION	FORMAT is NON_HT	Enumerated type: ERP-DSSS ERP-CCK ERP-OFDM ERP-PBCC DSSS-OFDM OFDM NON_HT_DUP_OFDM	Y	Y
	Otherwise	Not present		
L_LENGTH	FORMAT is NON_HT	Indicates the length of the PSDU in octets in the range of 1 to 4095. This value is used by the PHY to determine the number of octet transfers that occur between the MAC and the PHY.	Y	Y
	FORMAT is HT_MF	Indicates the value in the Length field of the L-SIG in the range of 1 to 4095. This use is defined in 9.13.4. This parameter may be used for the protection of more than one PPDU as described in 9.13.5.	Y	Y
	FORMAT is HT_GF	Not present	N	N

Table 20-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
			See NOTE 1	
L_DATARATE	FORMAT is NON_HT	Indicates the rate used to transmit the PSDU in megabits per second. Allowed values depend on the value of the NON_HT_MODULATION parameter as follows: ERP-DSSS: 1 and 2 ERP-CCK: 5.5 and 11 ERP-PBCC: 5.5, 11, 22, and 33 DSSS-OFDM, ERP-OFDM, NON_HT_DUP_OFDM: 6, 9, 12, 18, 24, 36, 48, and 54 OFDM: 6, 9, 12, 18, 24, 36, 48, and 54	Y	Y
	FORMAT is HT_MF	Indicates the data rate value that is in the L-SIG. This use is defined in 9.13.4.	Y	Y
	FORMAT is HT_GF	Not present	N	N
LSIGVALID	FORMAT is HT_MF	True if L-SIG Parity is valid False if L-SIG Parity is not valid	N	Y
	Otherwise	Not present	N	N
SERVICE	FORMAT is NON_HT and NON_HT_MODULATION is one of — DSSS-OFDM — ERP-OFDM — OFDM	Scrambler initialization, 7 null bits + 9 reserved null bits	Y	N
	FORMAT is HT_MF or HT_GF	Scrambler initialization, 7 null bits + 9 reserved null bits	Y	N
	Otherwise	Not present	N	N
TXPWR_LEVEL		The allowed values for the TXPWR_LEVEL parameter are in the range from 1 to 8. This parameter is used to indicate which of the available TxPowerLevel attributes defined in the MIB shall be used for the current transmission.	Y	N
RSSI		The allowed values for the RSSI parameter are in the range from 0 through RSSI maximum. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU. RSSI shall be measured during the reception of the PLCP preamble. In HT-mixed format, the reported RSSI shall be measured during the reception of the HT-LTFs. RSSI is intended to be used in a relative manner, and it shall be a monotonically increasing function of the received power.	N	Y

Table 20-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR (See NOTE 1)	RXVECTOR (See NOTE 1)
PREAMBLE_TYPE	FORMAT is NON_HT and NON_HT_MODULATION is one of — ERP-DSSS — ERP-CCK — ERP-PBCC — DSSS-OFDM	Enumerated type: SHORTPREAMBLE LONGPREAMBLE	Y	Y
	Otherwise	Not present	N	N
MCS	FORMAT is HT_MF or HT_GF	Selects the modulation and coding scheme used in the transmission of the packet. The value used in each MCS is the index defined in 20.6. Integer: range 0 to 76. Values of 77 to 127 are reserved. The interpretation of the MCS index is defined in 20.6.	Y	Y
	Otherwise	Not present	N	N
REC_MCS	FORMAT is HT_MF or HT_GF	Indicates the MCS that the STA's receiver recommends.	N	O
	Otherwise	Not present	N	N
CH_BANDWIDTH	FORMAT is HT_MF or HT_GF	Indicates whether the packet is transmitted using 40 MHz or 20 MHz channel width. Enumerated type: HT_CBW20 for 20 MHz and 40 MHz upper and 40 MHz lower modes HT_CBW40 for 40 MHz	Y	Y
	FORMAT is NON_HT	Enumerated type: NON_HT_CBW40 for non-HT duplicate format NON_HT_CBW20 for all other non-HT formats	Y	Y
CH_OFFSET		Indicates which portion of the channel is used for transmission. Refer to Table 20-2 for valid combinations of CH_OFFSET and CH_BANDWIDTH. Enumerated type: CH_OFF_20 indicates the use of a 20 MHz channel (that is not part of a 40 MHz channel). CH_OFF_40 indicates the entire 40 MHz channel. CH_OFF_20U indicates the upper 20 MHz of the 40 MHz channel CH_OFF_20L indicates the lower 20 MHz of the 40 MHz channel.	Y	N
LENGTH	FORMAT is HT_MF or HT_GF	Indicates the length of an HT PSDU in the range of 0 to 65 535 octets. A value of zero indicates a NDP that contains no data symbols after the HT preamble (see 20.3.9).	Y	Y
	Otherwise	Not present	N	N

Table 20-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR (See NOTE 1)	RXVECTOR (See NOTE 1)
SMOOTHING	FORMAT is HT_MF or HT_GF	Indicates whether frequency-domain smoothing is recommended as part of channel estimation. (See NOTE 2.) Enumerated type: SMOOTHING_REC indicates that smoothing is recommended. SMOOTHING_NOT_REC indicates that smoothing is not recommended.	Y	Y
	Otherwise	Not present	N	N
SOUNDING	FORMAT is HT_MF or HT_GF	Indicates whether this packet is a sounding packet. Enumerated type: SOUNDING indicates this is a sounding packet. NOT_SOUNDING indicates this is not a sounding packet.	Y	Y
	Otherwise	Not present	N	N
AGGREGATION	FORMAT is HT_MF or HT_GF	Indicates whether the PSDU contains an A-MPDU. Enumerated type: AGGREGATED indicates this packet has A-MPDU aggregation. NOT_AGGREGATED indicates this packet does not have A-MPDU aggregation.	Y	Y
	Otherwise	Not present	N	N
STBC	FORMAT is HT_MF or HT_GF	Indicates the difference between the number of space-time streams (N_{STS}) and the number of spatial streams (N_{SS}) indicated by the MCS as follows: 0 indicates no STBC ($N_{STS} = N_{SS}$). 1 indicates $N_{STS} - N_{SS} = 1$. 2 indicates $N_{STS} - N_{SS} = 2$. Value of 3 is reserved.	Y	Y
	Otherwise	Not present	N	N
FEC_CODING	FORMAT is HT_MF or HT_GF	Indicates which FEC encoding is used. Enumerated type: BCC_CODING indicates binary convolutional code. LDPC_CODING indicates low-density parity check code.	Y	Y
	Otherwise	Not present	N	N
GI_TYPE	FORMAT is HT_MF or HT_GF	Indicates whether a short guard interval is used in the transmission of the packet. Enumerated type: LONG_GI indicates short GI is not used in the packet. SHORT_GI indicates short GI is used in the packet.	Y	Y
	Otherwise	Not present	N	N

Table 20-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
			See NOTE 1	
NUM_EXTEN_SS	FORMAT is HT_MF or HT_GF	Indicates the number of extension spatial streams that are sounded during the extension part of the HT training in the range of 0 to 3.	Y	Y
	Otherwise	Not present	N	N
ANTENNA_SET	FORMAT is HT_MF or HT_GF	Indicates which antennas of the available antennas are used in the transmission. The length of the field is 8 bits. A 1 in bit position *n,* relative to the LSB, indicates that antenna *n* is used. At most 4 bits out of 8 may be set to 1. This field is present only if ASEL is applied.	O	N
	Otherwise	Not present	N	N
N_TX	FORMAT is HT_MF or HT_GF	The N_TX parameter indicates the number of transmit chains.	Y	N
	Otherwise	Not present	N	N
EXPANSION_MAT	EXPANSION_MAT_TYPE is COMPRESSED_SV	Contains a set of compressed beamforming feedback matrices as defined in 20.3.12.2.5. The number of elements depends on the number of spatial streams and the number of transmit chains.	Y	N
	EXPANSION_MAT_TYPE is NON_COMPRESSED_SV	Contains a set of noncompressed beamforming feedback matrices as defined in 20.3.12.2.4. The number of complex elements is $N_{ST} \times N_r \times N_c$ where N_{ST} is the total number of subcarriers, N_c is the number of columns, and N_r is the number of rows in each matrix.	Y	N
	EXPANSION_MAT_TYPE is CSI_MATRICES	Contains a set of CSI matrices as defined in 20.3.12.2.1. The number of complex elements is $N_{ST} \times N_r \times N_c$ where N_{ST} is the total number of subcarriers, N_c is the number of columns, and N_r is the number of rows in each matrix.	Y	N
	Otherwise.	Not present	N	N
EXPANSION_MAT_TYPE	EXPANSION_MAT is present.	Enumerated type: COMPRESSED_SV indicates that EXPANSION_MAT is a set of compressed beamforming feedback matrices. NON_COMPRESSED_SV indicates that EXPANSION_MAT is a set of noncompressed beamforming feedback matrices. CSI_MATRICES indicates that EXPANSION_MAT is a set of channel state matrices.	Y	N
	Otherwise	Not present	N	N

Table 20-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR (See NOTE 1)	RXVECTOR (See NOTE 1)
CHAN_MAT	CHAN_MAT_TYPE is COMPRESSED_SV.	Contains a set of compressed beamforming feedback matrices as defined in 20.3.12.2.5 based on the channel measured during the training symbols of the received PPDU. The number of elements depends on the number of spatial streams and the number of transmit chains.	N	Y
	CHAN_MAT_TYPE is NON_COMPRESSED_SV.	Contains a set of noncompressed beamforming feedback matrices as defined in 20.3.12.2.4 based on the channel measured during the training symbols of the received PPDU. The number of complex elements is $N_{ST} \times N_r \times N_c$ where N_{ST} is the total number of subcarriers, N_c is the number of columns, and N_r is the number of rows in each matrix.	N	Y
	CHAN_MAT_TYPE is CSI_MATRICES.	Contains a set of CSI matrices as defined in 20.3.12.2.1 based on the channel measured during the training symbols of the received PPDU. The number of complex elements is $N_{ST} \times N_r \times N_c$ where N_{ST} is the total number of subcarriers, N_c is the number of columns, and N_r is the number of rows in each matrix.	N	Y
	Otherwise.	Not present	N	N
CHAN_MAT_TYPE	FORMAT is HT_MF or HT_GF.	Enumerated type: COMPRESSED_SV indicates that CHAN_MAT is a set of compressed beamforming vector matrices. NON_COMPRESSED_SV indicates that CHAN_MAT is a set of noncompressed beamforming vector matrices. CSI_MATRICES indicates that CHAN_MAT is a set of channel state matrices.	N	Y
	Otherwise	Not present	N	N
RCPI		Is a measure of the received RF power averaged over all the receive chains in the data portion of a received frame. Refer to 20.3.22.6 for the definition of RCPI.	N	Y
SNR	CHAN_MAT_TYPE is CSI_MATRICES	Is a measure of the received SNR per chain. SNR indications of 8 bits are supported. SNR shall be the decibel representation of linearly averaged values over the tones represented in each receive chain as described in 7.3.1.27	N	Y
	CHAN_MAT_TYPE is COMPRESSED_SV or NON_COMPRESSED_SV	Is a measure of the received SNR per stream. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones represented in each stream as described in 7.3.1.28 and 7.3.1.29	N	Y

Table 20-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Condition	Value	TXVECTOR	RXVECTOR
			See NOTE 1	
NO_SIG_EXTN	FORMAT is HT_MF or HT_GF Or FORMAT is NON_HT and NON_HT_MODULATION is ERP-OFDM, DSSS-OFDM, or NON_HT_DUPOFDM.	Indicates whether signal extension needs to be applied at the end of transmission. Boolean values: TRUE indicates no signal extension is present. FALSE indicates signal extension may be present depending on other TXVECTOR parameters (see 20.2.2).	Y	N
	Otherwise	Not present	N	N

NOTE 1—In the “TXVECTOR” and “RXVECTOR” columns, the following apply:
Y = Present; N = Not present; O = Optional
NOTE 2—Setting the smoothing bit is defined in 20.3.11.10.1.

20.2.3 Effect of CH_BANDWIDTH, CH_OFFSET, and MCS parameters on PPDU format

The structure of the PPDU transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH, CH_OFFSET, and MCS parameters as defined in Table 20-1. The effect of the FORMAT parameter is described in 20.1.4.

The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table 20-2 shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported.

Table 20-2—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET
HT_CBW20	CH_OFF_20 or CH_OFFSET is not present: *20 MHz HT format*—A STA that has a 20 MHz operating channel width transmits an HT-mixed or HT-greenfield format packet of 20 MHz bandwidth with one to four spatial streams. CH_OFF_40: *Not defined* CH_OFF_20U: *40 MHz HT upper format*—The STA transmits an HT-mixed or HT-greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel. CH_OFF_20L: *40 MHz HT lower format*—The STA transmits an HT-mixed or HT-greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel.

Table 20-2—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters *(continued)*

CH_BANDWIDTH	CH_OFFSET
HT_CBW40	Not present: *Not defined* CH_OFF_20: *Not defined* CH_OFF_40: *40 MHz HT format*—A PPDU of this format occupies a 40 MHz channel to transmit an HT-mixed or HT-greenfield format packet of 40 MHz bandwidth with one to four spatial streams. CH_OFF_20U: *Not defined* CH_OFF_20L: *Not defined*
NON_HT_CBW20	CH_OFF_20 or CH_OFFSET is not present: *20 MHz non-HT format*—A STA that has a 20 MHz operating channel width transmits a non-HT format packet according to Clause 17 or Clause 19 operation. CH_OFF_40: Not defined CH_OFF_20U: *40 MHz non-HT upper format*—The STA transmits a non-HT packet of type ERP-DSSS, ERP-CCK, ERP-OFDM, ERP-PBCC, DSSS-OFDM, or OFDM in the upper 20 MHz of a 40 MHz channel. CH_OFF_20L: *40 MHz non-HT lower format*—The STA transmits a non-HT packet of type ERP-DSSS, ERP-CCK, ERP-OFDM, ERP-PBCC, DSSS-OFDM, or OFDM in the lower 20 MHz of a 40 MHz channel.
NON_HT_CBW40	Not present: *Not defined* CH_OFF_20: *Not defined* CH_OFF_40: *Non-HT duplicate format*—The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel. See 20.3.11.11. CH_OFF_20U: *Not defined* CH_OFF_20L: *Not defined*

NOTE—Support of 20 MHz non-HT format and 20 MHz HT format with one and two spatial streams is mandatory at APs. Support of 20 MHz non-HT format and 20 MHz HT format with one spatial stream is mandatory at non-AP STAs.

20.2.4 Support for NON_HT formats

When the FORMAT parameter is set to NON_HT, the behavior of the HT PHY is defined in other clauses as shown in Table 20-3, dependent on the operational band. In this case, the PHY-TXSTART.request is handled by mapping the TXVECTOR parameters as defined in Table 20-3 and following the operation as defined in the referenced clause. Likewise the PHY-RXSTART.indication emitted when a NON_HT PPDU is received is defined in the referenced clauses, with mapping of RXVECTOR parameters as defined in Table 20-3.

Table 20-3—Mapping of the HT PHY parameters for NON_HT operation

HT PHY parameter	2.4 GHz operation defined by Clause 15	2.4 GHz operation defined by Clause 18	2.4 GHz operation defined by Clause 19	5.0 GHz operation defined by Clause 17
L_LENGTH	LENGTH	LENGTH	LENGTH	LENGTH
L_DATARATE	DATARATE	DATARATE	DATARATE	DATARATE

Table 20-3—Mapping of the HT PHY parameters for NON_HT operation *(continued)*

HT PHY parameter	2.4 GHz operation defined by Clause 15	2.4 GHz operation defined by Clause 18	2.4 GHz operation defined by Clause 19	5.0 GHz operation defined by Clause 17
LSIGVALID	—	—	—	—
TXPWR_LEVEL	TXPWR_LEVEL	TXPWR_LEVEL	TXPWR_LEVEL	TXPWR_LEVEL
RSSI	RSSI	RSSI	RSSI	RSSI
FORMAT	—	—	—	—
PREAMBLE_TYPE	—	—	PREAMBLE_TYPE	—
NON_HT_MODULATION	—	MODULATION	MODULATION	—
SERVICE	SERVICE	SERVICE	SERVICE	SERVICE
MCS	—	—	—	—
CH_BANDWIDTH	—	—	—	—
CH_OFFSET	—	—	—	—
LENGTH	—	—	—	—
SMOOTHING	—	—	—	—
SOUNDING	—	—	—	—
AGGREGATION	—	—	—	—
STBC	—	—	—	—
FEC_CODING	—	—	—	—
GI_TYPE	—	—	—	—
NUM_EXTEN_SS	—	—	—	—
ANTENNA_SET	—	—	—	—
EXPANSION_MAT	—	—	—	—
EXPANSION_MAT_TYPE	—	—	—	—
CHAN_MAT	—	—	—	—
CHAN_MAT_TYPE	—	—	—	—
N_TX	—	—	—	—
RCPI	RCPI	RCPI	RCPI	RCPI
REC_MCS	—	—	—	—
NO_SIG_EXTN	—	—	—	—
NOTE—A dash (—) in an entry above indicates that the related parameter is not present.				

Non-HT format PPDUs structured according to Clause 15, Clause 17, Clause 18, or Clause 19 are transmitted

- Within the limits of the transmit spectrum mask specified in the respective clauses, or
- As non-HT duplicate PPDUs within the limits of the 40 MHz transmit spectrum mask defined in 20.3.21.1, or
- As 20 MHz format non-HT PPDUs, within the limits of the 40 MHz transmit spectrum mask defined in 20.3.21.1, in the upper (CH_BANDWIDTH of value NON_HT_CBW20 and CH_OFFSET of value CH_OFF_20U) or lower (CH_BANDWIDTH of value NON_HT_CBW20 and CH_OFFSET of value CH_OFF_20U) 20 MHz of the 40 MHz channel

Non-HT PPDUs transmitted using the 40 MHz transmit spectrum mask are referred to as 40 MHz mask non-HT PPDUs. Refer to 11.14.9 for CCA sensing rules for transmission of 40 MHz mask non-HT PPDUs.

20.3 HT PLCP sublayer

20.3.1 Introduction

A convergence procedure, in which PSDUs are converted to and from PPDUs, is provided for the HT PHY in 20.3. During transmission, the PSDU is processed (i.e., scrambled and coded) and appended to the PLCP preamble to create the PPDU. At the receiver, the PLCP preamble is processed to aid in demodulation and delivery of the PSDU.

Two preamble formats are defined. For HT-mixed format operation, the preamble has a non-HT portion and an HT portion. The non-HT portion of the HT-mixed format preamble enables detection of the PPDU and acquisition of carrier frequency and timing by both HT STAs and STAs that are compliant with Clause 17 and/or Clause 19. The non-HT portion of the HT-mixed format preamble also consists of the SIGNAL field defined in Clause 17 and is thus decodable by STAs compliant with Clause 17 and Clause 19 as well as HT STAs.

The HT portion of the HT-mixed format preamble enables estimation of the MIMO channel to support demodulation of the HT data by HT STAs. The HT portion of the HT-mixed format preamble also includes the HT-SIG field, which supports HT operation. The SERVICE field is prepended to the PSDU.

For HT-greenfield operation, compatibility with Clause 17 and Clause 19 STAs is not required. Therefore, the non-HT portions of the preamble are not included in the HT-greenfield format preamble.

20.3.2 PPDU format

Two formats are defined for the PLCP: HT-mixed format and HT-greenfield format. These two formats are called *HT formats*. Figure 20-1 shows the non-HT format[1] and the HT formats. There is also an MCS 32 format (specified in 20.3.11.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.11.11) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel.

[1] The non-HT format is shown related to the terminology of this subclause. The non-HT PPDU format is defined in 17.3.3 and 17.3.2.

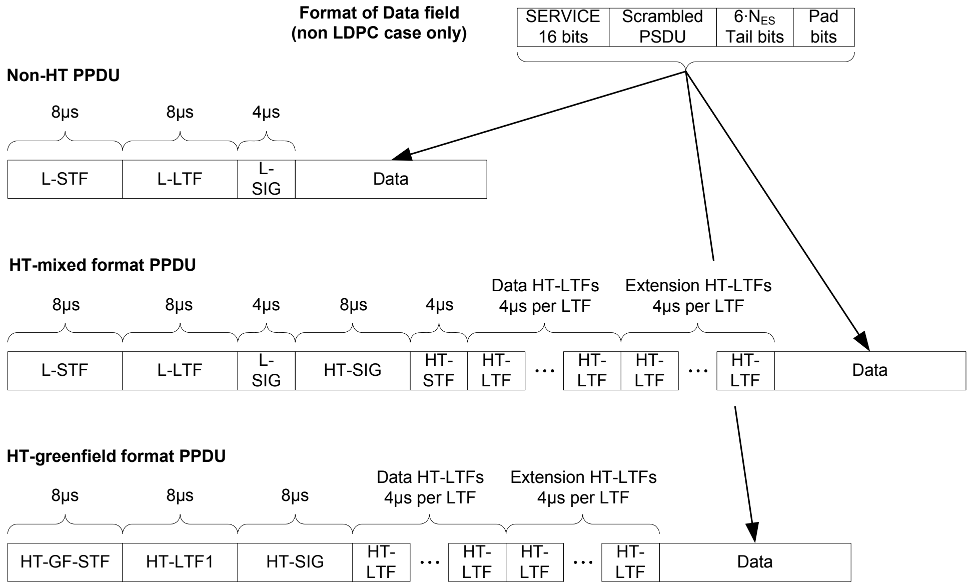


Figure 20-1—PPDU format

The elements of the PLCP packet are summarized in Table 20-4.

Table 20-4—Elements of the HT PLCP packet

Element	Description
L-STF	Non-HT Short Training field
L-LTF	Non-HT Long Training field
L-SIG	Non-HT SIGNAL field
HT-SIG	HT SIGNAL field
HT-STF	HT Short Training field
HT-GF-STF	HT-Greenfield Short Training field
HT-LTF1	First HT Long Training field (Data)
HT-LTFs	Additional HT Long Training fields (Data and Extension)
Data	The Data field includes the PSDU

The HT-SIG, HT-STF, HT-GF-STF, HT-LTF1, and HT-LTFs exist only in HT packets. In non-HT and non-HT duplicate formats only the L-STF, L-LTF, L-SIG, and Data fields exist.

In both HT-mixed format and HT-greenfield format frames, there are two types of HT-LTFs: Data HT-LTFs (HT-DLTFs) and Extension HT-LTFs (HT-ELTFs). HT-DLTFs are always included in HT PPDUs to provide the necessary reference for the receiver to form a channel estimate that allows it to demodulate the data portion of the frame. The number of HT-DLTFs, N_{HTDLTF}, may be 1, 2, or 4 and is determined by the number of space-time streams being transmitted in the frame (see Table 20-12). HT-ELTFs provide additional reference in sounding PPDUs so that the receiver can form an estimate of additional dimensions of the channel beyond those that are used by the data portion of the frame. The number of HT-ELTFs, N_{HTELTF}, may be 0, 1, 2, or 4 (see Table 20-13). PLCP preambles in which HT-DLTFs are followed by HT-ELTFs are referred to as staggered preambles. The HT-mixed format and HT-greenfield format frames shown in Figure 20-1 both contain staggered preambles for illustrative purposes.

Transmissions of frames with TXVECTOR parameter NO_SIG_EXTN set to FALSE are followed by a period of no transmission for a duration of aSignalExtension µs. See 9.2.10a.

A Signal Extension shall be present in a transmitted PPDU, based on the parameters of the TXVECTOR, when the NO_SIG_EXTN parameter is set to FALSE and either of the following is TRUE:

— The FORMAT parameter is set to HT_MF or HT_GF.
— The FORMAT parameter is set to NON_HT, and the NON_HT_MODULATION parameter is set to ERP-OFDM, DSSS-OFDM, or NON_HT_DUPOFDM.

A Signal Extension shall be assumed to be present (for the purpose of timing of PHY-RXEND.indication and PHY-CCA.indication primitives, as described below and in 20.3.24) in a received PPDU when either of the following is true, based on the determined parameter values of the RXVECTOR:

— The FORMAT parameter is set to HT_MF or HT_GF.
— The FORMAT parameter is set to NON_HT, and the NON_HT_MODULATION parameter is set to ERP-OFDM, DSSS-OFDM, or NON_HT_DUPOFDM.

A PPDU containing a Signal Extension is called a *signal extended PPDU*. When transmitting a signal extended PPDU, the PHY-TXEND.indication primitive shall be emitted a period of aSignalExtension µs after the end of the last symbol of the PPDU. When receiving a signal extended PPDU, the PHY-RXEND.indication primitive shall be emitted a period of aSignalExtension µs after the end of the last symbol of the PPDU.

20.3.3 Transmitter block diagram

HT-mixed format and HT-greenfield format transmissions can be generated using a transmitter consisting of of the following blocks:

a) *Scrambler* scrambles the data to reduce the probability of long sequences of zeros or ones; see 20.3.11.2.
b) *Encoder parser*, if BCC encoding is to be used, demultiplexes the scrambled bits among N_{ES} (number of BCC encoders for the Data field) BCC encoders, in a round robin manner.
c) *FEC encoders* encode the data to enable error correction. An FEC encoder may include a binary convolutional encoder followed by a puncturing device, or it may include an LDPC encoder.
d) *Stream parser* divides the outputs of the encoders into blocks that are sent to different interleaver and mapping devices. The sequence of the bits sent to an interleaver is called a *spatial stream*.
e) *Interleaver* interleaves the bits of each spatial stream (changes order of bits) to prevent long sequences of adjacent noisy bits from entering the BCC decoder. Interleaving is applied only when BCC encoding is used.
f) *Constellation mapper* maps the sequence of bits in each spatial stream to constellation points (complex numbers).
g) *STBC* encoder spreads constellation points from N_{SS} spatial streams into N_{STS} space-time streams using a space-time block code. STBC is used only when $N_{SS} < N_{STS}$; see 20.3.11.8.1.
h) *Spatial mapper* maps space-time streams to transmit chains. This may include one of the following:
    1) *Direct mapping*: Constellation points from each space-time stream are mapped directly onto the transmit chains (one-to-one mapping).

2) *Spatial expansion*: Vectors of constellation points from all the space-time streams are expanded via matrix multiplication to produce the input to all the transmit chains.

3) *Beamforming*: Similar to spatial expansion, each vector of constellation points from all the space-time streams is multiplied by a matrix of steering vectors to produce the input to the transmit chains.

i) *Inverse discrete Fourier transform (IDFT)* converts a block of constellation points to a time domain block.

j) *Cyclic shift (CSD) insertion* is where the insertion of the cyclic shifts prevents unintentional beamforming. CSD insertion may occur before or after the IDFT. There are three cyclic shift types as follows:

1) A cyclic shift specified per transmitter chain with the values defined in Table 20-8 (a possible implementation is shown in Figure 20-2).

2) A cyclic shift specified per space-time stream with the values defined in Table 20-9 (a possible implementation is shown in Figure 20-3).

3) A cyclic shift $M_{CSD}(k)$ that may be applied as a part of the spatial mapper; see 20.3.11.10.1.

k) *GI insertion* prepends to the symbol a circular extension of itself.

l) *Windowing* optionally smooths the edges of each symbol to increase spectral decay.

Figure 20-2 and Figure 20-3 show example transmitter block diagrams. In particular, Figure 20-2 shows the transmitter blocks used to generate the HT-SIG of the HT-mixed format PPDU. These transmitter blocks are also used to generate the non-HT portion of the HT-mixed format PPDU, except that the BCC encoder and interleaver are not used when generating the L-STF and L-LTFs. Figure 20-3 shows the transmitter blocks used to generate the Data field of the HT-mixed format and HT-greenfield format PPDUs. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the HT-STF, HT-GF-STF, and HT-LTFs. The HT-greenfield format SIGNAL field is generated using the transmitter blocks shown in Figure 20-2, augmented by additional CSD and spatial mapping blocks.

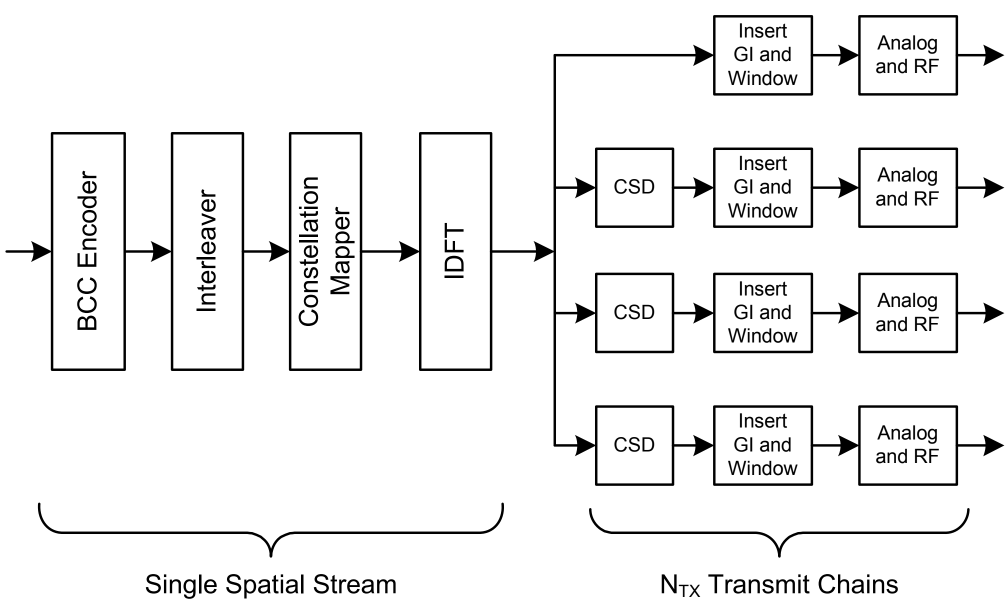
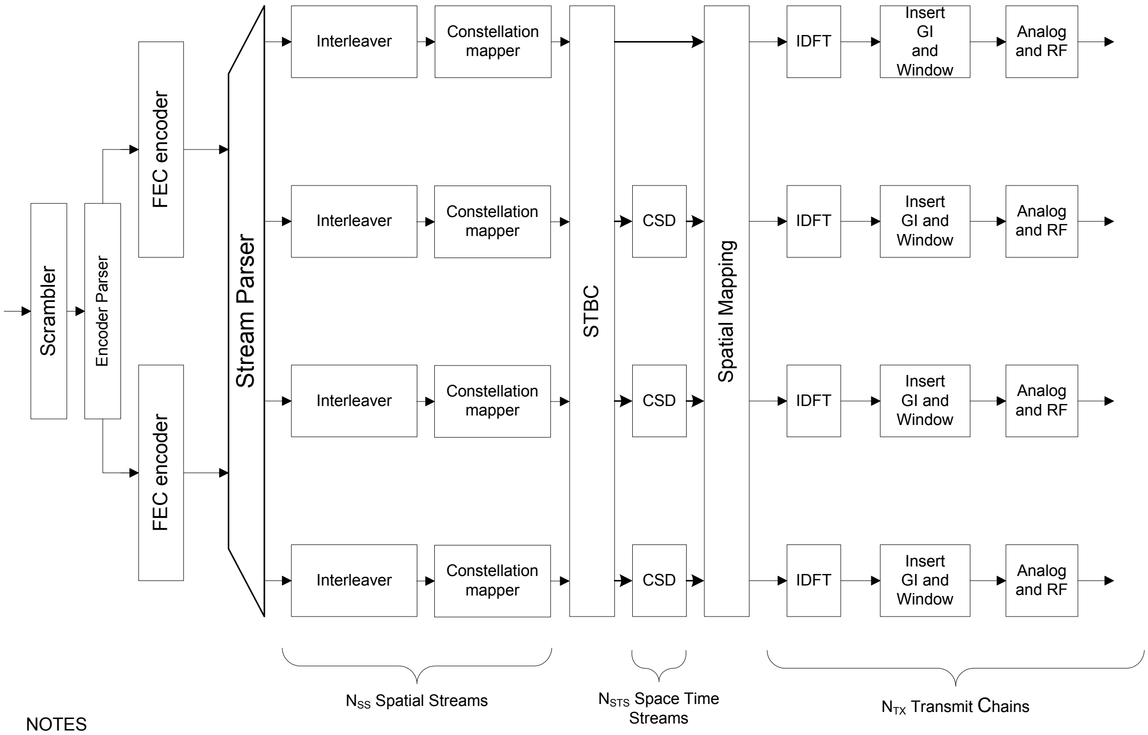


Figure 20-2—Transmitter block diagram 1



NOTES
—There may be 1 or 2 FEC encoders when BCC encoding is used.
—The stream parser may have 1, 2, 3 or 4 outputs.
—When LDPC encoding is used, the interleavers are not used
—When STBC is used, the STBC block has more outputs than inputs.
—When spatial mapping is used, there may be more transmit chains than space time streams.
—The number of inputs to the spatial mapper may be 1, 2, 3, or 4.

Figure 20-3—Transmitter block diagram 2

20.3.4 Overview of the PPDU encoding process

The encoding process is composed of the steps described below. The following overview is intended to facilitate an understanding of the details of the convergence procedure:

a) Determine the number of transmit chains, N_{TX}, from the N_TX field of the TXVECTOR. Produce the PLCP preamble training fields for each of the N_{TX} transmit chains based on the FORMAT, NUM_EXTEN_SS, CH_BANDWIDTH, and MCS parameters of the TXVECTOR. The format and relative placement of the PLCP preamble training fields vary depending on the frame format being used, as indicated by these parameters. Apply cyclic shifts. Determine spatial mapping to be used for HT-STF and HT-LTFs in HT-mixed format frame and HT-GF-STF and HT-LTFs in HT-greenfield format frame from the EXPANSION_MAT parameter of the TXVECTOR. Refer to 20.3.9 for details.

b) Construct the PLCP preamble SIGNAL fields from the appropriate fields of the TXVECTOR by adding tail bits, applying convolutional coding, formatting into one or more OFDM symbols, applying cyclic shifts, applying spatial processing, calculating an inverse Fourier transform for each OFDM symbol and transmit chain, and prepending a cyclic prefix or GI to each OFDM symbol in each transmit chain. The number and placement of the PLCP preamble SIGNAL fields depend on the frame format being used. Refer to 20.3.9.3.5, 20.3.9.4.3, and 20.3.9.5.3.

c) Concatenate the PLCP preamble training and SIGNAL fields for each transmit chain one field after another, in the appropriate order, as described in 20.3.2 and 20.3.7.

d) Use the MCS and CH_BANDWIDTH parameters of the TXVECTOR to determine the number of data bits per OFDM symbol (N_{DBPS}), the coding rate (R), the number of coded bits in each OFDM subcarrier (N_{BPSC}), and the number of coded bits per OFDM symbol (N_{CBPS}). Determine the number of encoding streams (N_{ES}) from the MCS, CH_BANDWIDTH, and FEC_CODING parameters of the TXVECTOR. Refer to 20.3.11.3 for details.

e) Append the PSDU to the SERVICE field (see 20.3.11.1). If BCC encoding is to be used, as indicated by the FEC_CODING parameter of the TXVECTOR, tail bits are appended to the PSDU**.** If a single BCC encoder is used (i.e., when the value of N_{ES} is 1), the bit string is extended by 6 zero bits. If two BCC encoders are used (i.e., when the value of N_{ES} is 2), the bit string is extended by 12 zero bits. The number of symbols, N_{SYM}, is calculated according to Equation (20-32), and if necessary, the bit string is further extended with zero bits so that the resulting length is a multiple of $N_{SYM} \times N_{DBPS}$, as described in 20.3.11. If LDPC encoding is to be used, as indicated by the FEC_CODING parameter of the TXVECTOR, the resulting bit string is padded, if needed, by repeating coded bits rather than using zero bits, as given in the encoding procedure of 20.3.11.6.5. The number of resulting symbols is given by Equation (20-41), and the number of repeated coded bits used for padding is given by Equation (20-42). The resulting bit string constitutes the DATA part of the packet.

f) Initiate the scrambler with a pseudo-random nonzero seed, generate a scrambling sequence, and exclusive-OR (XOR) it with the string of data bits, as described in 17.3.5.4.

g) If BCC encoding is to be used, replace the scrambled zero bits that served as tail bits (6 bits if the value of N_{ES} is 1, or 12 bits if the value of N_{ES} is 2) following the data with the same number of nonscrambled zero bits, as described in 17.3.5.2. (These bits return the convolutional encoder to the zero state.)

h) If BCC encoding is to be used and the value of N_{ES} is 2, divide the scrambled data bits between two BCC encoders by sending alternating bits to the two different encoders, as described in 20.3.11.4.

i) If BCC encoding is to be used, encode the extended, scrambled data string with a rate 1/2 convolutional encoder (see 17.3.5.5). Omit (puncture) some of the encoder output string (chosen according to puncturing pattern) to reach the desired coding rate, *R*. Refer to 20.3.11.5 for details. If LDPC encoding is to be used, encode the scrambled data stream according to 20.3.11.6.5.

j) Parse the coded bit stream that results from the BCC encoding or LDPC encoding into N_{SS} spatial streams, where the value of N_{SS} is determined from the MCS parameter of the TXVECTOR. See 20.3.11.7.2 for details.

k) Divide each of the N_{SS} encoded and parsed spatial streams of bits into groups of $N_{CBPSS}(i)$ bits. If BCC encoding is to be used, within each spatial stream and group, perform an interleaving (reordering) of the bits according to a rule corresponding to $N_{BPSCS}(i)$, where i is the index of the spatial stream. Refer to 20.3.6 for details.

l) For each of the N_{SS} encoded, parsed, and interleaved spatial streams, divide the resulting coded and interleaved data string into groups of $N_{BPSCS}(i)$ bits, where i is the index of the spatial stream. For each of the bit groups, convert the bit group into a complex number according to the modulation encoding tables. Refer to 17.3.5.7 for details.

m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET parameter of TXVECTOR and the CH_BANDWIDTH parameter of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to $N_{SD} - 1$, and these indices have an associated one-to-one correspondence with subcarrier indices via the mapping function $M^r(k)$ as described in 20.3.11.10, 20.3.11.10.2, 20.3.11.10.3, 20.3.11.10.4, and 20.3.11.11.

n) If STBC is to be applied, as indicated by the STBC parameter in the TXVECTOR, operate on the complex number associated with each data subcarrier in sequential pairs of OFDM symbols as described in 20.3.11.8.1 to generate N_{STS} OFDM symbols for every N_{SS} OFDM symbols associated with the N_{SS} spatial streams. If STBC is not to be used, the number of space-time streams is the same as the number of spatial streams, and the sequences of OFDM symbols in each space-time stream are composed of the sequences of OFDM symbols in the corresponding spatial stream. In each group of N_{SD} resulting complex numbers in each space-time stream, the complex numbers indexed 0 to $N_{SD} - 1$ are mapped onto OFDM subcarriers via the mapping function $M^r(k)$ as described in 20.3.11.10, 20.3.11.10.2, 20.3.11.10.3, 20.3.11.10.4, and 20.3.11.11.

o) Determine whether 20 MHz or 40 MHz operation is to be used from the CH_BANDWIDTH parameter of the TXVECTOR. Specifically, when CH_BANDWIDTH is HT_CBW20 or NON_HT_CBW20, 20 MHz operation is to be used. When CH_BANDWIDTH is HT_CBW40 or NON_HT_CBW40, 40 MHz operation is to be used. For 20 MHz operation (with the exception of non-HT formats), insert four subcarriers as pilots into positions –21, –7, 7, and 21. The total number of the subcarriers, N_{ST}, is 56. For 40 MHz operation (with the exception of MCS 32 and non-HT duplicate format), insert six subcarriers as pilots into positions –53, –25, –11, 11, 25, and 53, resulting in a total of $N_{ST} = 114$ subcarriers. See 20.3.11.10.4 for pilot locations when using MCS 32 and 20.3.11.11 for pilot locations when using non-HT duplicate format. The pilots are modulated using a pseudo-random cover sequence. Refer to 20.3.11.9 for details. For 40 MHz operation, apply a +90 degree phase shift to the complex value in each OFDM subcarrier with an index greater than 0, as described in 20.3.11.10.3, 20.3.11.10.4, and 20.3.11.11.

p) Map each of the complex numbers in each of the N_{ST} subcarriers in each of the OFDM symbols in each of the N_{STS} space-time streams to the N_{TX} transmit chain inputs. For direct-mapped operation, $N_{TX} = N_{STS}$, and there is a one-to-one correspondence between space-time streams and transmit chains. In this case, the OFDM symbols associated with each space-time stream are also associated with the corresponding transmit chain. Otherwise, a spatial mapping matrix associated with each OFDM subcarrier, as indicated by the EXPANSION_MAT parameter of the TXVECTOR, is used to perform a linear transformation on the vector of N_{STS} complex numbers associated with each subcarrier in each OFDM symbol. This spatial mapping matrix maps the vector of N_{STS} complex numbers in each subcarrier into a vector of N_{TX} complex numbers in each subcarrier. The sequence of N_{ST} complex numbers associated with each transmit chain (where each of the N_{ST} complex numbers is taken from the same position in the N_{TX} vector of complex numbers across the N_{ST} subcarriers associated with an OFDM symbol) constitutes an OFDM symbol associated with the corresponding transmit chain. For details, see 20.3.11.10. Spatial mapping matrices may include cyclic shifts, as described in 20.3.11.10.1.

q) If the CH_BANDWIDTH and CH_OFFSET parameters of the TXVECTOR indicate that upper or lower 20 MHz are to be used in 40 MHz, move the complex numbers associated with subcarriers –28 to 28 in each transmit chain to carriers 4 to 60 in the upper channel or –60 to –4 in the lower channel. Note that this shifts the signal in frequency from the center of the 40 MHz channel to +10 MHz or –10 MHz offset from the center of the 40 MHz channel. The complex numbers in the other subcarriers are set to 0.

r) For each group of N_{ST} subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using IDFT. Prepend to the Fourier-transformed waveform a circular extension of itself, thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the GI according to the GI_TYPE parameter of the TXVECTOR. Refer to 20.3.11.10 and 20.3.11.11 for details. When beamforming is not used, it is sometimes possible to implement the cyclic shifts in the time domain.

s) Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 and 20.3.7 for details.

t) Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if ASEL is applied.

20.3.5 Modulation and coding scheme (MCS)

The MCS is a value that determines the modulation, coding, and number of spatial channels. It is a compact representation that is carried in the HT-SIG. Rate-dependent parameters for the full set of MCSs are shown in Table 20-29 through Table 20-43 (in 20.6). These tables give rate-dependent parameters for MCSs with indices 0 through 76. MCSs with indices 0 to 7 and 32 have a single spatial stream; MCSs with indices 8 to 31 have multiple spatial streams using equal modulation (EQM) on all the streams; MCSs with indices 33 to 76 have multiple spatial streams using unequal modulation (UEQM) on the spatial streams. MCS indices 77 to 127 are reserved.

Table 20-29 through Table 20-32 show rate-dependent parameters for EQM MCSs for one, two, three, and four streams for 20 MHz operation. Table 20-33 through Table 20-36 show rate-dependent parameters for EQM MCSs in one, two, three, and four streams for 40 MHz operation. The same EQM MCSs are used for 20 MHz and 40 MHz operation. Table 20-37 shows rate-dependent parameters for the 40 MHz, 6 Mb/s MCS 32 format.

The remaining tables, Table 20-38 to Table 20-43, show rate-dependent parameters for the MCSs with UEQM of the spatial streams for use with $N_{SS} > 1$, including,

- Transmit beamforming
- STBC modes for which two spatial streams (N_{SS}=2) are encoded into three space-time streams (N_{STS}=3) and three spatial streams (N_{SS}=3) are encoded into four space-time streams (N_{STS}=4). These STBC mode cases are specified in Table 20-17.

UEQM MCSs are detailed in the following tables:

- Table 20-38 through Table 20-40 are for 20 MHz operation.
- Table 20-41 through Table 20-43 are for 40 MHz operation.

MCS 0 through 15 are mandatory in 20 MHz with 800 ns GI at an AP. MCS 0 through 7 are mandatory in 20 MHz with 800 ns GI at all STAs. All other MCSs and modes are optional, specifically including transmit and receive support of 400 ns GI, operation in 40 MHz, and support of MCSs with indices 16 through 76.

20.3.6 Timing-related parameters

Table 20-5 defines the timing-related parameters.

Table 20-5—Timing-related constants

Parameter	TXVECTOR CH_BANDWIDTH			
	NON_HT_CBW20	HT_CBW_20	HT_CBW40 or NON_HT_CBW40	
			HT format	MCS 32 and non-HT duplicate
N_{SD}: Number of complex data numbers	48	52	108	48
N_{SP}: Number of pilot values	4	4	6	4
N_{ST}: Total number of subcarriers See NOTE 1	52	56	114	104

Table 20-5—Timing-related constants *(continued)*

Parameter	TXVECTOR CH_BANDWIDTH			
	NON_HT_CBW20	HT_CBW_20	HT_CBW40 or NON_HT_CBW40	
			HT format	MCS 32 and non-HT duplicate
N_{SR}: Highest data subcarrier index	26	28	58	58
Δ_F : Subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double guard interval	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short guard interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	
$T_{HT\text{-}GF\text{-}STF}$: HT-greenfield short training field duration	N/A	8 µs=10× $T_{DFT}/4$	8 µs See NOTE 2	
$T_{L\text{-}LTF}$: Non-HT long training field duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs	
T_{SYM}: Symbol interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs	
T_{SYMS}: Short GI symbol interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2	
$T_{L\text{-}SIG}$: Non-HT SIGNAL field duration	4 µs= T_{SYM}	4 µs	4 µs	
$T_{HT\text{-}SIG}$: HT SIGNAL field duration	N/A	8 µs= $2T_{SYM}$	8 µs See NOTE 2	
$T_{HT\text{-}STF}$: HT short training field duration	N/A	4 µs	4 µs See NOTE 2	
$T_{HT\text{-}LTF1}$: First HT long training field duration	N/A	4 µs in HT-mixed format, 8 µs in HT-greenfield format	4 µs in HT-mixed format, 8 µs in HT-greenfield format See NOTE 2	
$T_{HT\text{-}LTFs}$: Second, and subsequent, HT long training fields duration	N/A	4 µs	4 µs See NOTE 2	

NOTE 1—$N_{ST}=N_{SD}+N_{SP}$ except in the cases of MCS 32 and non-HT duplicate, where the number of data subcarriers differs from the number of complex data numbers, and the number of pilot subcarriers differs from the number of pilot values. In those cases, data numbers and pilot values are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 subcarriers.
NOTE 2—Not applicable in non-HT formats.
NOTE 3—N/A = Not applicable.

Table 20-6 defines parameters used frequently in Clause 20.

Table 20-6—Frequently used parameters

Symbol	Explanation
N_{CBPS}	Number of coded bits per symbol
$N_{CBPSS}(i)$	Number of coded bits per symbol per the *i*-th spatial stream
N_{DBPS}	Number of data bits per symbol
N_{BPSC}	Number of coded bits per single carrier
$N_{BPSCS}(i)$	Number of coded bits per single carrier for spatial stream *i*
N_{RX}	Number of receive chains
N_{STS}	Number of space-time streams
N_{SS}	Number of spatial streams
N_{ESS}	Number of extension spatial streams
N_{TX}	Number of transmit chains
N_{ES}	Number of BCC encoders for the Data field
N_{HTLTF}	Number of HT Long Training fields (see 20.3.9.4.6)
N_{HTDLTF}	Number of Data HT Long Training fields
N_{HTELTF}	Number of Extension HT Long Training fields
R	Coding rate

20.3.7 Mathematical description of signals

For the description of the convention on mathematical description of signals, see 17.3.2.4.

In the case of either a 20 MHz non-HT format (TXVECTOR parameter FORMAT set to NON_HT, MODULATION parameter set to one of {DSSS-OFDM, ERP-OFDM, OFDM}) transmission or a 20 MHz HT format (TXVECTOR parameter FORMAT set to HT_MF or HT_GF, CH_BANDWIDTH set to HT_CBW_20) transmission, the channel is divided into 64 subcarriers. In the 20 MHz non-HT format, the signal is transmitted on subcarriers –26 to –1 and 1 to 26, with 0 being the center (dc) carrier. In the 20 MHz HT format, the signal is transmitted on subcarriers –28 to –1 and 1 to 28.

In the case of the 40 MHz HT format, a 40 MHz channel is used. The channel is divided into 128 subcarriers. The signal is transmitted on subcarriers –58 to –2 and 2 to 58.

In the case of 40 MHz HT upper format or 40 MHz HT lower format, the upper or lower 20 MHz is divided into 64 subcarriers. The signal is transmitted on subcarriers –60 to –4 in the case of a 40 MHz HT lower format transmission and on subcarriers 4 to 60 in the case of a 40 MHz HT upper format transmission.

In the case of the MCS 32 and non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 subcarriers, and the data are transmitted on subcarriers –58 to –6 and 6 to 58.

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal is related to the complex baseband signal by the relation shown in Equation (20-1).

$$r_{RF}(t) = \mathrm{Re}\{r(t)\exp(j2\pi f_c t)\} \tag{20-1}$$

where

$\mathrm{Re}\{.\}$ represents the real part of a complex variable

f_c is the center frequency of the carrier

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure 20-4.

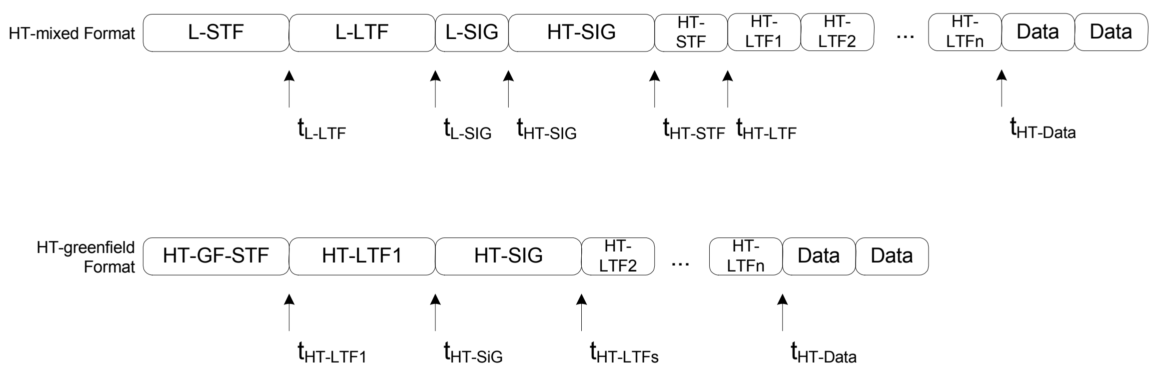


Figure 20-4—Timing boundaries for PPDU fields

The time offset, t_{Field}, determines the starting time of the corresponding field.

In HT-mixed format, the signal transmitted on transmit chain i_{TX} shall be as shown in Equation (20-2).

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) &= r_{L\text{-}STF}^{(i_{TX})}(t) + r_{L\text{-}LTF}^{(i_{TX})}(t - t_{L\text{-}LTF}) \\ &+ r_{L\text{-}SIG}^{(i_{TX})}(t - t_{L\text{-}SIG}) + r_{HT\text{-}SIG}^{(i_{TX})}(t - t_{HT\text{-}SIG}) + r_{HT\text{-}STF}^{(i_{TX})}(t - t_{HT\text{-}STF}) \\ &+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT\text{-}LTF}^{(i_{TX},\, i_{LTF})}(t - t_{HT\text{-}LTF} - (i_{LTF}-1)T_{HT\text{-}LTFs}) + r_{HT\text{-}DATA}^{(i_{TX})}(t - t_{HT\text{-}DATA}) \end{aligned} \tag{20-2}$$

where

$t_{L\text{-}LTF} = T_{L\text{-}STF}$

$t_{L\text{-}SIG} = t_{L\text{-}LTF} + T_{L\text{-}LTF}$

$t_{HT\text{-}SIG} = t_{L\text{-}SIG} + T_{L\text{-}SIG}$

$t_{HT\text{-}STF} = t_{HT\text{-}SIG} + T_{HT\text{-}SIG}$

$t_{HT\text{-}LTF} = t_{HT\text{-}STF} + T_{HT\text{-}STF}$

$$t_{HT\text{-}Data} = t_{HT\text{-}LTF} + N_{LTF} \cdot T_{HT\text{-}LTFs}$$

In the case of HT-greenfield format, the transmitted signal on transmit chain i_{TX} shall be as shown in Equation (20-3).

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=2}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-3}$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT\text{-}SIG} = t_{HT\text{-}LTF1} + T_{HT\text{-}LTF1}$$

$$t_{HT\text{-}LTFs} = t_{HT\text{-}SIG} + T_{HT\text{-}SIG}$$

$$t_{HT\text{-}Data} = t_{HT\text{-}LTFs} + (N_{LTF} - 1) \cdot T_{HT\text{-}LTFs}$$

Each baseband waveform, $r_{\mathrm{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform (DFT) per OFDM symbol as shown in Equation (20-4).

$$r_{\mathrm{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\mathrm{Field}}^{\mathrm{Tone}} \cdot N_{TX}}} w_{T_{\mathrm{Field}}}(t) \sum_k \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \tag{20-4}$$

This general representation holds for all fields. A suggested definition of the windowing function, $w_{T_{\mathrm{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for transmit chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel as shown in Equation (20-5) and Equation (20-6).

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \tag{20-5}$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \tag{20-6}$$

The $1/\sqrt{N_{\mathrm{Field}}^{\mathrm{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table 20-7 summarizes the various values of $N_{\mathrm{Field}}^{\mathrm{Tone}}$.

Table 20-7—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}, see NOTE 1	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
MCS 32, see NOTE 3	—	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2—The values 56 and 114 are for HT-greenfield format; the values 52 and 104 are for HT-mixed format.

NOTE 3—This is the Data field in an MCS 32 format PPDU.

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with f_c in Equation (20-1) replaced by $f_c \pm 10$ MHz.

This rule applies to 20 MHz HT transmission in the upper/lower 20 MHz of a 40 MHz channel (TXVECTOR primitive CH_BANDWIDTH set to HT_CBW20 and CH_OFFSET primitive set to CH_OFF_20U or CH_OFF_20L) and to 20 MHz non-HT transmission in the upper/lower 20 MHz of a 40 MHz channel (TXVECTOR primitive CH_BANDWIDTH set to NON_HT_CBW20 and CH_OFFSET primitive set to CH_OFF_20U or CH_OFF_20L).

20.3.9 HT preamble

20.3.9.1 Introduction

The HT preambles are defined in HT-mixed format and in HT-greenfield format to carry the required information to operate in a system with multiple transmit and multiple receive antennas.

In the HT-mixed format, to ensure compatibility with non-HT STAs, specific non-HT fields are defined so that they can be received by non-HT STAs compliant with Clause 17 or Clause 19 followed by the fields specific to HT STAs.

In the HT-greenfield format, all of the non-HT fields are omitted. The specific HT fields used are as follows:

— One HT-GF-STF for automatic gain control convergence, timing acquisition, and coarse frequency acquisition,

— One or several HT-LTFs, provided as a way for the receiver to estimate the channel between each spatial mapper input and receive chain. The first HT-LTFs (HT-DLTFs) are necessary for demodulation of the HT-Data portion of the PPDU and are followed, for sounding packets only, by optional HT-LTFs (HT-ELTFs) to sound extra spatial dimensions of the MIMO channel,

— HT-SIG, which provides all the information required to interpret the HT packet format.

In the case of multiple transmit chains, the HT preambles use cyclic shift techniques to prevent unintentional beamforming.

20.3.9.2 HT-mixed format preamble

In HT-mixed format frames, the preamble has fields that support compatibility with Clause 17 and Clause 19 STAs and fields that support HT operation. The non-HT portion of the HT-mixed format preamble enables detection of the PPDU and acquisition of carrier frequency and timing by both HT STAs and STAs that are compliant with Clause 17 or Clause 19. The non-HT portion of the HT-mixed format preamble contains the SIGNAL field (L-SIG) defined in Clause 17 and is thus decodable by STAs compliant with Clause 17 and Clause 19 as well as HT STAs.

The HT portion of the HT-mixed format preamble enables estimation of the MIMO channel to support demodulation of the data portion of the frame by HT STAs. The HT portion of the HT-mixed format preamble also contains the HT-SIG field that supports HT operation.

20.3.9.3 Non-HT portion of the HT-mixed format preamble

20.3.9.3.1 Introduction

The transmission of the non-HT training fields and the L-SIG as part of an HT-mixed format packet is described in 20.3.9.3.2 through 20.3.9.3.5.

20.3.9.3.2 Cyclic shift definition

The cyclic shift values defined in this subclause apply to the non-HT fields in the HT-mixed format preamble and the HT-SIG in the HT-mixed format preamble.

Cyclic shifts are used to prevent unintentional beamforming when the same signal or scalar multiples of one signal are transmitted through different spatial streams or transmit chains. A cyclic shift of duration T_{CS} on a signal $s(t)$ on interval $0 \le t \le T$ is defined as follows, where T is defined as T_{DFT} as referenced in Table 20-5.

With $T_{CS} \le 0$, replace $s(t)$ with $s(t - T_{CS})$ when $0 \le t < T + T_{CS}$ and with $s(t - T_{CS} - T)$ when $T + T_{CS} \le t \le T$. The cyclic-shifted signal is defined as shown in Equation (20-7).

$$s_{CS}(t;T_{CS})\big|_{T_{CS}<0} = \begin{cases} s(t - T_{CS}) & 0 \le t < T + T_{CS} \\ s(t - T_{CS} - T) & T + T_{CS} \le t \le T \end{cases} \tag{20-7}$$

The cyclic shift is applied to each OFDM symbol in the packet separately. Table 20-8 specifies the values for the cyclic shifts that are applied in the L-STF (in an HT-mixed format packet), the L-LTF, and L-SIG. It also applies to the HT-SIG in an HT-mixed format packet.

With more than four transmit chains, each cyclic shift on the additional transmit chains shall be between –200 ns and 0 ns inclusive.

Table 20-8—Cyclic shift for non-HT portion of packet

$T_{CS}^{i_{TX}}$ values for non-HT portion of packet				
Number of transmit chains	**Cyclic shift for transmit chain 1 (ns)**	**Cyclic shift for transmit chain 2 (ns)**	**Cyclic shift for transmit chain 3 (ns)**	**Cyclic shift for transmit chain 4 (ns)**
1	0	—	—	—
2	0	–200	—	—
3	0	–100	–200	—
4	0	–50	–100	–150

20.3.9.3.3 L-STF definition

The L-STF is identical to the Clause 17 short training symbol. The non-HT short training OFDM symbol in the 20 MHz channel width is shown in Equation (20-8).

$$\begin{aligned} S_{-26,26} = \sqrt{1/2} \\ &\{0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, \\ &0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0\} \end{aligned} \tag{20-8}$$

The normalization factor $\sqrt{1/2}$ is the QPSK normalization.

The non-HT short training OFDM symbol in a 40 MHz channel width is given by Equation (20-9), after rotating the tones in the upper subchannel (subcarriers 6–58) by +90º (see Equation (20-10)).

$$\begin{aligned} S_{-58,58} = \sqrt{1/2} \\ &\{0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, \\ &0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, \\ &0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, \\ &0, 0, 0, 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0\} \end{aligned} \tag{20-9}$$

In HT-mixed format, the L-STF on transmit chain i_{TX} shall be as shown in Equation (20-10).

$$r_{L-STF}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{L-STF}^{Tone}}} w_{T_{L-STF}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \Upsilon_k S_k \exp(j2\pi k \Delta_F (t - T_{CS}^{i_{TX}})) \tag{20-10}$$

where

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} and takes values from Table 20-8

Υ_k is defined in Equation (20-5) and Equation (20-6)

The L-STF has a period of 0.8 µs. The entire STF includes ten such periods, with a total duration of $T_{L\text{-}STF}$ = 8 µs.

20.3.9.3.4 L-LTF definition

The non-HT long training OFDM symbol is identical to the Clause 17 long training OFDM symbol. In the 20 MHz channel width, the long training OFDM symbol is given by Equation (20-11).

$$\begin{aligned} L_{-26,26} = \{&1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 0, \\ &1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1\} \end{aligned} \tag{20-11}$$

The non-HT long training OFDM symbol in a 40 MHz channel width is given by Equation (20-12), after rotating the tones in the upper subchannel (subcarriers 6–58) by +90º (see Equation (20-13)).

$$\begin{aligned} L_{-58,58} = \{&1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 0, \\ &1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1, 0, 0, 0, 0, 0, \\ &0, 0, 0, 0, 0, 0, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 0, \\ &1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1\} \end{aligned} \tag{20-12}$$

The subcarriers at ± 32 in 40 MHz, which are the dc subcarriers for the non-HT 20 MHz transmission, are both nulled in the L-LTF. Such an arrangement allows proper synchronization of a 20 MHz non-HT STA.

The L-LTF waveform shall be as shown in Equation (20-13).

$$r_{L-LTF}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{L-LTF}^{Tone}}} w_{T_{L-LTF}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \Upsilon_k L_k \exp(j2\pi k\Delta_F(t - T_{GI2} - T_{CS}^{i_{TX}})) \tag{20-13}$$

where

T_{GI2} is 1.6 μs

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} and takes values specified in Table 20-8

Υ_k is defined in Equation (20-5) and Equation (20-6)

The entire LTF includes two 3.2 μs IDFT/DFT periods and an additional 1.6 μs double GI. The entire LTF is modulated with the L-LTF waveform.

20.3.9.3.5 L-SIG definition

The L-SIG is used to communicate rate and length information.The structure of the L-SIG is shown in Figure 20-5.

Rate (4 bits)				R	Length (12 bits)												P	Tail (6 bits)					
R1	R2	R3	R4															“0”	“0”	“0”	“0”	“0”	“0”
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

Figure 20-5—L-SIG structure

The value in the Rate field is obtained from the L_DATARATE field of the TXVECTOR. The value in the Length field is obtained from the L_LENGTH field of the TXVECTOR. The Length field is transmitted LSB first.

The reserved bit shall be set to 0.

The parity field has the even parity of bits 0–16.

The L-SIG shall be encoded, interleaved and mapped, and it shall have pilots inserted following the steps described in 17.3.5.5, 17.3.5.6, and 17.3.5.8. The stream of 48 complex numbers generated by the steps described in 17.3.5.6 is denoted by $d_k, k = 0 \ldots 47$. The time domain waveform of the L-SIG in 20 MHz transmission shall be as given by Equation (20-14).

$$r_{L-SIG}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{L-SIG}^{Tone}}} w_{T_{SYM}}(t) \sum_{k=-26}^{26} (D_k + p_0 P_k) \exp(j2\pi k \Delta_F (t - T_{GI} - T_{CS}^{i_{TX}})) \qquad (20\text{-}14)$$

In a 40 MHz transmission the time domain waveform of the L-SIG shall be as given by Equation (20-15).

$$\begin{aligned} r_{L-SIG}^{(i_{TX})}(t) &= \frac{1}{\sqrt{N_{TX} \cdot N_{L-SIG}^{Tone}}} w_{T_{SYM}}(t) \sum_{k=-26}^{26} (D_k + p_0 P_k) \\ &\cdot (\exp(j2\pi(k-32)\Delta_F(t - T_{GI} - T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t - T_{GI} - T_{CS}^{i_{TX}}))) \end{aligned} \qquad (20\text{-}15)$$

where

$$D_k = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k)}, \text{otherwise} \end{cases}$$

$$M^r(k) = \begin{cases} k + 26, -26 \le k \le -22 \\ k + 25, -20 \le k \le -8 \\ k + 24, -6 \le k \le -1 \\ k + 23, 1 \le k \le 6 \\ k + 22, 8 \le k \le 20 \\ k + 21, 22 \le k \le 26 \end{cases}$$

P_k is defined in 17.3.5.9

p_0 is the first pilot value in the sequence defined in 17.3.5.9

N_{L-SIG}^{Tone} has the value given in Table 20-7

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} and is defined by Table 20-8 for HT-mixed format PPDUs

NOTE— D_k exists for $-N_{SR} \le k \le N_{SR}$ and takes the values from d_k that exists for $0 \le k \le N_{SD} - 1$. $M^r(k)$ is a “reverse” function of the function $M(k)$ defined in 17.3.5.9.

20.3.9.4 HT portion of HT-mixed format preamble

20.3.9.4.1 Introduction

When an HT-mixed format preamble is transmitted, the HT preamble consists of the HT-STF, the HT-LTFs, and the HT-SIG.

20.3.9.4.2 Cyclic shift definition

The cyclic shift values defined in this subclause apply to the HT-STF and HT-LTFs of the HT-mixed format preamble. The cyclic shift values defined in 20.3.9.3.2 apply to the HT-SIG in an HT-mixed format preamble.

Throughout the HT portion of an HT-mixed format preamble, cyclic shift is applied to prevent beamforming when similar signals are transmitted in different space-time streams. The same cyclic shift is applied to these streams during the transmission of the data portion of the frame. The values of the cyclic shifts to be used during the HT portion of the HT-mixed format preamble (with the exception of the HT_SIG) and the data portion of the frame are specified in Table 20-9.

Table 20-9—Cyclic shift values of HT portion of packet

$T_{CS}^{i_{STS}}$ values for HT portion of packet				
Number of space-time streams	**Cyclic shift for space-time stream 1 (ns)**	**Cyclic shift for space-time stream 2 (ns)**	**Cyclic shift for space-time stream 3 (ns)**	**Cyclic shift for space-time stream 4 (ns)**
1	0	—	—	—
2	0	–400	—	—
3	0	–400	–200	—
4	0	–400	–200	–600

20.3.9.4.3 HT-SIG definition

The HT-SIG is used to carry information required to interpret the HT packet formats. The fields of the HT-SIG are described in Table 20-10.

Table 20-10—HT-SIG fields

Field	Number of bits	Explanation and coding
Modulation and Coding Scheme	7	Index into the MCS table. See NOTE 1.
CBW 20/40	1	Set to 0 for 20 MHz or 40 MHz upper/lower. Set to 1 for 40 MHz.
HT Length	16	The number of octets of data in the PSDU in the range of 0 to 65 535. See NOTE 1 and NOTE 2.

Table 20-10—HT-SIG fields *(continued)*

Field	Number of bits	Explanation and coding
Smoothing	1	Set to 1 indicates that channel estimate smoothing is recommended. Set to 0 indicates that only per-carrier independent (unsmoothed) channel estimate is recommended. See 20.3.11.10.1.
Not Sounding	1	Set to 0 indicates that PPDU is a sounding PPDU. Set to 1 indicates that the PPDU is not a sounding PPDU.
Reserved	1	Set to 1.
Aggregation	1	Set to 1 to indicate that the PPDU in the data portion of the packet contains an A-MPDU; otherwise, set to 0.
STBC	2	Set to a nonzero number, to indicate the difference between the number of space-time streams (N_{STS}) and the number of spatial streams (N_{SS}) indicated by the MCS. Set to 00 to indicate no STBC ($N_{STS} = N_{SS}$). See NOTE 1.
FEC coding	1	Set to 1 for LDPC. Set to 0 for BCC.
Short GI	1	Set to 1 to indicate that the short GI is used after the HT training. Set to 0 otherwise.
Number of extension spatial streams	2	Indicates the number of extension spatial streams (N_{ESS}). Set to 0 for no extension spatial stream. Set to 1 for 1 extension spatial stream. Set to 2 for 2 extension spatial streams. Set to 3 for 3 extension spatial streams. See NOTE 1.
CRC	8	CRC of bits 0–23 in HT-SIG$_1$ and bits 0–9 in HT-SIG$_2$. See 20.3.9.4.4. The first bit to be transmitted is bit C7 as explained in 20.3.9.4.4.
Tail Bits	6	Used to terminate the trellis of the convolution coder. Set to 0.
NOTE 1—Integer fields are transmitted in unsigned binary format, LSB first. NOTE 2—A value of 0 in the HT Length field indicates a PPDU that does not include a data field, i.e., NDP. NDP transmissions are used for sounding purposes only (see 9.21.2). The packet ends after the last HT-LTF or the HT-SIG.		

The structure of the HT-SIG$_1$ and HT-SIG$_2$ fields is defined in Figure 20-6.

The HT-SIG is composed of two parts, HT-SIG$_1$ and HT-SIG$_2$, each containing 24 bits, as shown in Figure 20-6. All the fields in the HT-SIG are transmitted LSB first, and HT-SIG$_1$ is transmitted before HT-SIG$_2$.

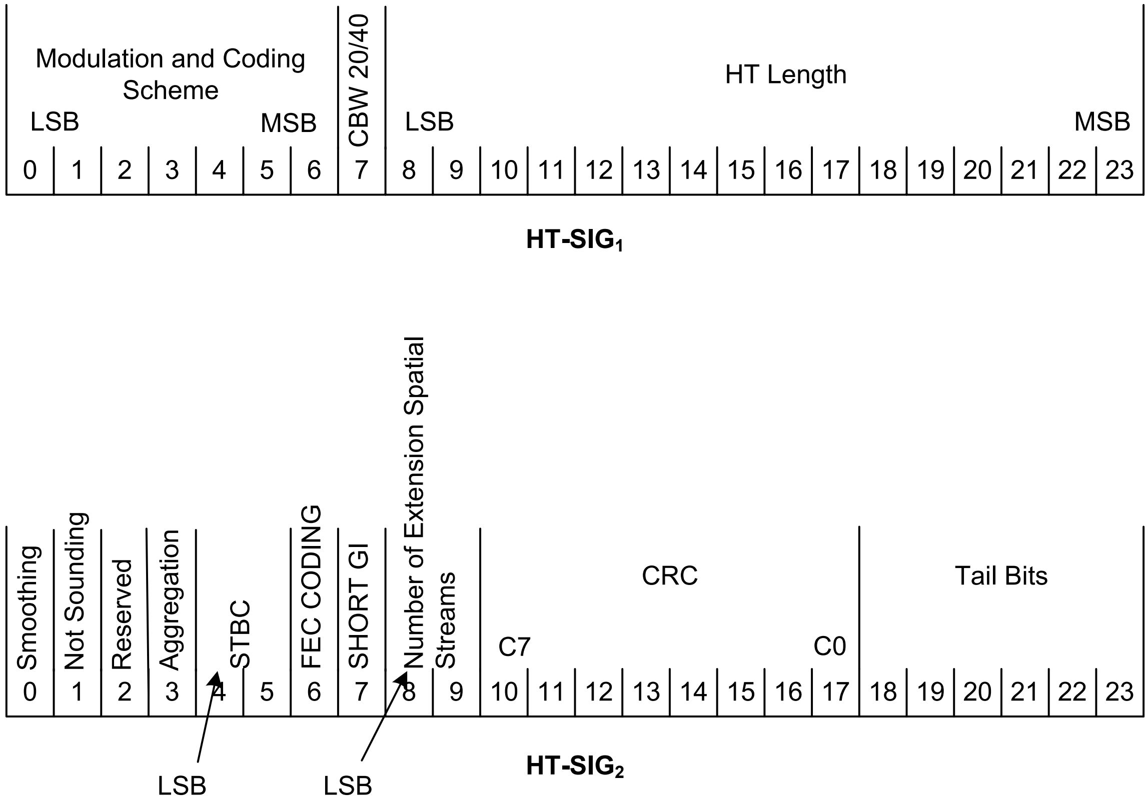


Figure 20-6—Format of HT-SIG$_1$ and HT-SIG$_2$

The HT-SIG parts shall be encoded at R = 1/2, interleaved, and mapped to a BPSK constellation, and they have pilots inserted following the steps described in 17.3.5.5, 17.3.5.6, 17.3.5.7, and 17.3.5.8, respectively. The BPSK constellation is rotated by 90° relative to the L-SIG in order to accommodate detection of the start of the HT-SIG. The stream of 96 complex numbers generated by these steps is divided into two groups of 48 complex numbers: $d_{k,n}, 0 \le k \le 47, n = 0, 1$. The time domain waveform for the HT-SIG in an HT-mixed format packet in a 20 MHz transmission shall be as shown in Equation (20-16).

$$
\begin{aligned}
r_{HT-SIG}^{i_{TX}}(t) &= \frac{1}{\sqrt{N_{TX} \cdot N_{HT-SIG}^{Tone}}} \sum_{n=0}^{1} w_{T_{SYM}}(t - nT_{SYM}) \\
&\cdot \sum_{k=-26}^{26} (jD_{k,n} + p_{n+1}P_k) \exp(j2\pi k\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{TX}}))
\end{aligned}
\tag{20-16}
$$

For a 40 MHz transmission, the time domain waveform shall be as shown in Equation (20-17).

$$r_{HT-SIG}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{HT-SIG}^{Tone}}} \sum_{n=0}^{1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_{n+1}P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{TX}}))) \tag{20-17}$$

where

$$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$$

$M^r(k)$ is defined in 20.3.9.3

P_k and p_n are defined in 17.3.5.9

N_{HT-SIG}^{Tone} has the value given in Table 20-7

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} and is defined by Table 20-8 for HT-mixed format PPDUs.

NOTE—This definition results in a quadrature binary phase shift keying (QBPSK) modulation in which the constellation of the data tones is rotated by 90º relative to the L-SIG in HT-mixed format PPDUs and relative to the first HT-LTF in HT-greenfield format PPDUs (see Figure 20-7). In HT-mixed format PPDUs, the HT-SIG is transmitted with the same number of subcarriers and the same cyclic shifts as the preceding non-HT portion of the preamble. This is done to accommodate the estimation of channel parameters needed to robustly demodulate and decode the information contained in the HT-SIG.

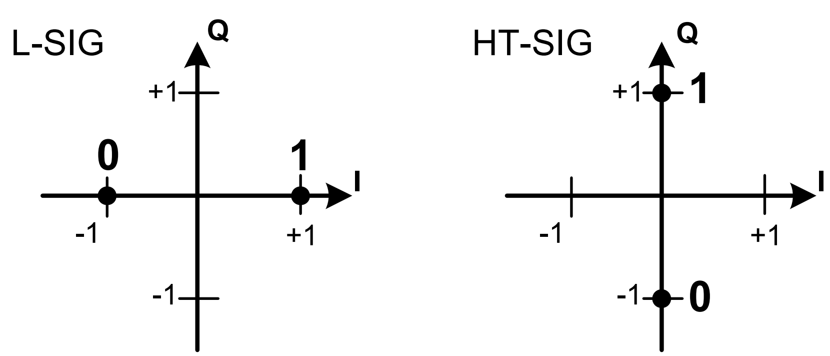


Figure 20-7—Data tone constellations in an HT-mixed format PPDU

20.3.9.4.4 CRC calculation for HT-SIG

The CRC protects bits 0–33 of the HT-SIG (bits 0–23 of HT-SIG$_1$ and bits 0–9 of HT-SIG$_2$). The value of the CRC field shall be the ones complement of

$$crc(D) = (M(D) \oplus I(D))D^8 \ \ modulo \ \ G(D) \tag{20-18}$$

where

$M(D) = m_0 D^{33} + m_1 D^{32} + \ldots + m_{32} D + m_{33}$ is the HT-SIG represented as a polynomial

where

m_0 is bit 0 of HT-SIG$_1$

m_{33} is bit 9 of HT-SIG$_2$

$I(D) = \sum_{i=26}^{33} D^i$ are initialization values that are added modulo 2 to the first 8 bits of HT-SIG$_1$

$G(D) = D^8 + D^2 + D + 1$ is the CRC generating polynomial

$crc(D) = c_0 D^7 + c_1 D^6 + \ldots + c_6 D + c_7$

The CRC field is transmitted with c_7 first.

Figure 20-8 shows the operation of the CRC. First, the shift register is reset to all ones. The bits are then passed through the XOR operation at the input. When the last bit has entered, the output is generated by shifting the bits out of the shift register, C7 first, through an inverter.

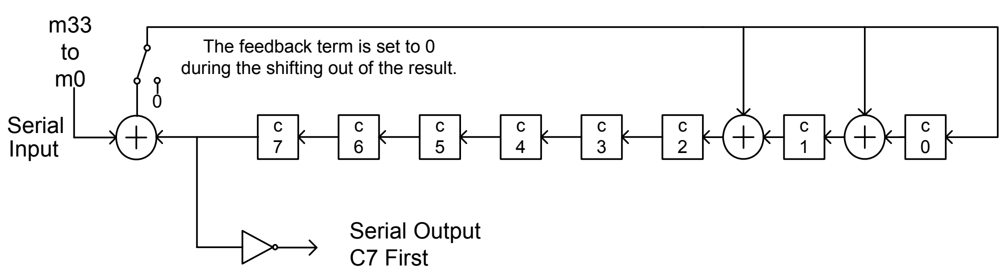


Figure 20-8—HT-SIG CRC calculation

As an example, if bits $\{m_0 \ldots m_{33}\}$ are given by {1 1 1 1 0 0 0 1 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0}, the CRC bits $\{c_7 \ldots c_0\}$ are {1 0 1 0 1 0 0 0}.

20.3.9.4.5 HT-STF definition

The purpose of the HT-STF is to improve automatic gain control estimation in a MIMO system. The duration of the HT-STF is 4 µs. In a 20 MHz transmission, the frequency sequence used to construct the HT-STF is identical to L-STF. In a 40 MHz transmission, the HT-STF is constructed from the 20 MHz version by duplicating and frequency shifting and by rotating the upper subcarriers by 90°. The frequency sequences are shown in Equation (20-19) and Equation (20-20).

For 20 MHz:

$$HTS_{-28,28} = \sqrt{1/2}\ \{0, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 0\} \tag{20-19}$$

For 40 MHz:

$$HTS_{-58,58} = \sqrt{1/2}\ \{0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0\} \tag{20-20}$$

The time domain representation of the transmission in transmit chain i_{TX} shall be as shown in Equation (20-21).

$$r_{HT-STF}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-STF}^{Tone}}} w_{T_{HT-STF}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} \Upsilon_k HTS_k \exp(j2\pi k\Delta_F(t - T_{CS}^{i_{STS}})) \tag{20-21}$$

where

$T_{CS}^{i_{STS}}$ represents the cyclic shift for the space-time stream i_{STS} and takes the values given in Table 20-9

Q_k is defined in 20.3.11.10.1

Υ_k is defined in Equation (20-5) and Equation (20-6)

20.3.9.4.6 HT-LTF definition

The HT-LTF provides a means for the receiver to estimate the MIMO channel between the set of QAM mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. If the transmitter is providing training for exactly the space-time streams (spatial mapper inputs) used for the transmission of the PSDU, the number of training symbols, N_{LTF}, is equal to the number of space-time streams, N_{STS}, except that for three space-time streams, four training symbols are required. If the transmitter is providing training for more space-time streams (spatial mapper inputs) than the number used for the transmission of the PSDU, the number of training symbols is greater than the number of space-time streams. This latter case happens in a sounding PPDU.

The HT-LTF portion has one or two parts. The first part consists of one, two, or four HT-LTFs that are necessary for demodulation of the HT-Data portion of the PPDU. These HT-LTFs are referred to as HT-DLTFs. The optional second part consists of zero, one, two, or four HT-LTFs that may be used to sound extra spatial dimensions of the MIMO channel that are not utilized by the HT-Data portion of the PPDU. These HT-LTFs are referred to as HT-ELTFs. If a receiver has not advertised its ability to receive HT-ELTFs, it shall either issue a PHY-RXEND.indicate(UnsupportedRate) primitive upon reception of a frame that includes HT-ELTFs or decode that frame. (When an HT packet includes one or more HT-ELTFs, it is optional for a receiver that has not advertised its capability to receive HT-ELTFs to decode the data portion of the PPDU.)

The number of HT-DLTFs is denoted N_{HTDLTF}. The number of HT-ELTFs is denoted N_{HTELTF}. The total number of HT-LTFs is shown in Equation (20-22).

$$N_{HTLTF} = N_{HTDLTF} + N_{HTELTF} \tag{20-22}$$

N_{HTLTF} shall not exceed 5. Table 20-11 shows the determination of the number of space-time streams from the MCS and STBC fields in the HT-SIG. Table 20-12 shows the number of HT-DLTFs as a function of the number of space-time streams (N_{STS}). Table 20-13 shows the number of HT-ELTFs as a function of the number of extension spatial streams (N_{ESS}). N_{STS} plus N_{ESS} is less than or equal to 4. In the case where N_{STS} equals 3, N_{ESS} cannot exceed one; if N_{ESS} equals one in this case then N_{LTF} equals 5.

Table 20-11—Determining the number of space-time streams

Number of Spatial Streams (from MCS) N_{SS}	STBC field	Number of space-time streams N_{STS}
1	0	1
1	1	2
2	0	2
2	1	3
2	2	4
3	0	3
3	1	4
4	0	4

Table 20-12—Number of HT-DLTFs required for data space-time streams

N_{STS}	N_{HTDLTF}
1	1
2	2
3	4
4	4

Table 20-13—Number of HT-ELTFs required for extension spatial streams

N_{ESS}	N_{HTELTF}
0	0
1	1
2	2
3	4

The HT-LTF sequence shown in Equation (20-23) is transmitted in the case of 20 MHz operation.

$$
\begin{aligned}
HTLTF_{-28,28} = \{&1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 0, \\
&1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1, -1, -1\}
\end{aligned}
\tag{20-23}
$$

NOTE—This sequence is an extension of the L-LTF where the four extra subcarriers are filled with +1 for negative frequencies and –1 for positive frequencies.

In 40 MHz transmissions, including MCS 32 format frames, the sequence to be transmitted is shown in Equation (20-24).

$$
\begin{aligned}
HTLTF_{-58,58} = \{&1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, \\
&1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1, -1, -1, -1, 1, 0, \\
&0, 0, -1, 1, 1, -1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, \\
&1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1\}
\end{aligned}
\tag{20-24}
$$

NOTE—This sequence is also constructed by extending the L-LTF in the following way: first, the L-LTF is duplicated and shifted as explained in 20.3.9.3.4 for the non-HT duplicate format; then the missing subcarriers [–32, –5, –4, –3, –2, 2, 3, 4, 5, 32] are filled with the values [1, –1, –1, –1, 1, –1, 1, 1, –1, 1], respectively.

This sequence, occupying 114 tones, is used even if the data portion is transmitted with MCS 32 format, which uses 104 tones.

NOTE—This sequence uses 114 tones when MCS 32 format is used to retain consistency with other 40 MHz formats and to facilitate channel estimation for beamforming and link adaptation.

In an HT-mixed format preamble, each HT-LTF consists of a single occurrence of the sequence plus a GI insertion and has a duration of 4 µs. In case of multiple space-time streams, cyclic shift is invoked as specified in Table 20-9.

The generation of HT-DLTFs is shown in Figure 20-9. The generation of HT-ELTFs is shown in Figure 20-10. In these figures, and in the following text, the following notational conventions are used:

— $[X]_{m,n}$ indicates the element in row *m* and column *n* of matrix *X*
— $[X]_N$ indicates a matrix consisting of the first *N* columns of matrix *X*
— $[X]_{M:N}$ indicates a matrix consisting of columns *M* through *N* of matrix *X*

where

$M \le N$

X is either Q_k or P_{HTLTF}

The mapping between space-time streams and transmit chains is defined by the columns of an antenna map matrix Q_k for subcarrier *k*. The first N_{STS} columns define the space-time streams used for data transmission, and the next N_{ESS} columns (up to $N_{TX} - N_{STS}$ columns) define the extension spatial streams. Thus, for the purpose of defining HT-LTFs, Q_k is an $N_{TX} \times (N_{STS} + N_{ESS})$ dimension matrix. Columns $1 \ldots N_{STS}$ of Q_k are excited by the HT-DLTFs, and columns $N_{STS} + 1 \ldots N_{STS} + N_{ESS}$ are excited by the HT-ELTFs, where $N_{STS} + N_{ESS} \le N_{TX}$ is the total number of spatial streams being probed by the HT-LTFs.

Possible forms of Q_k and other limitations on Q_k are specified in 20.3.11.10.1. P_{HTLTF} is defined in Equation (20-27).

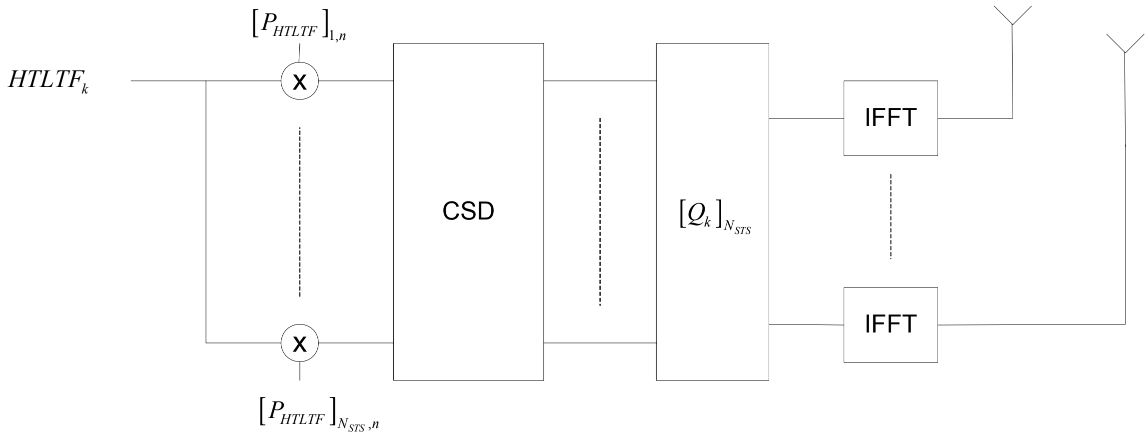


Figure 20-9—Generation of HT-DLTFs

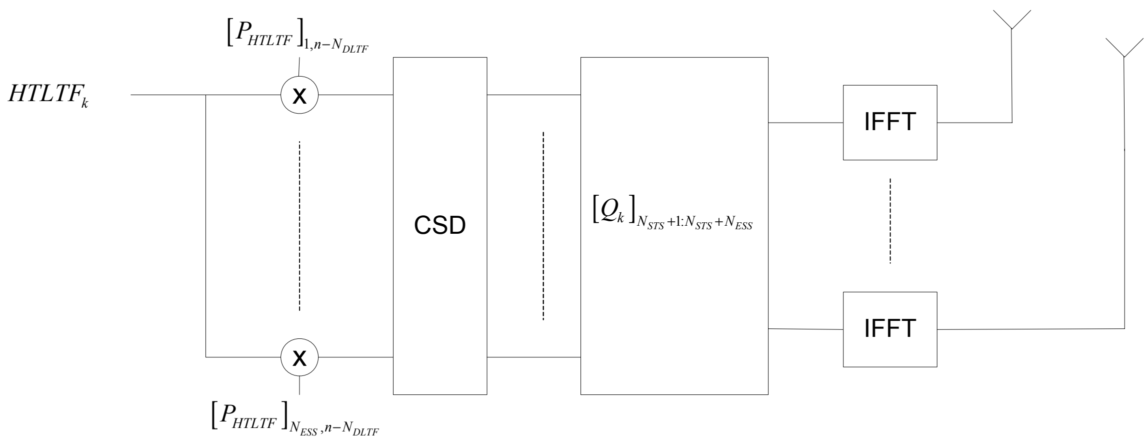


Figure 20-10—Generation of HT-ELTFs

The time domain representation of the waveform transmitted on transmit chain i_{TX} during HT-DLTF n, where $1 \le n \le N_{HTDLTF}$, shall be as shown in Equation (20-25).

$$r_{HT-LTF}^{n,i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-LTF}^{Tone}}} w_{T_{HT-LTFs}}(t) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX},i_{STS}} [P_{HTLTF}]_{i_{STS},n} \Upsilon_k HTLTF_k \exp(j2\pi k \Delta_F (t - T_{GI} - T_{CS}^{i_{STS}})) \tag{20-25}$$

For the HT-ELTFs $(N_{HTDLTF} < n \le N_{HTLTF})$, it shall be as shown in Equation (20-26).

$$r_{HT-LTF}^{n, i_{TX}}(t) = \frac{1}{\sqrt{N_{HT-LTF}^{Tone} \cdot N_{ESS}}} w_{T_{HT-LTFs}}(t) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{ESS}=1}^{N_{ESS}} \Big([Q_k]_{i_{TX}, N_{STS}+i_{ESS}} [P_{HTLTF}]_{i_{ESS}, n-N_{HTDLTF}} \Upsilon_k HTLTF_k \cdot \exp(j2\pi k \Delta_F (t - T_{GI} - T_{CS}^{i_{ESS}})) \Big) \tag{20-26}$$

where

$T_{CS}^{i_{STS}}$	cyclic shift values are given in Table 20-9
$T_{CS}^{i_{ESS}}$	cyclic shift values are given in Table 20-9 with $i_{ESS} = i_{STS}$
Q_k	is defined in 20.3.11.10.1
Υ_k	is defined in Equation (20-5) and Equation (20-6)
P_{HTLTF}	the HT-LTF mapping matrix, is given by Equation (20-27)

$$P_{HTLTF} = \begin{bmatrix} 1 & -1 & 1 & 1 \\ 1 & 1 & -1 & 1 \\ 1 & 1 & 1 & -1 \\ -1 & 1 & 1 & 1 \end{bmatrix} \tag{20-27}$$

20.3.9.5 HT-greenfield format preamble

For HT-greenfield operation, compatibility with Clause 17 and Clause 19 STAs is not required. Therefore, the portions of the preamble that are compatible with Clause 17 and Clause 19 STAs are not included. The result is a shorter and more efficient PLCP frame format that includes a STF, LTF(s), and an HT-SIG.

20.3.9.5.1 Cyclic shift definition for HT-greenfield format preamble

Throughout the HT-greenfield format preamble, cyclic shift is applied to prevent beamforming when similar signals are transmitted on different spatial streams. The same cyclic shift is applied to these streams during the transmission of the data portion of the frame. The values of the cyclic shift to be used during the HT-greenfield format preamble, as well as the data portion of the HT-greenfield format frame, are specified in Table 20-9.

20.3.9.5.2 HT-GF-STF definition

The HT-GF-STF is placed at the beginning of an HT-greenfield format frame. The time domain waveform for the HT-GF-STF on transmit chain i_{TX} shall be as shown in Equation (20-28).

$$r_{HT-GF-STF}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-GF-STF}^{Tone}}} w_{T_{HT-GF-STF}}(t) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} [P_{HTLTF}]_{i_{STS}, 1} \Upsilon_k S_k \exp(j2\pi k \Delta_F (t - T_{CS}^{i_{STS}})) \tag{20-28}$$

where

$T_{CS}^{i_{STS}}$	represents the cyclic shift for the space-time stream i_{STS} and takes values from Table 20-9
Q_k	is defined in 20.3.11.10.1
P_{HTLTF}	is defined in Equation (20-27)
S_k	is defined in non-HT-STF (L-STF), Equation (20-8) for 20 MHz operation and Equation (20-9) for 40 MHz operation
Υ_k	is defined in Equation (20-5) and Equation (20-6)

The waveform defined by Equation (20-28) has a period of 0.8 μs, and the HT-GF-STF includes ten such periods, with a total duration of $T_{HT-GF-STF}$ = 8 μs.

20.3.9.5.3 HT-greenfield format HT-SIG

The content and format of the HT-SIG of an HT-greenfield format frame is identical to the HT-SIG in an HT-mixed format frame, as described in 20.3.9.4.3. The placement of the HT-SIG in an HT-greenfield format frame is shown in Figure 20-1. In HT-greenfield format frames, the HT-SIG is transmitted with the same cyclic shifts and the same spatial mapping as the preceding portions of the preamble. This use of the same cyclic shifts and spatial mapping is done to accommodate the estimation of channel parameters needed to robustly demodulate and decode the information contained in the HT-SIG.

The time domain waveform for the HT-SIG on transmit chain i_{TX} with 20 MHz operation shall be as shown in Equation (20-29).

$$r_{HT-SIG}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-SIG}^{Tone}}} \sum_{n=0}^{1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} [P_{HTLTF}]_{i_{STS}, 1} (jD_{k,n} + p_n P_k) \cdot \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \tag{20-29}$$

where

P_k and p_n are defined in 17.3.5.9

$D_{k,n}$ is defined in 20.3.9.4.3

$T_{CS}^{i_{STS}}$ represents the cyclic shift for space-time stream i_{STS} and takes values from Table 20-9

Q_k is defined in 20.3.11.10.1

P_{HTLTF} is defined in Equation (20-27)

The time domain waveform for the HT-SIG on transmit chain i_{TX} with 40 MHz operation shall be as shown in Equation (20-30).

$$\begin{aligned} r_{HT-SIG}^{i_{TX}}(t) &= \frac{1}{\sqrt{N_{STS} \cdot N_{HT-SIG}^{Tone}}} \sum_{n=0}^{1} w_{T_{SYM}}(t - nT_{SYM}) \\ &\cdot \sum_{k=-26}^{26} \sum_{i_{STS}=1}^{N_{STS}} [P_{HTLTF}]_{i_{STS},1}(jD_{k,n} + p_n P_k) \\ &\cdot ([Q_{k-32}]_{i_{TX},i_{STS}} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \\ &+ j[Q_{k+32}]_{i_{TX},i_{STS}} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))) \end{aligned} \tag{20-30}$$

where

p_n and P_k are defined in 17.3.5.9

$D_{k,n}$ is defined in 20.3.9.4.3

$T_{CS}^{i_{STS}}$ represents the cyclic shift for space-time stream i_{STS} and takes values from Table 20-9

Q_k is defined in 20.3.11.10.1

P_{HTLTF} is defined in Equation (20-27)

20.3.9.5.4 HT-greenfield format LTF

The format of the LTF portion of the preamble in an HT-greenfield format frame is similar to that of the HT-LTF in an HT-mixed format frame, as described in 20.3.9.4.6, with the difference that the first HT-LTF (HT-LTF1) is twice as long (8 µs) as the other HT-LTFs. The time domain waveform for the long training symbol on transmit chain i_{TX} for the first HT-LTF in an HT-greenfield format frame shall be as shown in Equation (20-31).

$$r_{HT-LTF}^{1,i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-LTF}^{Tone}}} w_{T_{HT-LTF1}}(t)$$
$$\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} [P_{HTLTF}]_{i_{STS},1} \Upsilon_k HTLTF(k) \exp(j2\pi k\Delta_F(t - T_{GI2} - T_{CS}^{i_{STS}})) \tag{20-31}$$

where

$T_{CS}^{i_{STS}}$ represents the cyclic shift for space-time stream i_{STS} and takes values from Table 20-9

Q_k is defined in 20.3.11.10.1

P_{HTLTF} is defined in Equation (20-27)

The first HT-LTF (HT-LTF1) consists of two periods of the long training symbol, preceded by a double-length (1.6 μs) cyclic prefix. The placement of the first and subsequent HT-LTFs in an HT-greenfield format frame is shown in Figure 20-1.

20.3.10 Transmission of NON_HT format PPDUs with more than one antenna

When an HT device transmits a NON_HT format PPDU with the MODULATION parameter set to OFDM or ERP-OFDM using more than one transmit chain, it shall apply the cyclic shifts defined in Table 20-8 to the transmission in each chain.

20.3.11 Data field

When BCC encoding is used, the Data field consists of the 16-bit SERVICE field, the PSDU, either six or twelve tail bits, depending on whether one or two encoding streams are represented, and pad bits. When LDPC encoding is used, the Data field consists of the 16-bit SERVICE field and the PSDU, processed by the procedure in 20.3.11.6.5.

The number of OFDM symbols in the data field when BCC encoding is used is computed as shown in Equation (20-32).

$$N_{SYM} = m_{STBC} \left\lceil \frac{8 \cdot length + 16 + 6 \cdot N_{ES}}{m_{STBC} \cdot N_{DBPS}} \right\rceil \tag{20-32}$$

where

m_{STBC} is 2 if STBC is used and 1 otherwise (making sure that the number of symbols is even when STBC is used)

$length$ is the value of the HT Length field in the HT-SIG field defined in Table 20-10

N_{DBPS} can take the values defined in Table 20-29 through Table 20-43

$\lceil x \rceil$ denotes the smallest integer greater than or equal to x

The number of "zero" pad bits is thus $N_{SYM} \times N_{DBPS} - 8 \times length - 16 - 6 \times N_{ES}$. The number of symbols in the data field when LDPC encoding is used is described in 20.3.11.6.

For LDPC encoding, the number of encoded data bits, N_{avbits}, is given by Equation (20-39); the number of OFDM symbols, N_{SYM}, is given by Equation (20-41); and the number of repeated encoded bits for padding, N_{rep}, is given by Equation (20-42), in 20.3.11.6.5.

20.3.11.1 SERVICE field

The SERVICE field is used for scrambler initialization. The SERVICE field is composed of 16 bits, all set to 0 before scrambling. In non-HT PPDUs, the SERVICE field is the same as in 17.3.5.1. In HT PPDUs, the SERVICE field is composed of 16 zero bits, scrambled by the scrambler, as defined in 20.3.11.2.

20.3.11.2 Scrambler

The data field shall be scrambled by the scrambler defined in 17.3.5.4 and initialized with a pseudo-random nonzero seed.

20.3.11.3 Coding

The Data field shall be encoded using either the BCC defined in 17.3.5.5 or the LDPC code defined in 20.3.11.6. The encoder is selected by the FEC coding field in the HT-SIG, as described in 20.3.9.4.3. A single FEC encoder is always used when LDPC coding is used. When the BCC FEC encoder is used, a single encoder is used, except that two encoders shall be used when the selected MCS has a PHY rate greater than 300 Mb/s. To determine whether to use one or two BCC FEC encoders, the rate is calculated based on the use of an 800 ns GI. The operation of the BCC FEC is described in 20.3.11.5. The operation of the LDPC coder is described in 20.3.11.6.

Support for the reception of BCC-encoded Data field frames is mandatory.

20.3.11.4 Encoder parsing operation for two BCC FEC encoders

If two BCC encoders are used, the scrambled data bits are divided between the encoders by sending alternating bits to different encoders. Bit with index i sent to the encoder j, denoted $x_i^{(j)}$, is shown in Equation (20-33).

$$x_i^{(j)} = b_{N_{ES} \cdot i + j} \qquad ; \qquad 0 \le j \le N_{ES} - 1 \tag{20-33}$$

Following the parsing operation, 6 scrambled “zero” bits following the end of the message bits in each BCC input sequence are replaced by unscrambled “zero” bits, as described in 17.3.5.2.

The replaced bits are shown in Equation (20-34).

$$x_i^{(j)} \quad : \quad 0 \le j \le N_{ES} - 1 \quad ; \quad \frac{length \cdot 8 + 16}{N_{ES}} \le i \le \frac{length \cdot 8 + 16}{N_{ES}} + 5 \tag{20-34}$$

20.3.11.5 Binary convolutional coding and puncturing

When BCC encoding is used, the encoder parser output sequences $\{x_i^0\}$, and $\{x_i^1\}$ where applicable, are each encoded by the rate 1/2 convolutional encoder defined in 17.3.5.5. After encoding, the encoded data shall be punctured by the method defined in 17.3.5.6 to achieve the rate selected by the MCS.

If rate 5/6 coding is selected, the puncturing scheme is defined in Figure 20-11.

Figure 20-11—Puncturing at rate 5/6

20.3.11.6 LDPC codes

20.3.11.6.1 Introduction

HT LDPC codes are described in 20.3.11.6.2 through 20.3.11.6.6. These codes are optionally used in the HT system as a high-performance error correcting code instead of the convolutional code (20.3.11.5). The LDPC encoder shall use the rate-dependent parameters in Table 20-29 through Table 20-43, with the exception of the N_{ES} parameter.

Support for LDPC codes is optional.

20.3.11.6.2 LDPC coding rates and codeword block lengths

The supported coding rates, information block lengths, and codeword block lengths are described in Table 20-14.

Table 20-14—LDPC parameters

Coding rate (R)	LDPC information block length (bits)	LDPC codeword block length (bits)
1/2	972	1944
1/2	648	1296
1/2	324	648
2/3	1296	1944
2/3	864	1296
2/3	432	648
3/4	1458	1944
3/4	972	1296
3/4	486	648
5/6	1620	1944
5/6	1080	1296
5/6	540	648

20.3.11.6.3 LDPC encoder

For each of the three available codeword block lengths, the LDPC encoder supports rate 1/2, rate 2/3, rate 3/4, and rate 5/6 encoding. The LDPC encoder is systematic, i.e., it encodes an information block, c=(i_0,i_1,..., $i_{(k-1)}$), of size k, into a codeword, **c,** of size n, **c**=(i_0,i_1,... $i_{(k-1)}$, p_0, p_1,..., $p_{(n-k-1)}$), by adding $n-k$ parity bits obtained so that $\mathbf{H}\times\mathbf{c}^T = \mathbf{0}$, where **H** is an $(n-k)\times n$ parity-check matrix. The selection of the codeword block length (n) is achieved via the LDPC PPDU encoding process described in 20.3.11.6.5.

20.3.11.6.4 Parity-check matrices

Each of the parity-check matrices can be partitioned into square subblocks (submatrices) of size $Z \times Z$. These submatrices are either cyclic-permutations of the identity matrix or null submatrices.

The cyclic-permutation matrix P_i is obtained from the $Z \times Z$ identity matrix by cyclically shifting the columns to the right by i elements. The matrix P_0 is the $Z \times Z$ identity matrix. Figure 20-12 illustrates examples (for a subblock size of 8 × 8) of cyclic-permutation matrices P_i.

$$P_0 = \begin{bmatrix} 1&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0\\ 0&0&1&0&0&0&0&0\\ 0&0&0&1&0&0&0&0\\ 0&0&0&0&1&0&0&0\\ 0&0&0&0&0&1&0&0\\ 0&0&0&0&0&0&1&0\\ 0&0&0&0&0&0&0&1 \end{bmatrix}, P_1 = \begin{bmatrix} 0&1&0&0&0&0&0&0\\ 0&0&1&0&0&0&0&0\\ 0&0&0&1&0&0&0&0\\ 0&0&0&0&1&0&0&0\\ 0&0&0&0&0&1&0&0\\ 0&0&0&0&0&0&1&0\\ 0&0&0&0&0&0&0&1\\ 1&0&0&0&0&0&0&0 \end{bmatrix}, P_5 = \begin{bmatrix} 0&0&0&0&0&1&0&0\\ 0&0&0&0&0&0&1&0\\ 0&0&0&0&0&0&0&1\\ 1&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0\\ 0&0&1&0&0&0&0&0\\ 0&0&0&1&0&0&0&0\\ 0&0&0&0&1&0&0&0 \end{bmatrix}$$

Figure 20-12—Examples of cyclic-permutation matrices with Z=8

Table R.1 displays the “matrix prototypes” of parity-check matrices for all four coding rates at block length n=648 bits. The integer i denotes the cyclic-permutation matrix P_i, as illustrated in Figure 20-12. Vacant entries of the table denote null (zero) submatrices.

Table R.2 displays the matrix prototypes of parity-check matrices for block length n=1296 bits, in the same fashion.

Table R.3 displays the matrix prototypes of parity-check matrices for block length n=1944 bits, in the same fashion.

20.3.11.6.5 LDPC PPDU encoding process

To encode an LDPC PPDU, step a) through step g) shall be performed in sequence.

a) Compute the number of available bits, N_{avbits}, in the minimum number of OFDM symbols in which the Data field of the packet may fit.

$$N_{pld} = length \times 8 + 16 \tag{20-35}$$

$$N_{avbits} = N_{CBPS} \times m_{STBC} \times \left\lceil \frac{N_{pld}}{N_{CBPS} \times R \times m_{STBC}} \right\rceil \tag{20-36}$$

where

m_{STBC} is 2 if STBC is used and 1 otherwise

length is the value of the HT Length field in the HT-SIG field defined in Table 20-10

$\lceil x \rceil$ denotes the smallest integer greater than or equal to x

N_{pld} is the number of bits in the PSDU and SERVICE field

b) Compute the integer number of LDPC codewords to be transmitted, N_{CW}, and the length of the codewords to be used, L_{LDPC} from Table 20-15.

Table 20-15—PPDU encoding parameters

Range of N_{avbits} (bits)	Number of LDPC codewords (N_{CW})	LDPC codeword length L_{LDPC} (bits)
$N_{avbits} \le 648$	1	1296, if $N_{avbits} \ge N_{pld} + 912 \times (1-R)$ 648, otherwise
$648 < N_{avbits} \le 1296$	1	1944, if $N_{avbits} \ge N_{pld} + 1464 \times (1-R)$ 1296, otherwise
$1296 < N_{avbits} \le 1944$	1	1944
$1944 < N_{avbits} \le 2592$	2	1944, if $N_{avbits} \ge N_{pld} + 2916 \times (1-R)$ 1296, otherwise
$2592 < N_{avbits}$	$\left\lceil \frac{N_{pld}}{1944 \cdot R} \right\rceil$	1944

c) Compute the number of shortening bits, N_{shrt}, to be padded to the N_{pld} data bits before encoding, as shown in Equation (20-37).

$$N_{shrt} = \max(0, (N_{CW} \times L_{LDPC} \times R) - N_{pld}) \tag{20-37}$$

When $N_{shrt} = 0$, shortening is not performed. (Note that N_{shrt} is inherently restricted to be non-negative due to the codeword length and count selection of 20-15). When $N_{shrt} > 0$, shortening bits shall be equally distributed over all N_{CW} codewords with the first $\mathrm{rem}(N_{shrt}, N_{CW})$ codewords shortened 1 bit more than the remaining codewords. Define $N_{spcw} = \lfloor N_{shrt}/N_{CW} \rfloor$. Then, when $N_{shrt} > 0$, the shortening is performed by setting information bits $i_{k-N_{spcw}-1}, \ldots, i_{k-1}$ to 0 in the first $\mathrm{rem}(N_{shrt}, N_{CW})$ codewords and setting information bits $i_{k-N_{spcw}}, \ldots, i_{k-1}$ to 0 in the remaining codewords. For all values of N_{shrt}, encode each of the N_{CW} codewords using the LDPC encoding technique described in 20.3.11.6.2 through 20.3.11.6.4. When $N_{shrt} > 0$, the shortened bits shall be discarded after encoding.

d) Compute the number of bits to be punctured, N_{punc}, from the codewords after encoding, as shown in Equation (20-38).

$$N_{punc} = \max(0, (N_{CW} \times L_{LDPC}) - N_{avbits} - N_{shrt}) \tag{20-38}$$

If $\left((N_{punc} > 0.1 \times N_{CW} \times L_{LDPC} \times (1-R)) \text{ AND} \left(N_{shrt} < 1.2 \times N_{punc} \times \frac{R}{1-R}\right)\right)$ is true OR if $(N_{punc} > 0.3 \times N_{CW} \times L_{LDPC} \times (1-R))$ is true, increment N_{avbits} and recompute N_{punc} by the following two equations once:

$$N_{avbits} = N_{avbits} + N_{CBPS} \times m_{STBC} \tag{20-39}$$

$$N_{punc} = \max(0, (N_{CW} \times L_{LDPC}) - N_{avbits} - N_{shrt}) \tag{20-40}$$

The punctured bits shall be equally distributed over all N_{CW} codewords with the first $\mathrm{rem}(N_{punc}, N_{CW})$ codewords punctured 1 bit more than the remaining codewords. Define $N_{\mathrm{ppcw}} = \lfloor N_{\mathrm{punc}}/N_{\mathrm{CW}} \rfloor$. When $N_{\mathrm{ppcw}} > 0$, the puncturing is performed by discarding parity bits $p_{n-k-N_{ppcw}-1}, \ldots, p_{n-k-1}$ of the first $\mathrm{rem}(N_{punc}, N_{CW})$ codewords and discarding parity bits $(p_{n-k-N_{ppcw}}, \ldots, p_{n-k-1})$ of the remaining codewords after encoding. The number of OFDM symbols to be transmitted in the PPDU is computed as shown in Equation (20-41).

$$N_{SYM} = N_{avbits} / N_{CBPS} \tag{20-41}$$

e) Compute the number of coded bits to be repeated, N_{rep}, as shown in Equation (20-42).

$$N_{rep} = \max(0, N_{avbits} - N_{CW} \times L_{LDPC} \times (1-R) - N_{pld}) \tag{20-42}$$

The number of coded bits to be repeated shall be equally distributed over all N_{CW} codewords with one more bit repeated for the first $\mathrm{rem}(N_{rep}, N_{CW})$ codewords than for the remaining codewords.

NOTE—When puncturing occurs, the coded bits are not repeated, and vice versa.

The coded bits to be repeated for any codeword shall be copied only from that codeword itself, starting from information bit i_0 and continuing sequentially through the information bits and, when necessary, into the parity bits, until the required number of repeated bits is obtained for that codeword. Note that these repeated bits are copied from the codeword after the shortening bits have been removed. If for a codeword the required number of repeated bits cannot be obtained in this manner (i.e., repeating the codeword once), the procedure is repeated until the required number is achieved. These repeated bits are then concatenated to the codeword after the parity bits in their same order. This process is illustrated in Figure 20-13. In this figure, the outlined arrows indicate the encoding procedure steps, while the solid arrows indicate the direction of puncturing and padding with repeated bits.

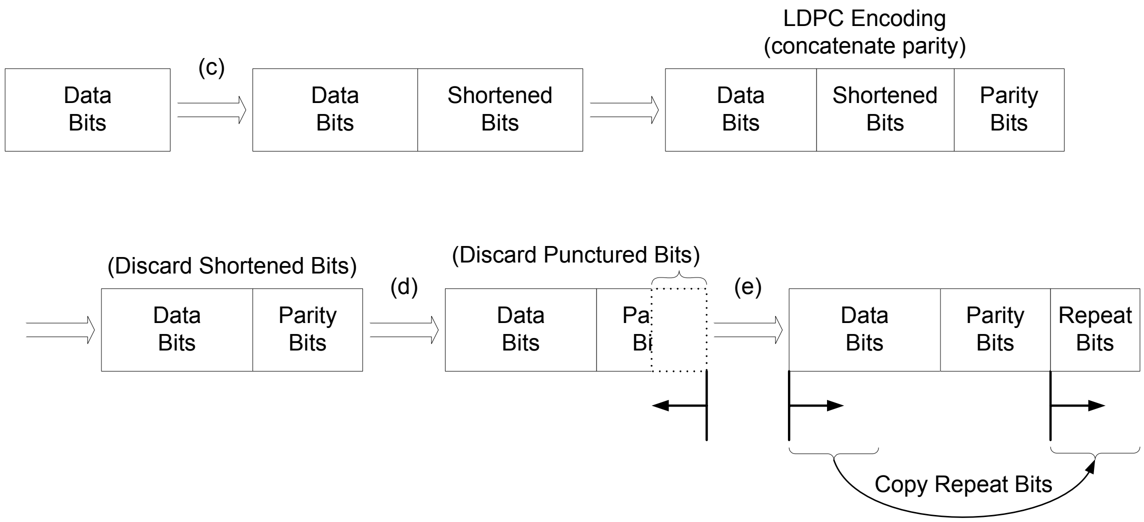


Figure 20-13—LDPC PPDU encoding padding and puncturing of a single codeword

f) For each of the N_{CW} codewords, process the data using the number of shortening bits per codeword as computed in step c) for encoding, and puncture or repeat bits per codeword as computed per step d) and step e), as illustrated in Figure 20-13.

g) Aggregate all codewords and parse as defined in 20.3.11.6.6.

20.3.11.6.6 LDPC parser

The succession of LDPC codewords that result from the encoding process of 20.3.11.6.5 shall be converted into a bitstream in sequential fashion. Within each codeword, bit i_0 is ordered first. The parsing of this encoded data stream into spatial streams shall follow exactly the parsing rules defined for the BCC encoder, as defined in 20.3.11.7.1. However, the frequency interleaver of 20.3.11.7.3 is bypassed.

20.3.11.7 Data interleaver

20.3.11.7.1 Overview

After coding and puncturing, the data bit streams at the output of the FEC encoders are rearranged into blocks of $N_{CBPSS}(i_{SS})$ bits, where $i_{SS} = 1, 2, \ldots N_{SS}$ is the spatial stream index. This operation is referred to as *stream parsing* and is described in 20.3.11.7.2. If BCC encoding was used, each of these blocks is then interleaved by an interleaver that is a modification of the Clause 17 interleaver.

20.3.11.7.2 Stream parser

The number of bits assigned to a single axis (real or imaginary) in a constellation point in spatial stream i_{SS} is denoted by Equation (20-43).

$$s(i_{SS}) = \max\left\{1, \frac{N_{BPSCS}(i_{SS})}{2}\right\} \tag{20-43}$$

The sum of these over all streams is $S = \sum_{i_{SS}=1}^{N_{SS}} s(i_{SS})$.

NOTE—If equal MCS is used for all spatial streams, this sum becomes $N_{SS} \cdot s$, where s is the number of bits for an axis common to all streams.

Consecutive blocks of $s(i_{SS})$ bits are assigned to different spatial streams in a round robin fashion.

If two encoders are present, the output of each encoder is used alternately for each round robin cycle, i.e., at the beginning S bits from the output of first encoder are fed into all spatial streams, and then S bits from the output of second encoder are used, and so on.

Input k to spatial stream i_{SS} shall be $y_i^{(j)}$, which is output bit i of the encoder j,

where

$$j = \left\lfloor \frac{k}{s(i_{SS})} \right\rfloor \bmod N_{ES} \tag{20-44}$$

$$i = \sum_{i'=1}^{i_{SS}-1} s(i') + S \cdot \left\lfloor \frac{k}{N_{ES} \cdot s(i_{SS})} \right\rfloor + k \bmod s(i_{SS}) \tag{20-45}$$

$1 \le i_{SS} \le N_{SS}$

$\lfloor x \rfloor$ is the largest integer less than or equal to x

$z \bmod t$ is the remainder resulting from the division of integer z by integer t

For $i_{SS} = 1$, the first term in Equation (20-45) has a value of 0.

20.3.11.7.3 Frequency interleaver

MCS 32 interleaving shall be as defined in 17.3.5.6. Interleaving for all other MCSs is defined in this subclause.

The bits at the output of the stream parser are divided into blocks of $N_{CBPSS}(i_{SS})$, $i_{SS} = 1, 2, \ldots N_{SS}$ bits; and if BCC encoding was used, each block shall be interleaved by an interleaver based on the Clause 17 interleaver. This interleaver, which is based on entering the data in rows and reading them out in columns, has a different number of columns and rows depending on whether a 20 MHz channel or a 40 MHz channel is used. Table 20-16 defines the interleaver parameters. If LDPC encoding was used, no frequency interleaving is performed; hence the parsed streams are immediately mapped to symbols as defined in 20.3.11.8.

Table 20-16—Number of rows and columns in the interleaver

Parameter	20 MHz	40 MHz
N_{COL}	13	18
N_{ROW}	$4 \times N_{BPSCS}(i_{SS})$	$6 \times N_{BPSCS}(i_{SS})$
N_{ROT}	11	29

If more than one spatial stream exists after the operations based on the Clause 17 interleaver have been applied, a third operation called *frequency rotation* shall be applied to the additional spatial streams. The parameter for the frequency rotation is N_{ROT}.

The interleaving is defined using three permutations. The first permutation is defined by the rule shown in Equation (20-46).

$$i = N_{ROW}(k \bmod N_{COL}) + \mathrm{floor}(k/N_{COL}) \qquad k = 0, 1, \ldots, N_{CBPSS}(i_{SS}) - 1 \tag{20-46}$$

The second permutation is defined by the rule shown in Equation (20-47).

$$\begin{aligned} j &= s(i_{SS}) \times \mathrm{floor}(i/s(i_{SS})) + (i + N_{CBPSS}(i_{SS}) - \mathrm{floor}(N_{COL} \times i/N_{CBPSS}(i_{SS}))) \bmod s(i_{SS}); \\ i &= 0, 1, \ldots, N_{CBPSS}(i_{SS}) - 1 \end{aligned} \tag{20-47}$$

The value of $s(i_{SS})$ is determined by the number of coded bits per subcarrier as shown in Equation (20-48).

$$s(i_{SS}) = \max(N_{BPSCS}(i_{SS})/2, 1) \tag{20-48}$$

If more than one spatial stream exists, a frequency rotation is applied to the output of the second permutation as shown in Equation (20-49).

$$\begin{aligned} r &= \left(j - \left(((i_{SS} - 1) \times 2) \bmod 3 + 3 \times \mathrm{floor}\left(\frac{i_{SS} - 1}{3}\right)\right) \times N_{ROT} \times N_{BPSCS}(i_{SS})\right) \bmod N_{CBPSS}(i_{SS}); \\ j &= 0, 1, \ldots, N_{CBPSS}(i_{SS}) - 1 \end{aligned} \tag{20-49}$$

where

$i_{SS} = 1, 2, \ldots, N_{SS}$ is the index of the spatial stream on which this interleaver is operating

The deinterleaver uses the following operations to perform the inverse rotation. The index of the bit in the received block (per spatial stream) is denoted by *r*. The first permutation reverses the third (frequency rotation) permutation of the interleaver as shown in Equation (20-50).

$$\begin{aligned} j &= \left(r + \left(((i_{SS} - 1) \times 2) \bmod 3 + 3 \times \mathrm{floor}\left(\frac{i_{SS} - 1}{3}\right)\right) \times N_{ROT} \times N_{BPSCS}(i_{SS})\right) \bmod N_{CBPSS}(i_{SS}); \\ r &= 0, 1, \ldots, N_{CBPSS}(i_{SS}) - 1 \end{aligned} \tag{20-50}$$

The second permutation reverses the second permutation in the interleaver as shown in Equation (20-51).

$$\begin{aligned} i &= s(i_{SS}) \times \mathrm{floor}(j/s(i_{SS})) + (j + \mathrm{floor}(N_{COL} \times j/N_{CBPSS}(i_{SS}))) \bmod s(i_{SS}); \\ j &= 0, 1, \ldots, N_{CBPSS}(i_{SS}) - 1 \end{aligned} \tag{20-51}$$

where $s(i_{SS})$ is defined in Equation (20-48).

The third permutation reverses the first permutation of the interleaver as shown in Equation (20-52).

$$k = N_{COL} \times i - (N_{CBPSS}(i_{SS}) - 1) \times \mathrm{floor}(i/N_{ROW}) \qquad i = 0, 1, \ldots, N_{CBPSS}(i_{SS}) - 1 \tag{20-52}$$

20.3.11.8 Constellation mapping

The mapping between bits at the output of the interleaver and complex constellation points for BPSK, QPSK, 16-QAM, and 64-QAM follows the rules defined in 17.3.5.7.

The streams of complex numbers are denoted as shown in Equation (20-53).

$$d_{k,l,n}, 0 \le k \le N_{SD} - 1; 1 \le l \le N_{SS}; 0 \le n \le N_{SYM} - 1 \quad (20\text{-}53)$$

20.3.11.8.1 Space-time block coding (STBC)

This subclause defines a set of optional robust transmission formats that are applicable only when N_{STS} is greater than N_{SS}. In this case, N_{SS} spatial streams are mapped to N_{STS} space-time streams, which are mapped to N_{TX} transmit chains. These formats are based on STBC. When the use of STBC is indicated in the STBC field of the HT-SIG, a symbol operation shall occur between the constellation mapper and the spatial mapper (see Figure 20-3) as defined in this subclause.

If STBC is applied, the stream of complex numbers, $d_{k,i,n}; k = 0 \ldots N_{SD} - 1; i = 1 \ldots N_{SS}; n = 0 \ldots N_{SYM} - 1$, generated by the constellation mapper, is the input of the STBC encoder, which produces as output the stream of complex numbers $\tilde{d}_{k,i,n}; k = 0 \ldots N_{SD} - 1; i = 1 \ldots N_{STS}; n = 0 \ldots N_{SYM} - 1$. For given values of k and i, STBC processing operates on the complex modulation symbols in sequential pairs of OFDM symbols so that the value of $\tilde{d}_{k,i,2m}$ depends on $d_{k,i,2m}$ and $d_{k,i,2m+1}$, and $\tilde{d}_{k,i,2m+1}$ also depends on $d_{k,i,2m}$ and $d_{k,i,2m+1}$, as defined in Table 20-17.

Table 20-17—Constellation mapper output to spatial mapper input for STBC

N_{STS}	HT-SIG MCS field (bits 0–6 in HT-SIG$_1$)	N_{SS}	HT-SIG STBC field (bits 4–5 in HT-SIG$_2$)	i_{STS}	$\tilde{d}_{k,i,2m}$	$\tilde{d}_{k,i,2m+1}$
2	0–7	1	1	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
				2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
3	8–15, 33–38	2	1	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
				2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
				3	$d_{k,2,2m}$	$d_{k,2,2m+1}$
4	8–15	2	2	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
				2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
				3	$d_{k,2,2m}$	$d_{k,2,2m+1}$
				4	$-d^*_{k,2,2m+1}$	$d^*_{k,2,2m}$
4	16–23, 39, 41, 43, 46, 48, 50	3	1	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
				2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
				3	$d_{k,2,2m}$	$d_{k,2,2m+1}$
				4	$d_{k,3,2m}$	$d_{k,3,2m+1}$

If STBC is not applied, $\tilde{d}_{k,i,n} = d_{k,i,n}$ and $N_{SS} = N_{STS}$.

NOTE 1—The specific STBC schemes for single spatial streams ($N_{SS} = 1$) with $N_{TX} \geq 3$ are not detailed in this subclause since they can be covered through the use of spatial expansion as detailed in 20.3.11.10.1.

NOTE 2—STBC is applied only for the HT-SIG MCS field values specified in Table 20-17 and is not used with MCS 32.

20.3.11.9 Pilot subcarriers

For a 20 MHz transmission, four pilot tones shall be inserted in the same subcarriers used in Clause 17, i.e., in subcarriers –21, –7, 7, and 21. The pilot sequence for the n^{th} symbols and $i_{STS}{}^{\text{th}}$ space-time stream shall be as shown in Equation (20-54).

$$\begin{aligned} P^{-28,28}_{(i_{STS},n)} = \Big\{ & 0,0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},n\oplus 4},0,0,0,0,0,0,0,0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},(n+1)\oplus 4},0,0,0,0,0,0,0, \\ & 0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},(n+2)\oplus 4},0,0,0,0,0,0,0,0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},(n+3)\oplus 4},0,0,0,0,0,0,0 \Big\} \end{aligned} \quad (20\text{-}54)$$

For a 40 MHz transmission (excluding MCS 32; see 20.3.11.10.4), pilot signals shall be inserted in subcarriers –53, –25, –11, 11, 25, and 53. The pilot sequence for symbol n and space-time stream i_{STS} shall be as shown in Equation (20-55).

$$\begin{aligned} P^{-58,58}_{(i_{STS},n)} = \Big\{ & 0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},n\oplus 6},0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0, \\ & 0,0,\Psi^{(N_{STS})}_{i_{STS},(n+1)\oplus 6},0,0,0,0,0,0,0,0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},(n+2)\oplus 6},0,0,0,0,0,0,0,0,0, \\ & 0,0,0,0,0,0,0,0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},(n+3)\oplus 6},0,0,0,0,0,0,0,0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},(n+4)\oplus 6}, \\ & 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,\Psi^{(N_{STS})}_{i_{STS},(n+5)\oplus 6},0,0,0,0,0 \Big\} \end{aligned} \quad (20\text{-}55)$$

where $n \oplus a$ indicates symbol number modulo integer a and the patterns $\Psi^{(N_{STS})}_{i_{STS},n}$ are defined in Table 20-18 and Table 20-19.

NOTE—For each space-time stream, there is a different pilot pattern, and the pilot patterns are cyclically rotated over symbols.

The basic patterns are also different according to the total number of space-time streams for the packet.

Table 20-18—Pilot values for 20 MHz transmission

N_{STS}	i_{STS}	$\Psi^{(N_{STS})}_{i_{STS},0}$	$\Psi^{(N_{STS})}_{i_{STS},1}$	$\Psi^{(N_{STS})}_{i_{STS},2}$	$\Psi^{(N_{STS})}_{i_{STS},3}$
1	1	1	1	1	–1
2	1	1	1	–1	–1
2	2	1	–1	–1	1
3	1	1	1	–1	–1
3	2	1	–1	1	–1

Table 20-18—Pilot values for 20 MHz transmission *(continued)*

N_{STS}	i_{STS}	$\Psi^{(N_{STS})}_{i_{STS},0}$	$\Psi^{(N_{STS})}_{i_{STS},1}$	$\Psi^{(N_{STS})}_{i_{STS},2}$	$\Psi^{(N_{STS})}_{i_{STS},3}$
3	3	–1	1	1	–1
4	1	1	1	1	–1
4	2	1	1	–1	1
4	3	1	–1	1	1
4	4	–1	1	1	1

Table 20-19—Pilots values for 40 MHz transmission (excluding MCS 32)

N_{STS}	i_{STS}	$\Psi^{(N_{STS})}_{i_{STS},0}$	$\Psi^{(N_{STS})}_{i_{STS},1}$	$\Psi^{(N_{STS})}_{i_{STS},2}$	$\Psi^{(N_{STS})}_{i_{STS},3}$	$\Psi^{(N_{STS})}_{i_{STS},4}$	$\Psi^{(N_{STS})}_{i_{STS},5}$
1	1	1	1	1	–1	–1	1
2	1	1	1	–1	–1	–1	–1
2	2	1	1	1	–1	1	1
3	1	1	1	–1	–1	–1	–1
3	2	1	1	1	–1	1	1
3	3	1	–1	1	–1	–1	1
4	1	1	1	–1	–1	–1	–1
4	2	1	1	1	–1	1	1
4	3	1	–1	1	–1	–1	1
4	4	–1	1	1	1	–1	1

20.3.11.10 OFDM modulation

The time domain signal is composed from the stream of complex numbers as shown in Equation (20-56)

$$\tilde{d}_{k,l,n},\ 0 \le k \le N_{SD} - 1; 1 \le l \le N_{STS}; 0 \le n \le N_{SYM} - 1 \tag{20-56}$$

and from the pilot signals. For a 40 MHz transmission, the upper subcarriers are rotated 90° relative to the lower subcarriers.

20.3.11.10.1 Spatial mapping

The transmitter may choose to rotate and/or scale the constellation mapper output vector (or the space-time block coder output, if applicable). This rotation and/or scaling is useful in the following cases:

— When there are more transmit chains than space-time streams, $N_{STS} < N_{TX}$

— As part of (an optional) sounding packet

— As part of (an optional) calibration procedure

— When the packet is transmitted using one of the (optional) beamforming techniques

If the data to be transmitted on subcarrier k on space-time stream i_{STS} are $X_k^{(i_{STS})}$, the transmitted data on the transmit chain i_{TX} shall be as shown in Equation (20-57).

$$r_{Field}^{(i_{TX})} = \frac{1}{\sqrt{N_{STS} \cdot N_{Field}^{Tone}}} w_{\mathrm{T}_{Field}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} X_k^{(i_{STS})} \exp(j2\pi k\Delta_F(t - T_{CS}^{i_{STS}})) \tag{20-57}$$

where

$[Q_k]_{i_{TX}, i_{STS}}$	is the element in row i_{TX} and column i_{STS} in a matrix Q_k with N_{TX} rows and N_{STS} columns; Q_k may be frequency dependent
Field	is any field, as defined in 20.3.7, excluding L-STF, L-LTF, L-SIG, and HT-SIG in HT_MF format PPDU

Below are examples of spatial mapping matrices that can be used. There exist many other alternatives; implementation is not restricted to the spatial mapping matrices shown.

a) *Direct mapping*: Q_k is a diagonal matrix of unit magnitude complex values that can take two forms:
   1) $Q_k = \mathbf{I}$, the identity matrix
   2) A CSD matrix in which the diagonal elements represent cyclic shifts in the time domain: $[Q_k]_{i,i} = \exp(-j2\pi k\Delta_F\tau_{CS}^i)$, where τ_{CS}^i, $i = 1, \ldots, N_{TX}$ represents the CSD applied.
b) *Indirect mapping:* Q_k may be the product of a CSD matrix and a square unitary matrix such as the Hadamard matrix or the Fourier matrix.
c) *Spatial expansion:* Q_k is the product of a CSD matrix and a square matrix formed of orthogonal columns. As an illustration:
   1) The spatial expansion may be performed by duplicating some of the N_{STS} streams to form the N_{TX} streams, with each stream being scaled by the normalization factor $\sqrt{N_{STS}/N_{TX}}$. The spatial expansion may be performed by using, for instance, one of the following matrices, denoted D, left-multiplied by a CSD matrix, denoted $M_{CSD}(k)$, and/or possibly multiplied by any square unitary matrix. The resulting spatial mapping matrix is then $Q_k = M_{CSD}(k) \cdot D$, where D may take on one of the following values:

      i) N_{TX}=2, N_{STS}=1, $D = \frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\end{bmatrix}^T$

      ii) N_{TX}=3, N_{STS}=1, $D = \frac{1}{\sqrt{3}}\begin{bmatrix}1 & 1 & 1\end{bmatrix}^T$

      iii) N_{TX}=4, N_{STS}=1, $D = \frac{1}{2}\begin{bmatrix}1 & 1 & 1 & 1\end{bmatrix}^T$

      iv) N_{TX}=3, N_{STS}=2, $D = \sqrt{\frac{2}{3}}\begin{bmatrix}1 & 0\\0 & 1\\1 & 0\end{bmatrix}$

      v) N_{TX}=4, N_{STS}=2, $D = \frac{1}{\sqrt{2}}\begin{bmatrix}1 & 0\\0 & 1\\1 & 0\\0 & 1\end{bmatrix}$

vi) N_{TX}=4, N_{STS}=3, $D = \frac{\sqrt{3}}{2}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$

2) Different spatial expansion over subcarriers should be used in HT-mixed format only and with the smoothing bit set to 0:

i) N_{TX}=2, N_{STS}=1, $[Q_k]_{N_{STS}} = \begin{bmatrix} 1 & 0 \end{bmatrix}^T$ or $[Q_k]_{N_{STS}} = \begin{bmatrix} 0 & 1 \end{bmatrix}^T$

ii) N_{TX}=3, N_{STS}=2, $[Q_k]_{N_{STS}} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}$ or $\begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}$

iii) N_{TX}=4, N_{STS}=2, $[Q_k]_{N_{STS}} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}$ or $\begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}$

iv) N_{TX}=4, N_{STS}=3, $[Q_k]_{N_{STS}} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ or $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

d) *Beamforming steering matrix:* Q_k is any matrix that improves the reception in the receiver based on some knowledge of the channel between the transmitter and the receiver. With transmit beamforming with explicit feedback, the steering matrix Q_k is determined using either H_{eff} for CSI feedback or V_k for noncompressed and compressed matrices feedback from the STA to which the beamformed packet is addressed.

When there are fewer space-time streams than transmit chains, the first N_{STS} columns of the matrices above that are square can be used.

The same matrix Q_k shall be applied to subcarrier *k* during all parts of the packet in HT-greenfield format and all parts of the packet following and including the HT-STF field in an HT-mixed format packet. This operation is transparent to the receiver.

If 95% of the sum of the energy from all impulse responses of the time domain channels between all space-time streams and all transmit chain inputs, induced by the CSD added according to Table 20-9 and the frequency-dependence in the matrix Q_k, is contained within 800 ns, the smoothing bit should be set to 1. Otherwise, it shall be set to 0.

The CSD of Table 20-9 shall be applied at the input of the spatial mapper.

For the identity matrix direct mapping, the smoothing bit should be set to 1.

If no spatial mapping is applied, the matrix Q_k is equal to the identity matrix and $N_{STS} = N_{TX}$.

Sounding PPDUs using spatial expansion shall use unitary Q_k.

20.3.11.10.2 Transmission in 20 MHz HT format

For 20 MHz HT transmissions, the signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ shall be as shown in Equation (20-58).

$$
\begin{aligned}
r_{HT-DATA}^{i_{TX}}(t) = {} & \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{\mathrm{T}_{SYM}}(t - nT_{SYM}) \\
& \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} ([Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k, i_{STS}, n} + p_{n+z} P_{(i_{STS}, n)}^{k})) \\
& \cdot \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))
\end{aligned} \tag{20-58}
$$

where

z is 3 in an HT-mixed format packet and 2 in an HT-greenfield format packet

p_n is defined in 17.3.5.9

$$
\tilde{D}_{k, i_{STS}, n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ \tilde{d}_{M^r(k), i_{STS}, n}, \text{ otherwise} \end{cases}
$$

$$
M^r(k) = \begin{cases} k + 28, -28 \le k \le -22 \\ k + 27, -20 \le k \le -8 \\ k + 26, -6 \le k \le -1 \\ k + 25, 1 \le k \le 6 \\ k + 24, 8 \le k \le 20 \\ k + 23, 22 \le k \le 28 \end{cases}
$$

$P_{(i_{STS}, n)}^{k}$ is defined in Equation (20-54)

20.3.11.10.3 Transmission in 40 MHz HT format

For 40 MHz HT transmissions, the signal from transmit chain i_{TX} shall be as shown in Equation (20-59).

$$
\begin{aligned}
r_{HT-DATA}^{i_{TX}}(t) = {} & \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{\mathrm{T}_{SYM}}(t - nT_{SYM}) \\
& \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} ([Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k, i_{STS}, n} + p_{n+z} P_{(i_{STS}, n)}^{k})) \Upsilon_k \\
& \cdot \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))
\end{aligned} \tag{20-59}
$$

where

z is 3 in an HT-mixed format packet and 2 in an HT-greenfield format packet

p_n is defined in 17.3.5.9

$$\tilde{D}_{k,i_{STS},n} = \begin{cases} 0, k = 0, \pm 1, \pm 11, \pm 25, \pm 53 \\ \tilde{d}_{M^r(k),i_{STS},n}, \text{ otherwise} \end{cases}$$

$$M^r(k) = \begin{cases} k+58, -58 \le k \le -54 \\ k+57, -52 \le k \le -26 \\ k+56, -24 \le k \le -12 \\ k+55, -10 \le k \le -2 \\ k+52, 2 \le k \le 10 \\ k+51, 12 \le k \le 24 \\ k+50, 26 \le k \le 52 \\ k+49, 54 \le k \le 58 \end{cases}$$

$P^k_{(i_{STS},n)}$ is defined in Equation (20-55)

NOTE—The 90º rotation that is applied to the upper part of the 40 MHz channel is applied in the same way to the HT-STF, HT-LTF, and HT-SIG. The rotation applies to both pilots and the data in the upper part of the 40 MHz channel.

20.3.11.10.4 Transmission in MCS 32 format

MCS 32 format provides the lowest transmission rate in 40 MHz. It is used only for one spatial stream and only with BPSK modulation and rate 1/2 coding.

In the MCS 32 format, the signal shall be as shown in Equation (20-60).

$$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{HT-Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \tag{20-60}$$
$$\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI}))$$
$$+ j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$$

where

z is defined in 20.3.11.10.2

P_k and p_n are defined in 17.3.5.9

$D_{k,n}$ is defined in 20.3.9.4.3

N_{SR} has the value defined for non-HT 20 MHz transmission

$[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent

$N_{HT-Duplicate}^{Tone}$ is defined in Table 20-7

The rules of spatial expansion CSD limitation, as specified in 20.3.11.10.1, shall apply to $[Q_k]_{i_{TX},1}$.

20.3.11.10.5 Transmission with a short GI

Short GI is used in the data field of the packet when the Short GI field in the HT-SIG is set to 1. When it is used, the same formula for the formation of the signal shall be used as in 20.3.11.10.2, 20.3.11.10.3, and 20.3.11.10.4, with T_{GI} replaced by T_{GIS} and T_{SYM} replaced by T_{SYMS}.

NOTE—Short GI is not used in HT-greenfield format with one spatial stream, in which case the HT-SIG is immediately followed by data. It is very difficult to parse the HT-SIG in time to demodulate these data with the correct GI length if the GI length is not known in advance.

20.3.11.11 Non-HT duplicate transmission

Non-HT duplicate transmission is used to transmit to Clause 17 STAs, Clause 19 STAs, and Clause 20 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG shall be transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission shall be as defined in Equation (20-61).

$$
\begin{aligned}
r_{LEG-DUP}^{i_{TX}}(t) = {} & \frac{1}{\sqrt{N_{HT-Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{\mathrm{T}_{SYM}}(t - nT_{SYM}) \\
& \cdot \sum_{k=-26}^{26} (D_{k,n} + p_{n+1}P_k)\left(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{TX}})\right) \\
& + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{TX}})))
\end{aligned}
\tag{20-61}
$$

where

P_k and p_n are defined in 17.3.5.9

$D_{k,n}$ is defined in 20.3.9.4.3

$T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table 20-8

$N_{HT-Duplicate}^{Tone}$ is defined in Table 20-7

20.3.12 Beamforming

Beamforming is a technique in which the beamformer utilizes the knowledge of the MIMO channel to generate a steering matrix Q_k that improves reception in the beamformee.

The equivalent complex baseband MIMO channel model is one in which, when a vector $\mathbf{x}_k = [x_1, x_2, \ldots x_{N_{TX}}]^T$ is transmitted in subcarrier k, the received vector $\mathbf{y}_k = [y_1, y_2, \ldots y_{N_{RX}}]^T$ is modeled as shown in Equation (20-62).

$$\mathbf{y}_k = H_k \mathbf{x}_k + \mathbf{n} \tag{20-62}$$

where

H_k is channel matrix of dimensions $N_{RX} \times N_{TX}$

n is white (spatially and temporally) Gaussian noise as illustrated in Figure 20-14

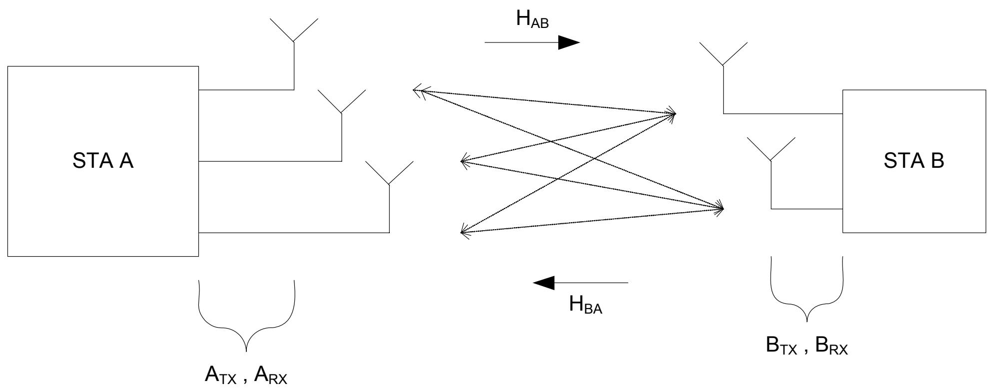


Figure 20-14—Beamforming MIMO channel model (3x2 example)

When beamforming is used, the beamformer replaces $\mathbf{x}_k$, which in this case has $N_{STS} \le N_{TX}$ elements, with $Q_k \mathbf{x}_k$, where Q_k has N_{TX} rows and N_{STS} columns, so that the received vector is as shown in Equation (20-63).

$$\mathbf{y}_k = H_k Q_k \mathbf{x}_k + \mathbf{n} \tag{20-63}$$

The beamforming steering matrix that is computed (or updated) from a new channel measurement replaces the existing Q_k for the next beamformed data transmission. There are several methods of beamforming, differing in the way the beamformer acquires the knowledge of the channel matrices H_k and on whether the beamformer generates Q_k or the beamformee provides feedback information for the beamformer to generate Q_k.

20.3.12.1 Implicit feedback beamforming

Implicit feedback beamforming is a technique that relies on reciprocity in the time division duplex channel to estimate the channel over which a device is transmitting based on the MIMO reference that is received from the device to which it plans to transmit. This technique allows the transmitting device to calculate a set of transmit steering matrices, Q_k, one for each subcarrier, which are intended to optimize the performance of the link.

Referring to Figure 20-14, beamforming transmissions from STA A to STA B using implicit techniques are enabled when STA B sends STA A a sounding PPDU, the reception of which allows STA A to form an estimate of the MIMO channel from STA B to STA A, for all subcarriers. For a TDD channel in which the forward and reverse channels are reciprocal, the channel from STA A to STA B in subcarrier k is the matrix transpose of the channel from STA B to STA A in subcarrier k to within a complex scaling factor, i.e., $H_{\mathrm{AB},k} = \rho[H_{\mathrm{BA},k}]^T$. Here $H_{\mathrm{AB},k}$ is the MIMO channel matrix from STA A to STA B at subcarrier k, and $H_{\mathrm{BA},k}$ is the channel matrix from STA B to STA A at subcarrier k. STA A uses this relationship to compute transmit steering matrices that are suitable for transmitting to STA B over $H_{\mathrm{AB},k}$.

NOTE—In order for the recipient of the sounding to compute steering matrices when steered or unsteered sounding is used, the steering matrices should have the property $(H_kQ_k)(H_kQ_k)^H = H_kH_k^H$, where X^H indicates the conjugate transpose of the matrix X.

While the over-the-air channel between the antenna(s) at one STA and the antenna(s) at a second STA is reciprocal, the observed baseband-to-baseband channel used for communication may not be, as it includes the transmit and receive chains of the STAs. Differences in the amplitude and phase characteristics of the transmit and receive chains associated with individual antennas degrade the reciprocity of the over-the-air channel and cause degradation of performance of implicit beamforming techniques. The over-the-air calibration procedure described in 9.19.2.4 may be used to restore reciprocity. The procedure provides the means for calculating a set of correction matrices that can be applied at the transmit side of a STA to correct the amplitude and phase differences between the transmit and receive chains in the STA. If this correction is done at least at the STA that serves as the beamformer, there is sufficient reciprocity for implicit feedback in the baseband-to-baseband response of the forward link and reverse channel.

Figure 20-15 illustrates the observed baseband-to-baseband channel, including reciprocity correction. The amplitude and phase responses of the transmit and receive chains can be expressed as diagonal matrices with complex valued diagonal entries, of the form $A_{TX,k}$ and $A_{RX,k}$ at STA A. The relationship between the baseband-to-baseband channel, $\tilde{H}_{\mathrm{AB},k}$, and the over-the-air channel, $H_{\mathrm{AB},k}$, is shown in Equation (20-64).

$$\tilde{H}_{\mathrm{AB},k} = B_{\mathrm{RX},k}H_{\mathrm{AB},k}A_{\mathrm{TX},k} \tag{20-64}$$

Similarly, the relationship between $\tilde{H}_{\mathrm{BA},k}$ and $H_{\mathrm{BA},k}$ is shown in Equation (20-65).

$$\tilde{H}_{\mathrm{BA},k} = A_{\mathrm{RX},k}H_{\mathrm{BA},k}B_{\mathrm{TX},k} \tag{20-65}$$

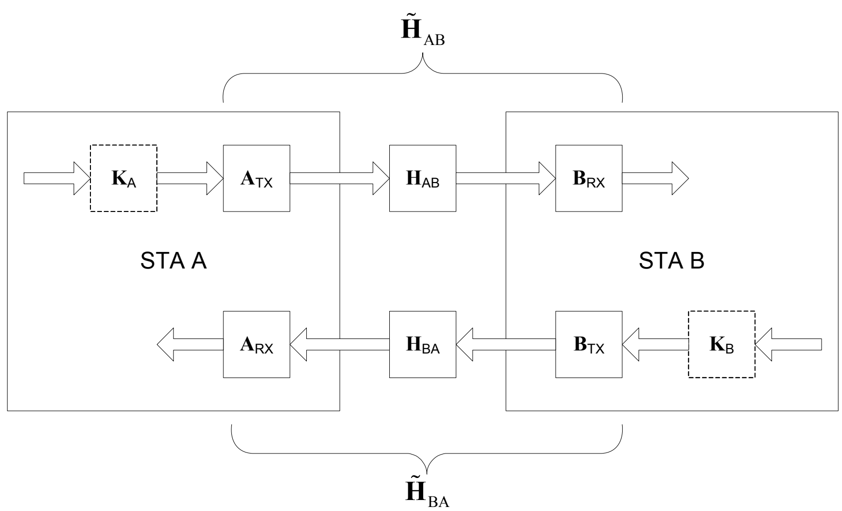


Figure 20-15—Baseband-to-baseband channel

As an example, consider the case where calibration is performed at both STA A and STA B. The objective is to compute correction matrices, $K_{\mathrm{A},k}$ and $K_{\mathrm{B},k}$, that restore reciprocity so that Equation (20-66) is true.

$$\tilde{H}_{\mathrm{AB},k}K_{\mathrm{A},k} = \rho[\tilde{H}_{\mathrm{BA},k}K_{\mathrm{B},k}]^{\mathrm{T}} \tag{20-66}$$

The correction matrices are diagonal matrices with complex valued diagonal entries. The reciprocity condition in Equation (20-66) is enforced when Equation (20-67) and Equation (20-68) are true.

$$K_{A,k} = \alpha_{A,k}[A_{TX,k}]^{-1}A_{RX,k} \tag{20-67}$$

and

$$K_{B,k} = \alpha_{B,k}[B_{TX,k}]^{-1}B_{RX,k} \tag{20-68}$$

where $\alpha_{A,k}$ and $\alpha_{B,k}$ are complex valued scaling factors.

Using these expressions for the correction matrices, the calibrated baseband-to-baseband channel between STA A and STA B is expressed as shown in Equation (20-69).

$$\hat{H}_{AB,k} = \tilde{H}_{AB,k}K_{A,k} = \alpha_{A,k}B_{RX,k}H_{AB,k}A_{RX,k} \tag{20-69}$$

If both sides apply the correction matrices, the calibrated baseband-to-baseband channel between STA A and STA B is expressed as shown in Equation (20-70).

$$\hat{H}_{BA,k} = \alpha_{B,k}A_{RX,k}H_{BA,k}B_{RX,k} = \frac{\alpha_{B,k}}{\alpha_{A,k}}[\hat{H}_{AB,k}]^{T} \tag{20-70}$$

Focusing on STA A, the procedure for estimating $K_{A,k}$ is as follows:

a) STA A sends STA B a sounding PPDU, the reception of which allows STA B to estimate the channel matrices $\tilde{H}_{AB,k}$.

b) STA B sends STA A a sounding PPDU, the reception of which allows STA A to estimate the channel matrices $\tilde{H}_{BA,k}$.

c) STA B sends the quantized estimates of $\tilde{H}_{AB,k}$ to STA A.

d) STA A uses its local estimates of $\tilde{H}_{BA,k}$ and the quantized estimates of $\tilde{H}_{AB,k}$ received from STA B to compute the correction matrices $K_{A,k}$.

Steps a) and b) occur over a short time interval to ensure that the channel changes as little as possible between measurements. A similar procedure is used to estimate $K_{B,k}$ at STA B. The details of the computation of the correction matrices is implementation specific and beyond the scope of this standard.

20.3.12.2 Explicit feedback beamforming

In explicit beamforming, in order for STA A to transmit a beamformed packet to STA B, STA B measures the channel matrices and sends STA A either the effective channel, $H_{eff,k}$, or the beamforming feedback matrix, V_k, for STA A to determine a steering matrix, $Q_{steer,k} = Q_kV_k$, with V_k found from H_kQ_k, where Q_k is the orthonormal spatial mapping matrix that was used to transmit the sounding packet that elicited the V_k feedback. The effective channel, $H_{eff,k} = H_kQ_k$, is the product of the spatial mapping matrix used on transmit with the channel matrix. When new steering matrix $Q_{steer,k}$ is found, $Q_{steer,k}$ may replace Q_k for the next beamformed data transmission.

NOTE—$Q_{steer,k}$ is a mathematical term to update a new steering matrix for Q_k in the next beamformed data transmission.

20.3.12.2.1 CSI matrices feedback

In CSI matrices feedback, the beamformer receives the quantized MIMO channel matrix, H_{eff}, from the beamformee. The beamformer then may use this matrix to compute a set of transmit steering matrices, Q_k. The CSI matrix, H_{eff}, shall be determined from the transmitter spatial mapper input to the receiver FFT outputs. The beamformee shall remove the CSD in Table 20-9 from the measured channel matrix.

The matrices $H_{eff}(k)$, where k is the subcarrier index, are encoded so that applying the procedure in 20.3.12.2.2 will optimally reconstruct the matrix.

20.3.12.2.2 CSI matrices feedback decoding procedure

The received, quantized matrix $H^q_{eff}(k)$ (of a specific subcarrier, k) shall be decoded as follows:

a) The real and imaginary parts of each element of the matrix, $H^{q(R)}_{eff(m,l)}(k)$ and $H^{q(I)}_{eff(m,l)}(k)$, are decoded as a pair of twos complement numbers to create the complex element, where $1 \le m \le N_r$ and $1 \le l \le N_c$.

b) Each element in the matrix of subcarrier k is then scaled using the value in the carrier matrix amplitude field (3 bits), $M_H(k)$, interpreted as a positive integer, in decibels, as follows:
   1) Calculate the linear value as defined in Equation (20-71).
   2) Calculate decoded values of the real and imaginary parts of the matrix element as defined in Equation (20-72) and Equation (20-73).

$$r(k) = 10^{M_H(k)/20} \tag{20-71}$$

$$\mathrm{Re}\{\tilde{H}_{eff(m,l)}(k)\} = \frac{H^{q(R)}_{eff(m,l)}(k)}{r(k)} \tag{20-72}$$

$$\mathrm{Im}\{\tilde{H}_{eff(m,l)}(k)\} = \frac{H^{q(I)}_{eff(m,l)}(k)}{r(k)} \tag{20-73}$$

20.3.12.2.3 Example of CSI matrices feedback encoding

The following is an example of an encoding process:

a) The maximums of the real and imaginary parts of each element of the matrix in each subcarrier are found, as defined by Equation (20-74).

$$m_H(k) = \max\left\{\max\left\{\left|\mathrm{Re}(H_{eff(m,l)}(k))\right|_{m=1,\,l=1}^{m=N_r,\,l=N_c}\right\}, \max\left\{\left|\mathrm{Im}(H_{eff(m,l)}(k))\right|_{m=1,\,l=1}^{m=N_r,\,l=N_c}\right\}\right\} \tag{20-74}$$

b) The scaling ratio is calculated and quantized to 3 bits as defined by Equation (20-75). A linear scaler is given by Equation (20-76).

$$M_H(k) = \min\left\{7, \left\lfloor 20\log_{10}\left(\frac{\max\{m_H(z)\}_{z=-N_{SR}}^{z=N_{SR}}}{m_H(k)}\right)\right\rfloor\right\} \tag{20-75}$$

where

$\lfloor x \rfloor$ is the largest integer smaller than or equal to x

$$M_H^{\text{lin}}(k) = \frac{\max\{m_H(z)\}_{z=-N_{SR}}^{z=N_{SR}}}{10^{M_H(k)/20}} \tag{20-76}$$

c) The real and imaginary parts of each element in the matrix $H_{eff(m,l)}(k)$ are quantized to N_b bits in twos complement encoding as defined by Equation (20-77) and Equation (20-78).

$$H_{eff(m,l)}^{q(R)}(k) = \text{round}\left(\frac{\text{Re}\{H_{eff(m,l)}(k)\}}{M_H^{\text{lin}}(k)}(2^{N_b-1}-1)\right) \tag{20-77}$$

$$H_{eff(m,l)}^{q(I)}(k) = \text{round}\left(\frac{\text{Im}\{H_{eff(m,l)}(k)\}}{M_H^{\text{lin}}(k)}(2^{N_b-1}-1)\right) \tag{20-78}$$

Each matrix is encoded using $3 + 2 \times N_b \times N_r \times N_c$ bits, where N_r and N_c are the number of rows and columns, respectively, in the channel matrix estimate computed by the receiving station and where N_b may have the value of 4, 5, 6, or 8 bits.

20.3.12.2.4 Noncompressed beamforming feedback matrix

In noncompressed beamforming feedback matrix, the beamformee shall remove the space-time stream CSD in Table 20-9 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrices, $V(k)$, found by the beamformee are sent to the beamformer in the order of real and imaginary components per tone as specified in 7.3.1.28. The beamformer can use these matrices to determine the steering matrices, Q_k.

The beamformee shall encode the matrices $V(k)$ so a beamformer applying the procedure below will optimally reconstruct the matrix.

The received matrix $V^q(k)$ (of a specific subcarrier k) shall be decoded as follows:

a) The real and imaginary parts of each element of the matrix, $V_{m,l}^{q,R}$ and $V_{m,l}^{q,I}$, shall be decoded as a pair of twos complement numbers to create the complex element, where $1 \le m \le N_r$ and $1 \le l \le N_c$.

b) The dimensions of the beamforming feedback matrices are $N_r \times N_c$, where N_r and N_c are the number of rows and columns, respectively, in the beamforming feedback matrix computed by the receiving station. Each matrix is encoded using $2 \times N_b \times N_r \times N_c$ bits. N_b may have the value of 2, 4, 6, or 8 bits.

c) Columns $1 \ldots N_c$ of the beamforming feedback matrix correspond to spatial streams $1 \ldots N_c$, respectively. The mapping of spatial stream to modulation is defined in the MCS tables in 20.6. A transmitter shall not reorder the columns of the beamforming feedback matrices.

20.3.12.2.5 Compressed beamforming feedback matrix

In compressed beamforming feedback matrix, the beamformee shall remove the space-time stream CSD in Table 20-9 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrices, $V(k)$, found by the beamformee are compressed in the form of angles, which are sent to the beamformer. The beamformer can use these angles to decompress the matrices and determine the steering matrices Q_k.

The matrix V per tone shall be compressed as follows: The unitary $N_r \times N_c$ beamforming feedback matrix V found by the beamformee shall be represented as shown in Equation (20-79).

$$V = \left[\prod_{i=1}^{\min(N_c, N_r-1)} \left[D_i\left(1_{i-1}\ e^{j\phi_{i,i}}\ \ldots\ e^{j\phi_{N_r-1,i}}\ 1\right) \prod_{l=i+1}^{N_r} G_{li}^T(\psi_{li})\right]\right]\tilde{I}_{N_r \times N_c} \tag{20-79}$$

The matrix $D_i\left(1_{i-1}\ e^{j\phi_{i,i}}\ \ldots\ e^{j\phi_{N_r-1,i}}\ 1\right)$ is an $N_r \times N_r$ diagonal matrix, where 1_{i-1} represents a sequence of ones with length of i–1, as shown in Equation (20-80).

$$D\left(1_{i-1}\ e^{j\phi_{i,i}} \ldots\ e^{j\phi_{N_r-1,i}}\ 1\right) = \begin{bmatrix} I_{i-1} & 0 & \ldots & \ldots & 0 \\ 0 & e^{j\phi_{i,i}} & 0 & \ldots & 0 \\ \vdots & 0 & \ddots & 0 & 0 \\ \vdots & \vdots & 0 & e^{j\phi_{N_r-1,i}} & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{20-80}$$

The matrix $G_{li}(\psi)$ is an $N_r \times N_r$ Givens rotation matrix as shown in Equation (20-81).

$$G_{li}(\psi) = \begin{bmatrix} I_{i-1} & 0 & 0 & 0 & 0 \\ 0 & \cos(\psi) & 0 & \sin(\psi) & 0 \\ 0 & 0 & I_{l-i-1} & 0 & 0 \\ 0 & -\sin(\psi) & 0 & \cos(\psi) & 0 \\ 0 & 0 & 0 & 0 & I_{N_r-l} \end{bmatrix} \tag{20-81}$$

where each I_m is an $m \times m$ identity matrix, and $\cos(\psi)$ and $\sin(\psi)$ are located at row l and column i. $\tilde{I}_{N_r \times N_c}$ is an identity matrix padded with zeros to fill the additional rows or columns when $N_r \neq N_c$.

For example, a 4×2 V matrix has the representation shown in Equation (20-82).

$$\begin{aligned} V = &\begin{bmatrix} e^{j\phi_{11}} & 0 & 0 & 0 \\ 0 & e^{j\phi_{21}} & 0 & 0 \\ 0 & 0 & e^{j\phi_{31}} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \cos\psi_{21} & \sin\psi_{21} & 0 & 0 \\ -\sin\psi_{21} & \cos\psi_{21} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^T \times \begin{bmatrix} \cos\psi_{31} & 0 & \sin\psi_{31} & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\psi_{31} & 0 & \cos\psi_{31} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^T \times \begin{bmatrix} \cos\psi_{41} & 0 & 0 & \sin\psi_{41} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -\sin\psi_{41} & 0 & 0 & \cos\psi_{41} \end{bmatrix}^T \\ &\times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & e^{j\phi_{22}} & 0 & 0 \\ 0 & 0 & e^{j\phi_{32}} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\psi_{32} & \sin\psi_{32} & 0 \\ 0 & -\sin\psi_{32} & \cos\psi_{32} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^T \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\psi_{42} & 0 & \sin\psi_{42} \\ 0 & 0 & 1 & 0 \\ 0 & -\sin\psi_{42} & 0 & \cos\psi_{42} \end{bmatrix}^T \times \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix} \end{aligned} \tag{20-82}$$

The procedure for finding a compressed V matrix is described as follows:

A unitary $N_r \times N_c$ beamforming feedback matrix V is column-wise phase invariant because the steering matrix needs a reference in phase per each column. In other words, V is equivalent to $\tilde{V}\tilde{D}$, where $\tilde{D}$ is a column-wise phase shift matrix such as $\tilde{D} = \mathrm{diag}\left(e^{j\theta_1}, e^{j\theta_2}, \ldots, e^{j\theta_{N_c}}\right)$. When the beamformee estimates the channel, it may find $\tilde{V}$ for the beamforming feedback matrix for the beamformer, but it should send $\tilde{V}\tilde{D}$ back to the beamformer, where $V = \tilde{V}\tilde{D}$. The angle, θ_i, in $\tilde{D}$ is found to make the last row of $\tilde{V}\tilde{D}$ to be non-negative real numbers.

The angles $\phi_{1,1} \ldots \phi_{N_r-1,1}$ in the diagonal matrix $D_1\left(e^{j\phi_{11}} \ldots e^{j\phi_{N_r-1,1}} \; 1 \right)^*$ shall satisfy the constraint that all elements in the first column of $D_1^* V$ are non-negative real numbers. Now, the first column of $(G_{N_r1} \ldots G_{31} G_{21} D_1^*) \times V$ can be $\begin{bmatrix} 1 & 0 & \ldots & 0 \end{bmatrix}^T$ by the Givens rotations G_{l1} such as shown in Equation (20-83).

$$\begin{bmatrix} \cos\psi_{N_r1} & 0 & 0 & \sin\psi_{N_r1} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -\sin\psi_{N_r1} & 0 & 0 & \cos\psi_{N_r1} \end{bmatrix} \cdots \begin{bmatrix} \cos\psi_{31} & 0 & \sin\psi_{31} & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\psi_{31} & 0 & \cos\psi_{31} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\psi_{21} & \sin\psi_{21} & 0 & 0 \\ -\sin\psi_{21} & \cos\psi_{21} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e^{j\phi_{11}} & 0 & 0 & 0 \\ 0 & \ddots & 0 & 0 \\ 0 & 0 & e^{j\phi_{N_r-1,1}} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^* \times V = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & & & \\ 0 & & V_2 & \\ 0 & & & \end{bmatrix} \tag{20-83}$$

For a new $(N_r - 1) \times (N_c - 1)$ submatrix V_2, this process is applied in the same way. Then, the angles $\phi_{2,2} \ldots \phi_{N_r-1,2}$ in the diagonal matrix $D_2\left(1 \; e^{j\phi_{22}} \ldots e^{j\phi_{N_r-1,2}} \; 1 \right)^*$ shall satisfy the constraint that all elements in the second column of $D_2^* \times \mathrm{diag}(1, V_2)$ are non-negative real numbers. Now, the first two columns of $(G_{N_r2} \ldots G_{32} D_2^*)(G_{N_r1} \ldots G_{31} G_{21} D_1^*) \times V$ can be $\tilde{I}_{N_r \times 2}$ by the Givens rotations G_{l2} such as shown in Equation (20-84).

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\psi_{N_r2} & 0 & \sin\psi_{N_r2} \\ 0 & 0 & 1 & 0 \\ 0 & -\sin\psi_{N_r2} & 0 & \cos\psi_{N_r2} \end{bmatrix} \cdots \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\psi_{32} & \sin\psi_{32} & 0 \\ 0 & -\sin\psi_{32} & \cos\psi_{32} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & e^{j\phi_{22}} & 0 & 0 \\ 0 & 0 & e^{j\phi_{N_r-1,2}} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}^* \times G_{N,1} \ldots G_{31} G_{21} D_1^* \times V = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & & \\ 0 & 0 & & V_3 \end{bmatrix} \tag{20-84}$$

This process continues until the first N_c columns of the right side matrix become $\tilde{I}_{N_r \times N_c}$. When $N_c < N_r$, this process does not need to continue because V_{N_c+1} will be nulled out by $\tilde{I}_{N_r \times N_c}$. Then, by multiplying the complex conjugate transpose of the products of the D_i and G_{li} matrices on the left, V can be expressed as shown in Equation (20-85).

$$V = D_1 G_{21}^T G_{31}^T \ldots G_{N_r1}^T \times D_2 G_{32}^T G_{42}^T \ldots G_{N_r2}^T \times \ldots \times D_p G_{p+1,p}^T G_{p+2,p}^T \ldots G_{N_r p}^T \times \tilde{I}_{N_r \times N_C} \tag{20-85}$$

where $p = \min(N_c, N_r - 1)$, which can be written in short form as in Equation (20-79).

The angles found from the decomposition process above, e.g., the values of $\psi_{i,j}$ and $\phi_{k,l}$, are quantized as described in 7.4.10.8.

Columns $1 \ldots N_c$ of the beamforming feedback matrix correspond to spatial streams $1 \ldots N_c$, respectively. The mapping of spatial stream to modulation is defined in the MCS tables in 20.6. A transmitter shall not reorder the columns of the beamforming feedback matrices in determining steering matrices.

20.3.13 HT Preamble format for sounding PPDUs

The MIMO channel measurement takes place in every PPDU as a result of transmitting the HT-LTFs as part of the PLCP preamble. The number of HT-LTFs transmitted shall be determined by the number of space-time streams transmitted unless additional dimensions are optionally sounded using HT-ELTFs and these are transmitted using the same spatial transformation that is used for the Data field of the HT PPDU. The use of the same spatial transformation enables the computation of the spatial equalization at the receiver.

When the number of space-time streams, N_{STS}, is less than the number of transmit antennas, or less than $\min(N_{TX}, N_{RX})$, sending only N_{STS} HT-LTFs does not allow the receiver to recover a full characterization of the MIMO channel, even though the resulting MIMO channel measurement is sufficient for receiving the Data field of the HT PPDU.

However, there are several cases where it is desirable to obtain as full a characterization of the channel as possible, thus requiring the transmission of a sufficient number of HT-LTFs to sound the full dimensionality of the channel, which is in some cases N_{TX} and in other cases $\min(N_{TX}, N_{RX})$. These cases of MIMO channel measurement are referred to as *MIMO channel sounding*. A sounding packet may be used to sound available channel dimensions. A sounding PPDU is identified by setting the Not Sounding field in the HT-SIG to 0. A sounding PPDU may have any allowed number of HT-LTFs satisfying $N_{LTF} \geq N_{STS}$. In general, if the Not Sounding field in the HT-SIG is set to 0 and $N_{LTF} > N_{STS}$, HT-ELTFs are used, except where $N_{SS} = 3$ and $N_{LTF} = 4$ or in an NDP.

20.3.13.1 Sounding with a NDP

A STA may sound the channel using a NDP (indicated by zero in the HT Length field in the HT-SIG) with the Not Sounding field set to 0. The number of LTFs is the number implied by the MCS, which shall indicate two or more spatial streams. The last HT-LTF of an NDP shall not be followed by a Data field (see Figure 20-16).

It is optional for a STA to process an NDP.

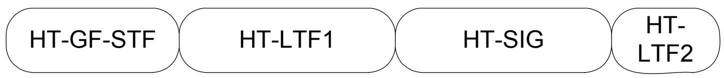


Figure 20-16—Example of an NDP used for sounding

20.3.13.2 Sounding PPDU for calibration

In the case of a bidirectional calibration exchange, two STAs exchange sounding PPDUs, the exchange of which enables the receiving STA to compute an estimate of the MIMO channel matrix H_k for each subcarrier *k*. In general, in an exchange of calibration messages, the number of spatial streams is less than the number of transmit antennas. In such cases, HT-ELTFs are used. In the case of sounding PPDUs for calibration, the antenna mapping matrix shall be as shown in Equation (20-86).

$$Q_k = C_{CSD}(k) P_{CAL} \tag{20-86}$$

where

$C_{CSD}(k)$ is a diagonal cyclic shift matrix in which the diagonal elements carry frequency-domain representation of the cyclic shifts given in Table 20-8

P_{CAL} is one of the following unitary matrices:

For $N_{TX} = 1, P_{CAL} = 1$

For $N_{TX} = 2, P_{CAL} = \frac{\sqrt{2}}{2}\begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}$

For $N_{TX} = 3, P_{CAL} = \frac{\sqrt{3}}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & e^{-j2\pi/3} & e^{-j4\pi/3} \\ 1 & e^{-j4\pi/3} & e^{-j2\pi/3} \end{bmatrix}$

$$\text{For } N_{TX} = 4, P_{CAL} = \frac{1}{2}\begin{bmatrix} 1 & -1 & 1 & 1 \\ 1 & 1 & -1 & 1 \\ 1 & 1 & 1 & -1 \\ -1 & 1 & 1 & 1 \end{bmatrix}$$

20.3.13.3 Sounding PPDU for channel quality assessment

In response to the reception of an MRQ, sent by STA A to STA B, the responding STA B returns to the requesting STA A an MCS selection that STA B determines to be a suitable MCS for STA A to use in subsequent transmissions to STA B. In determining the MCS, STA B performs a channel quality assessment, which entails using whatever information STA B has about the channel, such as an estimate of the MIMO channel derived from the sounding PPDU that carries the MRQ. To enable this calculation, the MRQ is sent in conjunction with a sounding PPDU.

The STA sending the MRQ (STA A) determines how many HT-LTFs to send, and whether to use HT-ELTFs or an NDP, based on the Transmit Beamforming Capabilities field, number of space-time streams used in the PPDU carrying the MRQ, the number of transmit chains it is using (N_{TX}), whether the transmit and receive STAs support STBC, and in some cases, the number of receive chains at the responding STA (N_{RX}).

The maximum number of available space-time streams is set by the number of transmit and receive chains and the STBC capabilities of the transmitter and receiver, as is shown in Table 20-20. While the number of receive chains at a STA is not communicated in a capabilities indicator, the maximum number of space-time streams supported may be inferred from the MCS capabilities and the STBC capabilities of the receiving STA. When the number of receive chains is known at the transmitter, the number of HT-LTFs sent to obtain a full channel quality assessment is determined according to the maximum number of space-time streams indicated in Table 20-20. The number of HT-LTFs to use in conjunction with the indicated number of space-time streams is determined according to 20.3.9.4.6.

Table 20-20—Maximum available space-time streams

N_{TX}	N_{RX}	$N_{STS,\max}$ without STBC	$N_{STS,\max}$ with STBC
1	1	1	N/A
2	1	1	2
3	1	1	2
3	2	2	3
4	1	1	2
4	2	2	4

If the requesting STA A sends an MRQ in a PPDU that uses fewer space-time streams in the data portion than the maximum number of space-time streams possible given the number of antennas at STA A and the responding STA B, the channel quality assessment made by STA B may be based on the HT-DLTFs alone. In this case, the MFB will be limited to MCSs using the number of streams used in the Data field of the HT PPDU, or fewer. To determine whether an MCS should be chosen that uses more spatial streams than the

PPDU containing the MRQ, it is necessary for the requesting STA A to either use HT-ELTFs (i.e., send the MRQ in a staggered sounding PPDU) or use an NDP (i.e., send the MRQ in conjunction with an NDP).

The sounding PPDU may have non-identity spatial mapping matrix Q_k. For different receiving STAs, Q_k may vary.

20.3.14 Regulatory requirements

Wireless LANs (WLANs) implemented in accordance with this standard are subject to equipment certification and operating requirements established by regional and national regulatory administrations. The PMD specification establishes minimum technical requirements for interoperability, based upon established regulations at the time this standard was issued. These regulations are subject to revision or may be superseded. Requirements that are subject to local geographic regulations are annotated within the PMD specification. Regulatory requirements that do not affect interoperability are not addressed in this standard. Implementers are referred to the regulatory sources in Annex I for further information. Operation in countries within defined regulatory domains may be subject to additional or alternative national regulations.

20.3.15 Channel numbering and channelization

The STA may operate in the 5 GHz band and/or 2.4 GHz band. When using 20 MHz channels, it uses channels defined in 17.3.8.3 (5 GHz band) or 18.4.6 (2.4 GHz band). When using 40 MHz channels, it can operate in the channels defined in 20.3.15.1 and 20.3.15.2.

The set of valid operating channel numbers by regulatory domain is defined in Annex J.

20.3.15.1 Channel allocation in the 2.4 GHz Band

Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by Equation (20-87).

$$\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \tag{20-87}$$

where

$n_{ch} = 1, 2, \ldots, 13$

20.3.15.2 Channel allocation in the 5 GHz band

Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given in Equation (20-88).

$$\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \tag{20-88}$$

where

$n_{ch} = 0, 1, \ldots, 200$

Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined.

20.3.15.3 40 MHz channelization

The set of valid operating channel numbers by regulatory domain is defined in Annex J.

The 40 MHz channels are specified by two fields: (*Nprimary_ch*, *Secondary*). The first field represents the channel number of the primary channel, and the second field indicates whether the secondary channel is above or below the primary channel (1 indicates above, –1 indicates below). The secondary channel number shall be $Nprimary\_ch + Secondary \times 4$.

For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40.

20.3.16 Transmit and receive in-band and out-of-band spurious transmissions

The OFDM PHY shall conform to in-band and out-of-band spurious emissions as set by regulatory bodies.

20.3.17 Transmitter RF delay

The transmitter RF delay shall follow 17.3.8.5.

20.3.18 Slot time

The slot time shall follow 17.3.8.6 for 5 GHz bands and 19.4.4 for 2.4 GHz bands.

20.3.19 Transmit and receive port impedance

The transmit and receive antenna port impedance for each transmit and receive antenna shall follow 17.3.8.7.

20.3.20 Transmit and receive operating temperature range

The transmit and receive temperature range shall follow 17.3.8.8.

20.3.21 PMD transmit specification

20.3.21.1 Transmit spectrum mask

NOTE 1—In the presence of additional regulatory restrictions, the device has to meet both the regulatory requirements and the mask defined in this subclause, i.e., its emissions can be no higher at any frequency offset than the minimum of the values specified in the regulatory and default masks.

NOTE 2—The transmit spectral mask figures in this subclause are not drawn to scale.

When transmitting in a 20 MHz channel, the transmitted spectrum shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth not exceeding 18 MHz, –20 dBr at 11 MHz frequency offset, –28 dBr at 20 MHz frequency offset, and the maximum of –45 dBr and –53 dBm/MHz at 30 MHz frequency offset and above. The transmitted spectral density of the transmitted signal shall fall within the spectral mask, as shown in Figure 20-17. The measurements shall be made using a 100 kHz resolution bandwidth and a 30 kHz video bandwidth.

When transmitting in a 40 MHz channel, the transmitted spectrum shall have a 0 dBr bandwidth not exceeding 38 MHz, –20 dBr at 21 MHz frequency offset, –28 dBr at 40 MHz offset, and the maximum of –45 dBr and –56 dBm/MHz at 60 MHz frequency offset and above. The transmitted spectral density of the transmitted signal shall fall within the spectral mask, as shown in Figure 20-18.

Transmission with CH_OFF_20U, CH_OFF_20L, or CH_OFF_40 shall conform to the same mask that is used for the 40 MHz channel.

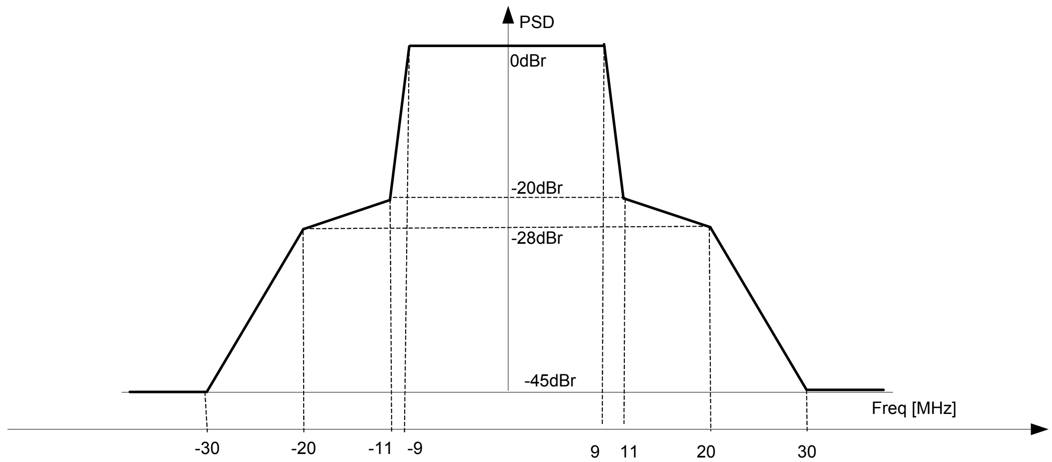


Figure 20-17—Transmit spectral mask for 20 MHz transmission

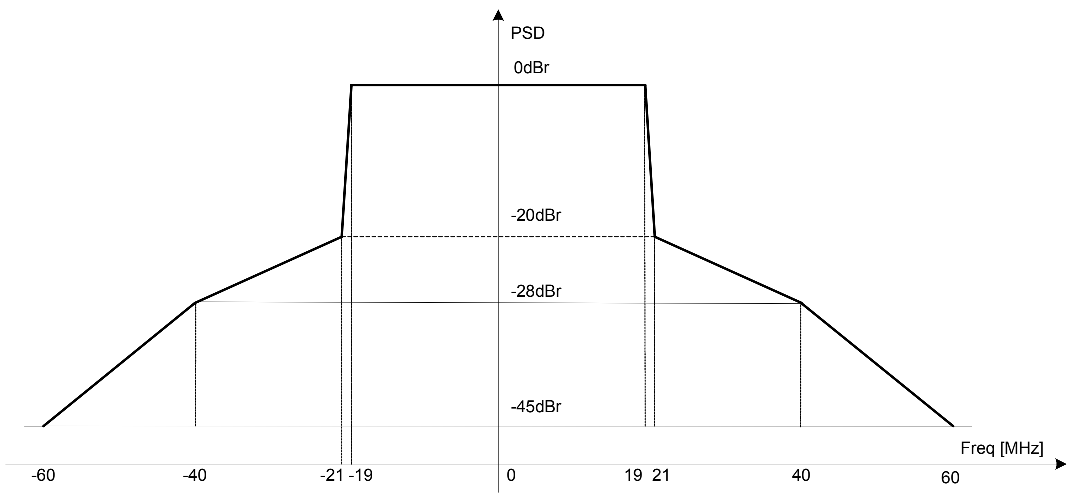


Figure 20-18—Transmit spectral mask for a 40 MHz channel

20.3.21.2 Spectral flatness

In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the subcarriers with indices –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the subcarriers with indices –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of subcarriers with indices –16 to –1 and +1 to +16.

In a 40 MHz transmission (excluding PPDUs in MCS 32 format and non-HT duplicate format), the average energy of the constellations in each of the subcarriers with indices –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the subcarriers with indices –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of subcarriers with indices –42 to –2 and +2 to +42.

In MCS 32 format and non-HT duplicate format, the average energy of the constellations in each of the subcarriers with indices –42 to –33, –31 to –6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the subcarriers with indices –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of subcarriers with indices –42 to –33, –31 to –6, +6 to +31, and +33 to +42.

The tests for the spectral flatness requirements can be performed with spatial mapping $Q_k = \mathbf{I}$ (see 20.3.11.10.1).

20.3.21.3 Transmit power

The maximum allowable transmit power by regulatory domain is defined in Annex I.

20.3.21.4 Transmit center frequency tolerance

The transmitter center frequency tolerance shall be ± 20 ppm maximum for the 5 GHz band and ± 25 ppm maximum for the 2.4 GHz band. The different transmit chain center frequencies (LO) and each transmit chain symbol clock frequency shall all be derived from the same reference oscillator.

20.3.21.5 Packet alignment

If no signal extension is required (see 20.3.2), the receiver shall emit a PHY-CCA.indication(idle) primitive (see 12.3.5.10) at the 4 µs boundary following the reception of the last symbol of the packet. If a signal extension is required, the receiver shall emit a PHY-CCA.indication(idle) primitive a duration of aSignalExtension µs after the 4 µs boundary following the reception of the last symbol of the packet. This situation is illustrated for an HT-greenfield format packet using short GI in Figure 20-19.

If no signal extension is required, the transmitter shall emit a PHY-TXEND.confirm primitive (see 12.3.5.7) at the 4 µs boundary following the trailing boundary of the last symbol of the packet on the air. If a signal extension is required, the transmitter shall emit a PHY-TXEND.confirm primitive (see 12.3.5.7) a duration of aSignalExtension µs after the 4 µs boundary following the trailing boundary of the last symbol of the packet on the air. This situation is illustrated in Figure 20-19.

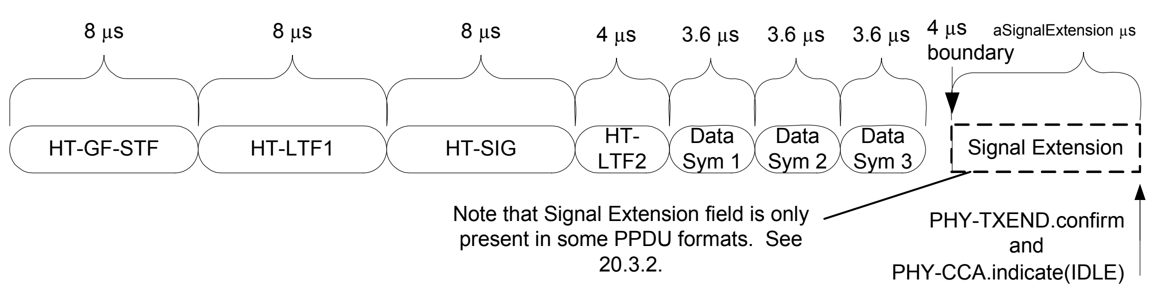


Figure 20-19—Packet alignment example (HT-greenfield format packet with short GI)

20.3.21.6 Symbol clock frequency tolerance

The symbol clock frequency tolerance shall be ± 20 ppm maximum for 5 GHz bands and ± 25 ppm for 2.4 GHz bands. The transmit center frequency and the symbol clock frequency for all transmit antennas shall be derived from the same reference oscillator.

20.3.21.7 Modulation accuracy

20.3.21.7.1 Introduction to modulation accuracy tests

Transmit modulation accuracy specifications are described in 20.3.21.7.2 and 20.3.21.7.3. The test method is described in 20.3.21.7.4.

20.3.21.7.2 Transmit center frequency leakage

The transmitter center frequency leakage shall follow 17.3.9.6.1 for all transmissions in a 20 MHz channel width. For transmissions in a 40 MHz channel width, the center frequency leakage shall not exceed –20 dB relative to overall transmitted power, or, equivalently, 0 dB relative to the average energy of the rest of the subcarriers. For upper or lower 20 MHz transmissions in a 40 MHz channel, the center frequency leakage (center of a 40 MHz channel) shall not exceed –17 dB relative to overall transmitted power, or, equivalently, 0 dB relative to the average energy of the rest of the subcarriers. The transmit center frequency leakage is specified per antenna.

20.3.21.7.3 Transmitter constellation error

The relative constellation frame-averaged RMS error, calculated first by averaging over subcarriers, OFDM frames, and spatial streams, shall not exceed a data-rate-dependent value according to Table 20-21. The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized testing instrumentation input ports. In the test, $N_{SS} = N_{STS}$ with EQM MCSs shall be used. Each output port of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The same requirement applies both to 20 MHz channels and 40 MHz channels.

Table 20-21—Allowed relative constellation error versus constellation size and coding rate

Modulation	Coding rate	Relative constellation error (dB)
BPSK	1/2	–5
QPSK	1/2	–10
QPSK	3/4	–13
16-QAM	1/2	–16
16-QAM	3/4	–19
64-QAM	2/3	–22
64-QAM	3/4	–25
64-QAM	5/6	–28

20.3.21.7.4 Transmitter modulation accuracy (EVM) test

The transmit modulation accuracy test shall be performed by instrumentation capable of converting the transmitted signals into a streams of complex samples at 40 Msample/s or more, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, dc offsets, phase noise, and analog-to-digital quantization noise. Each transmit chain is connected directly through a cable to the setup input port. A possible embodiment of such a setup is converting the signals to a low intermediate frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope, and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or an equivalent procedure:

a) Detect the start of frame.
b) Detect the transition from short sequences to channel estimation sequences, and establish fine timing (with one sample resolution).
c) Estimate the coarse and fine frequency offsets.
d) Derotate the frame according to estimated frequency offset.
e) Estimate the complex channel response coefficients for each of the subcarriers and each of the transmit chains.
f) For each of the data OFDM symbols, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers in all spatial streams, derotate the subcarrier values according to estimated phase, group the results from all the receiver chains in each subcarrier to a vector, multiply the vector by a zero-forcing equalization matrix generated from the channel estimated during the channel estimation phase.
g) For each data-carrying subcarrier in each spatial stream, find the closest constellation point and compute the Euclidean distance from it.
h) Compute the average of the RMS of all errors in a frame. It is given by Equation (20-89).

$$Error_{RMS} = \frac{\displaystyle\sum_{i_f=1}^{N_f} \sqrt{\frac{\displaystyle\sum_{i_s=1}^{N_{SYM}}\left[\sum_{i_{ss}=1}^{N_{SS}}\left(\sum_{i_{sc}=1}^{N_{ST}}\left((I(i_f, i_s, i_{ss}, i_{sc}) - I_0(i_f, i_s, i_{ss}, i_{sc}))^2 + (Q(i_f, i_s, i_{ss}, i_{sc}) - Q_0(i_f, i_s, i_{ss}, i_{sc}))^2\right)\right)\right]}{N_{SYM} \times N_{SS} \times N_{ST} \times P_0}}}{N_f} \quad (20\text{-}89)$$

where

N_f	is the number of frames for the measurement
$I_0(i_f, i_s, i_{ss}, i_{sc})$, $Q_0(i_f, i_s, i_{ss}, i_{sc})$	denotes the ideal symbol point in the complex plane in subcarrier i_{sc}, spatial stream i_{ss}, and OFDM symbol i_s of frame i_f
$I(i_f, i_s, i_{ss}, i_{sc})$, $Q(i_f, i_s, i_{ss}, i_{sc})$	denotes the observed symbol point in the complex plane in subcarrier i_{sc}, spatial stream i_{ss}, and OFDM symbol i_s of frame i_f
P_0	is the average power of the constellation

The vector error on a phase plane is shown in Figure 17-13.

The test shall be performed over at least 20 frames (N_f), and the average of the RMS shall be taken. The frames under test shall be at least 16 OFDM symbols long. Random data shall be used for the symbols.

20.3.22 HT PMD receiver specification

20.3.22.1 Receiver minimum input sensitivity

The packet error rate (PER) shall be less than 10% for a PSDU length of 4096 octets with the rate-dependent input levels listed in Table 20-22 or less. The minimum input levels are measured at the antenna connectors and are referenced as the average power per receive antenna. The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized device under test input ports. Each output port of the transmitting STA shall be connected through a cable to one input port of the device under test. The test in this subclause and the minimum sensitivity levels specified in Table 20-22 apply only to non-STBC modes, MCSs 0–31, 800 ns GI, and BCC.

Table 20-22—Receiver minimum input level sensitivity

Modulation	Rate (R)	Adjacent channel rejection (dB)	Nonadjacent channel rejection (dB)	Minimum sensitivity (20 MHz channel spacing) (dBm)	Minimum sensitivity (40 MHz channel spacing) (dBm)
BPSK	1/2	16	32	–82	–79
QPSK	1/2	13	29	–79	–76
QPSK	3/4	11	27	–77	–74
16-QAM	1/2	8	24	–74	–71
16-QAM	3/4	4	20	–70	–67
64-QAM	2/3	0	16	–66	–63
64-QAM	3/4	–1	15	–65	–62
64-QAM	5/6	–2	14	–64	–61

20.3.22.2 Adjacent channel rejection

For all transmissions in a 20 MHz channel width, the adjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 20-22 and raising the power of the interfering signal until 10% PER is caused for a PSDU length of 4096 octets. The power difference between the interfering channel and the desired channel is the corresponding adjacent channel rejection. The adjacent channel center frequencies shall be separated by 20 MHz when operating in the 5 GHz band, and the adjacent channel center frequencies shall be separated by 25 MHz when operating in the 2.4 GHz band.

For all transmissions in a 40 MHz channel width, the adjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 20-22 and raising the power of the interfering signal until 10% PER is caused for a PSDU length of 4096 octets. The power difference between the interfering channel and the desired channel is the corresponding adjacent channel rejection. The adjacent channel center frequencies shall be separated by 40 MHz.

The interfering signal in the adjacent channel shall be a conformant OFDM signal, unsynchronized with the signal in the channel under test. For a conforming OFDM PHY, the corresponding rejection shall be no less than specified in Table 20-22. The interference signal shall have a minimum duty cycle of 50%.

The test in this subclause and the adjacent channel rejection levels specified in Table 20-22 apply only to non-STBC modes, MCSs 0–31, 800 ns GI, and BCC.

20.3.22.3 Nonadjacent channel rejection

For all transmissions in a 20 MHz channel width in the 5 GHz band, the nonadjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 20-22 and raising the power of the interfering signal until a 10% PER occurs for a PSDU length of 4096 octets. The power difference between the interfering channel and the desired channel is the corresponding nonadjacent channel rejection. The nonadjacent channel center frequencies shall be separated by 40 MHz or more.

For all transmissions in a 40 MHz channel width in the 5 GHz band, the nonadjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 20-22 and raising the power of the interfering signal until a 10% PER occurs for a PSDU length of 4096 octets. The power difference between the interfering channel and the desired channel is the corresponding nonadjacent channel rejection. The nonadjacent channel center frequencies shall be separated by 80 MHz or more.

The interfering signal in the nonadjacent channel shall be a conformant OFDM signal, unsynchronized with the signal in the channel under test. For a conforming OFDM PHY, the corresponding rejection shall be no less than specified in Table 20-22. The interference signal shall have a minimum duty cycle of 50%. The nonadjacent channel rejection for transmissions in a 20 MHz or 40 MHz channel width is applicable only to 5 GHz band.

The test in this subclause and the nonadjacent channel rejection level specified in Table 20-22 apply only to non-STBC modes, MCSs 0–31, 800 ns GI, and BCC.

20.3.22.4 Receiver maximum input level

The receiver shall provide a maximum PER of 10% at a PSDU length of 4096 octets, for a maximum input level of –30 dBm in the 5 GHz band and –20 dBm in the 2.4 GHz band, measured at each antenna for any baseband modulation.

20.3.22.5 CCA sensitivity

CCA sensitivity requirements for non-HT PPDUs in the primary channel are described in 17.3.10.5 and 19.4.6.

20.3.22.5.1 CCA sensitivity in 20 MHz

For an HT STA with the operating channel width set to 20 MHz, the start of a valid 20 MHz HT signal at a receive level equal to or greater than the minimum modulation and coding rate sensitivity of –82 dBm shall cause the PHY to set PHY-CCA.indicate(BUSY) with a probability > 90% within 4 µs. The receiver shall hold the CCA signal busy for any signal 20 dB or more above the minimum modulation and coding rate sensitivity (–82 + 20 = –62 dBm) in the 20 MHz channel.

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

20.3.22.5.2 CCA sensitivity in 40 MHz

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

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

When the secondary channel is idle, the start of a valid 20 MHz HT signal in the primary channel at a receive level equal to or greater than the minimum modulation and coding rate sensitivity of –82 dBm shall cause the PHY to set PHY-CCA.indicate(BUSY, {primary}) with a probability > 90% within 4 µs. The start of a valid 40 MHz HT signal that occupies both the primary and secondary channels at a receive level equal to or greater than the minimum modulation and coding rate sensitivity of –79 dBm shall cause the PHY to set PHY-CCA.indicate(BUSY, {primary, secondary}) for both the primary and secondary channels with a probability per channel > 90% within 4 µs.

A receiver that does not support the reception of HT-GF format PPDUs shall hold the CCA signal busy (PHY_CCA.indicate(BUSY, {primary})) for any valid HT-GF signal in the primary channel at a receive level equal to or greater than –72 dBm when the secondary channel is idle. A receiver that does not support the reception of HT-GF format PPDUs shall hold both the 20 MHz primary channel CCA and the 20 MHz secondary channel CCA busy (PHY_CCA.indicate(BUSY, {primary, secondary})) for any valid 40 MHz HT-GF signal in both the primary and secondary channels at a receive level equal to or greater than –69 dBm.

The receiver shall hold the 20 MHz primary channel CCA signal busy for any signal at or above –62 dBm in the 20 MHz primary channel. This level is 20 dB above the minimum modulation and coding rate sensitivity for a 20 MHz PPDU. When the primary channel is idle, the receiver shall hold the 20 MHz secondary channel CCA signal busy for any signal at or above –62 dBm in the 20 MHz secondary channel. The receiver shall hold both the 20 MHz primary channel CCA and the 20 MHz secondary channel CCA busy for any signal present in both the primary and secondary channels that is at or above –62 dBm in the primary channel and at or above –62 dBm in the secondary channel.

20.3.22.6 Received channel power indicator (RCPI) measurement

The RCPI is a measure of the received RF power in the selected channel. This parameter shall be a measure by the PHY of the received RF power in the channel measured over the data portion of the received frame. The received power shall be the average of the power in all active receive chains. RCPI shall be a monotonically increasing, logarithmic function of the received power level defined in dBm. The allowed values for the Received Channel Power Indicator (RCPI) parameter shall be an 8 bit value in the range from 0 through 220, with indicated values rounded to the nearest 0.5 dB as follows:

— 0: Power < –110 dBm
— 1: Power = –109.5 dBm
— 2: Power = –109.0 dBm
— And so on up to
— 220: Power > 0 dBm
— 221–254: reserved
— 255: Measurement not available

where

$$\text{RCPI} = \text{int}\{(\text{Power in dBm} + 110)*2\} \text{ for } 0 \text{ dBm} > \text{Power} > -110 \text{ dBm} \tag{20-90}$$

RCPI shall equal the received RF power within an accuracy of ± 5 dB (95% confidence interval) within the specified dynamic range of the receiver. The received RF power shall be determined assuming a receiver noise equivalent bandwidth equal to the channel width multiplied by 1.1.

20.3.22.7 Reduced interframe space (RIFS)

The receiver shall be able to decode a packet that was transmitted by a STA with a RIFS separation from the previous packet.

20.3.23 PLCP transmit procedure

There are three options for the transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure 20-20 and Figure 20-21, are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF, respectively. These transmit procedures do not describe the operation of optional features, such as LDPC or STBC. The third option is to follow the transmit procedure in Clause 17 or Clause 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure in Clause 17, except that the signal in Clause 17 is generated simultaneously on each of the upper and lower 20 MHz channels that constitute the 40 MHz channel as defined in 20.3.8 and 20.3.11.11. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME, as specified in 20.4. Other transmit parameters, such as MCS coding types and transmit power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2.

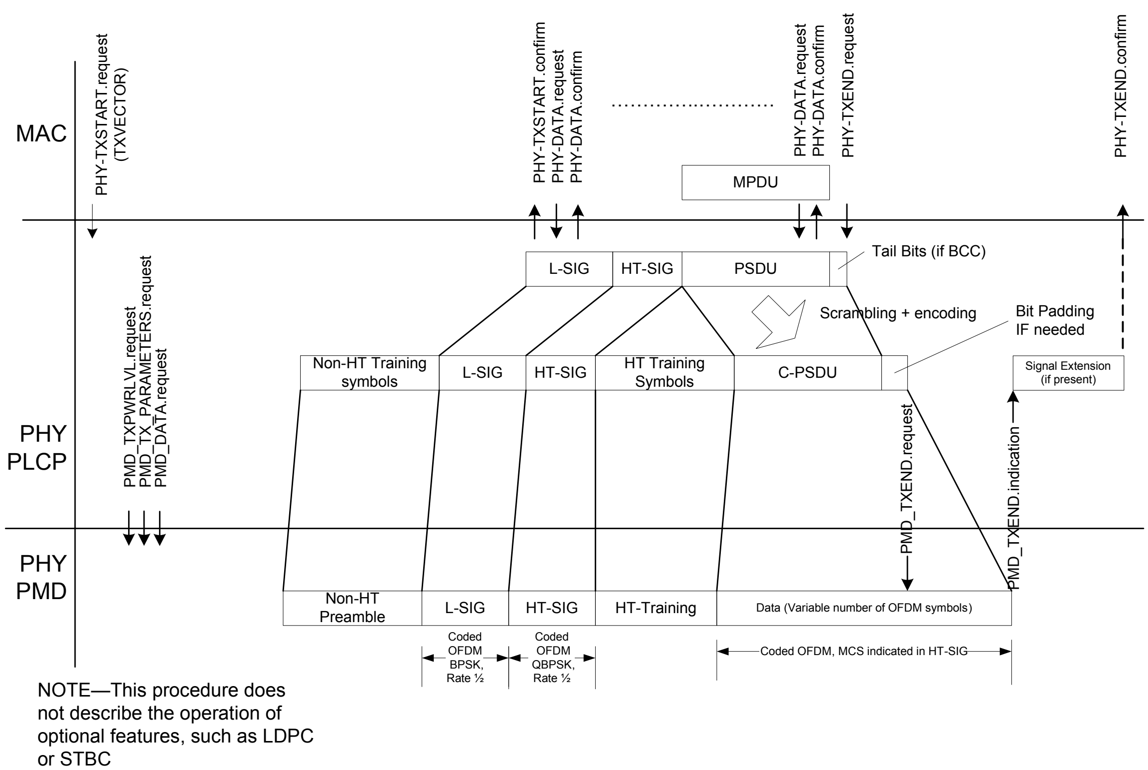


Figure 20-20—PLCP transmit procedure (HT-mixed format PPDU)

A clear channel shall be indicated by PHY-CCA.indication(IDLE). Note that under some circumstances, the MAC uses the latest value of PHY-CCA.indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table 20-1.

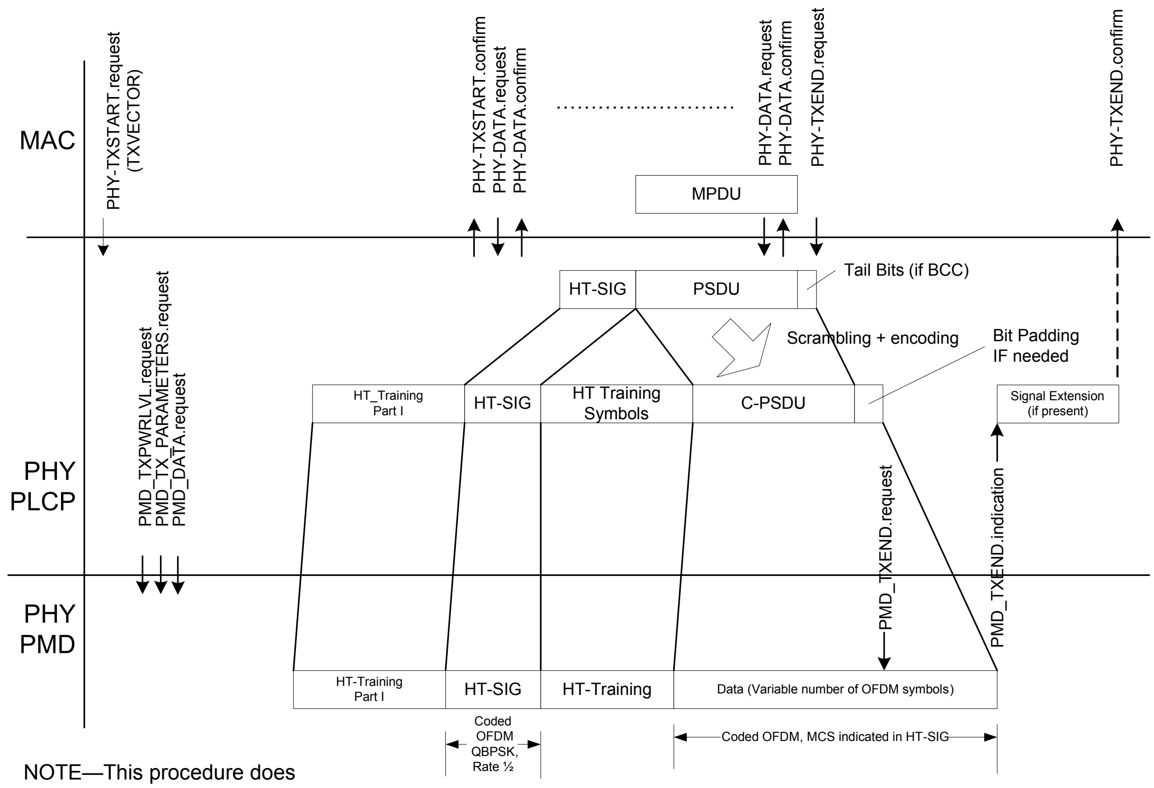


Figure 20-21—PLCP transmit procedure (HT-greenfield format PPDU)

The PLCP shall issue the parameters in the following PMD primitives to configure the PHY:

— PMD_TXPWRLVL
— PMD_TX_PARAMETERS

The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the FEC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2.

The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the FEC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3. At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHY-TXSTART shall be disabled by receiving a PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field.

The packet transmission shall be completed, and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the length of the coded PSDU (C-PSDU) is not an integral multiple of the OFDM symbol length, bits shall be stuffed to make the C-PSDU length an integral multiple of the OFDM symbol length.

In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread.

In some PPDU formats (as defined in 20.3.2), a signal extension is present. When no signal extension is present, the PHY-TXEND.confirm is generated at the end of last symbol of the PPDU. When a signal extension is present, the PHY-TXEND.confirm is generated at the end of the signal extension.

A typical state machine implementation of the transmit PLCP is provided in Figure 20-22. Requests (.request) and confirmations (.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC.

20.3.24 PLCP receive procedure

Typical PLCP receive procedures are shown in Figure 20-23 and Figure 20-24. The receive procedures correspond to HT-mixed format and HT-greenfield format, respectively. A typical state machine implementation of the receive PLCP is given in Figure 20-25. These receive procedures and state machine do not describe the operation of optional features, such as LDPC or STBC. If the detected format indicates a non-HT PPDU format, refer to the receive procedure and state machine in Clause 17 or Clause 19. Further, through station management (via the PLME), the PHY is set to the appropriate frequency, as specified in 20.4. Other receive parameters, such as RSSI and indicated DATARATE, may be accessed via the PHY-SAP.

Upon receiving the transmitted PLCP preamble, PMD_RSSI.indication shall report a receive signal strength to the PLCP. This PHY indicates activity to the MAC via PHY-CCA.indication. PHY-CCA.indication(BUSY, channel-list) shall also be issued as an initial indication of reception of a signal. The channel-list parameter of the PHY-CCA.indication is determined as follows:

- It is absent when the operating channel width is 20 MHz
- It is set to {primary} when the operating channel width is 40 MHz and the signal is present only in the primary channel
- It is set to {secondary} when the operating channel width is 40 MHz and the signal is present only in the secondary channel
- It is set to {primary, secondary} when the operating channel width is 40 MHz and the signal is present in both the primary and secondary channels.

The PMD primitive PMD_RSSI is issued to update the RSSI and parameter reported to the MAC.

After the PHY-CCA.indication(BUSY, channel-list) is issued, the PHY entity shall begin receiving the training symbols and searching for SIGNAL and HT-SIG in order to set the length of the data stream, the demodulation type, code type, and the decoding rate. If signal loss occurs before validating L-SIG and/or HT-SIG, the HT PHY shall maintain PHY-CCA.indication(BUSY, channel-list) until the received level drops below the CCA sensitivity level (for a missed preamble) specified in 20.3.22.5. If the check of the HT-SIG CRC is not valid, a PHY-RXSTART.indication is not issued. The PHY shall issue the error condition PHY-RXEND.indication(FormatViolation). The HT PHY shall maintain PHY-CCA.indication(BUSY, channel-list) until the received level drops below the CCA sensitivity level (for a missed preamble) specified in 20.3.22.5.

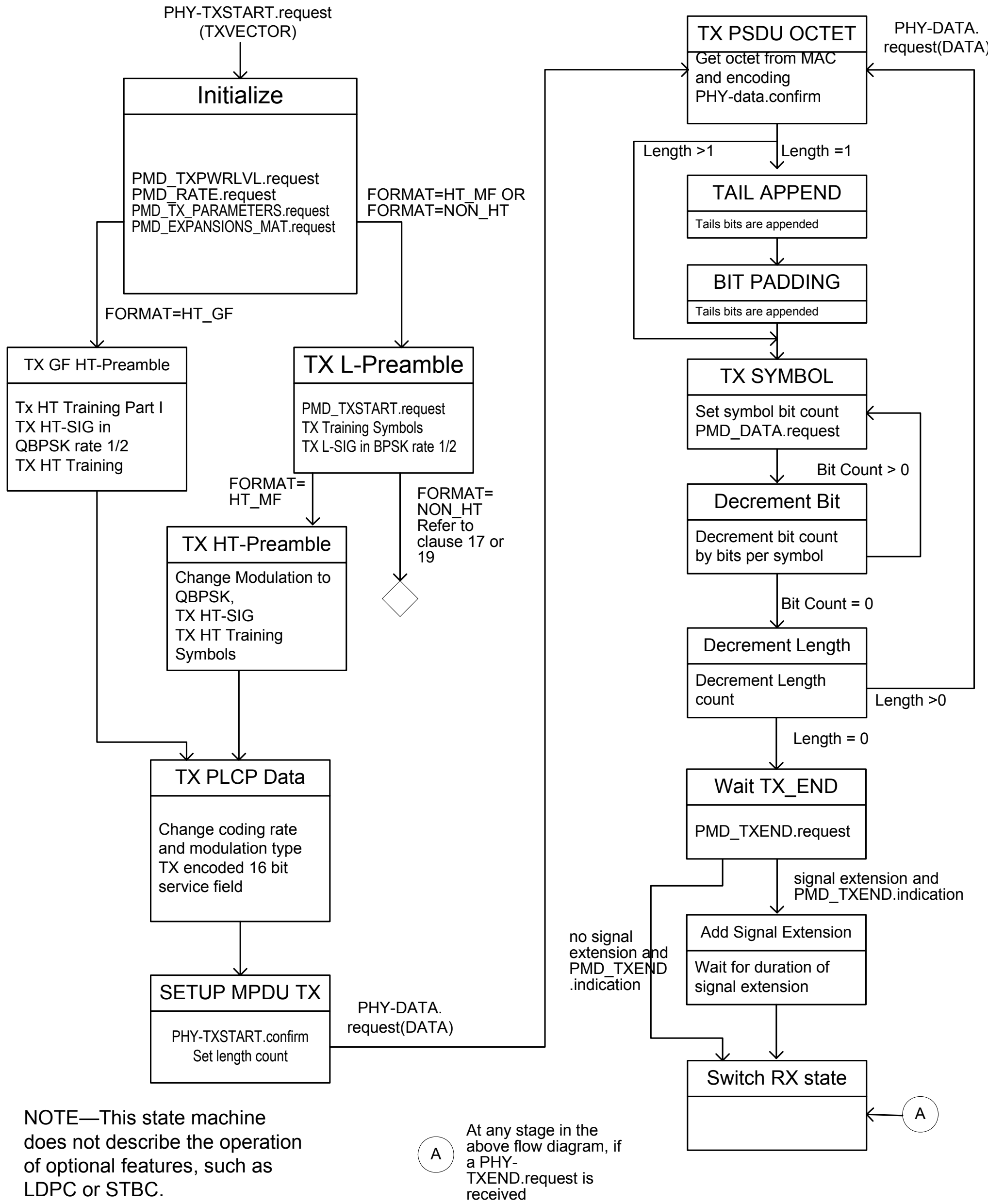


Figure 20-22—PLCP transmit state machine

If the PLCP preamble reception is successful and a valid HT-SIG CRC is indicated:

— Upon reception of an HT-mixed format preamble, the HT PHY shall maintain PHY-CCA.indication(BUSY, channel-list) for the predicted duration of the transmitted frame, as defined by TXTIME in 20.4.3, for all supported and unsupported modes except Reserved HT-SIG Indication. Reserved HT-SIG Indication is defined in the fourth bullet below.

— Upon reception of a GF preamble by an HT STA that does not support GF, PHY-CCA.indication(BUSY, channel-list) shall be maintained until either the predicted duration of the packet from the contents of the HT-SIG field, as defined by TXTIME in 20.4.3, except Reserved HT-SIG Indication, elapses or until the received level drops below the receiver minimum sensitivity level of BPSK, R=1/2 in Table 20-22 + 10 dB (–72 dBm for 20 MHz, –69 dBm for 40 MHz). Reserved HT-SIG Indication is defined in the fourth bullet below.

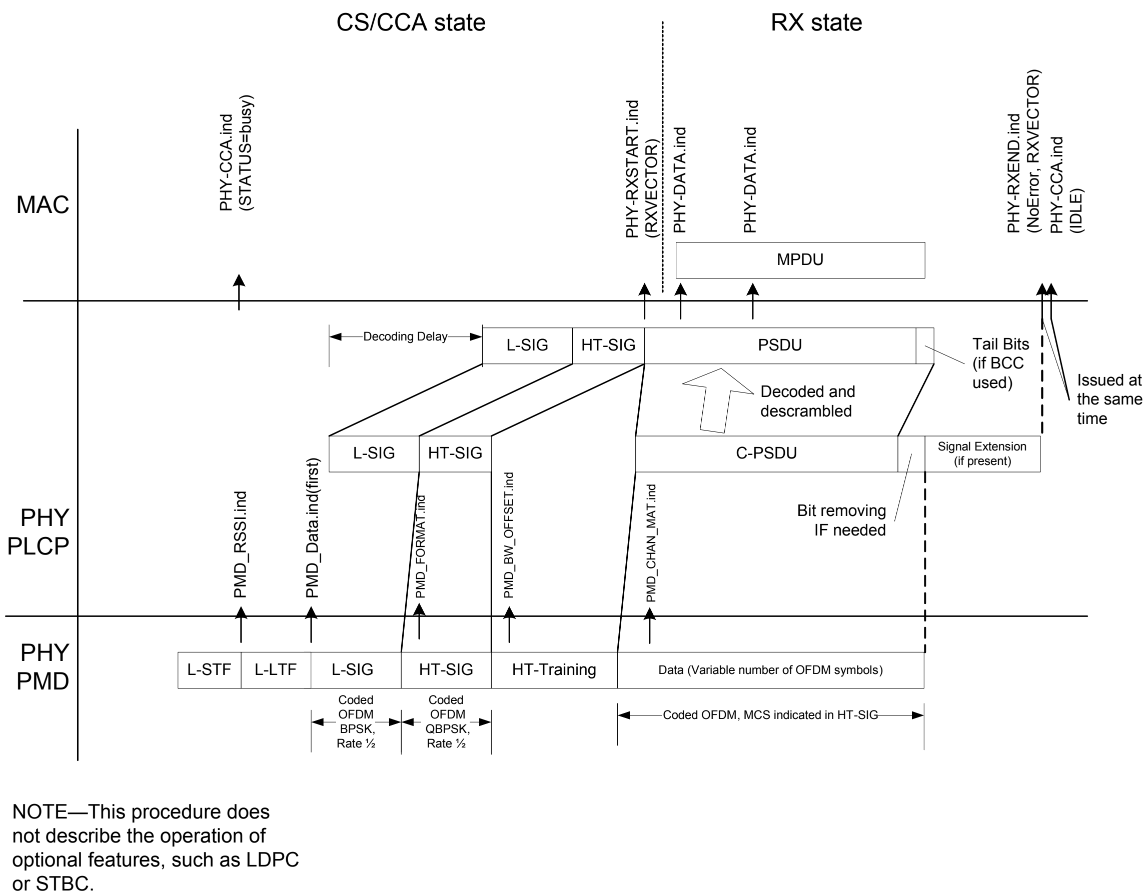
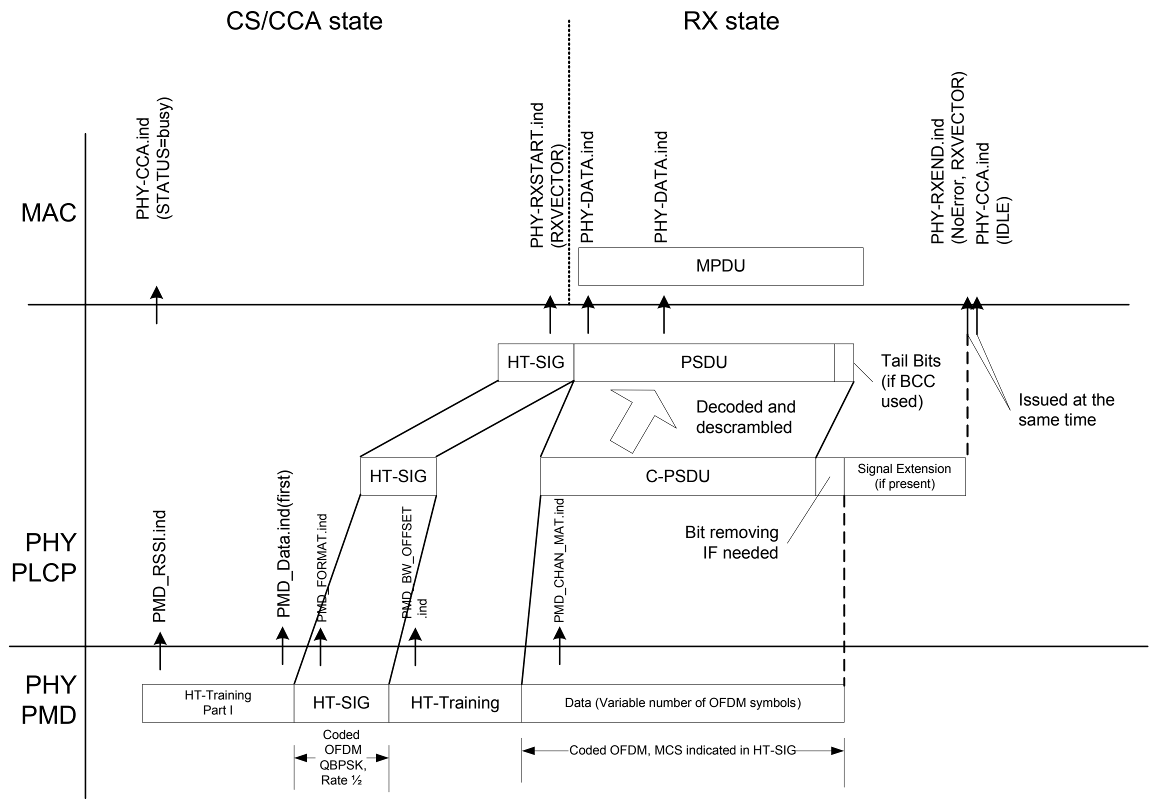


Figure 20-23—PLCP receive procedure for HT-mixed format PLCP format

— Upon reception of a GF preamble by an HT STA that supports GF, the HT PHY shall maintain PHY-CCA.indication(BUSY, channel-list) for the predicted duration of the transmitted frame, as defined by TXTIME in 20.4.3, for all supported and unsupported modes except Reserved HT-SIG Indication. Reserved HT-SIG Indication is defined in the fourth bullet below.

— If the HT-SIG indicates a Reserved HT-SIG Indication, the HT PHY shall maintain PHY-CCA.indication(BUSY, channel-list) until the received level drops below the CCA sensitivity level (minimum modulation and coding rate sensitivity + 20 dB) specified in 20.3.22.5. Reserved HT-SIG Indication is defined as an HT-SIG with MCS field in the range 77–127 or Reserved field = 0 or STBC field = 3 and any other HT-SIG field bit combinations that do not correspond to modes of PHY operation defined in Clause 20.

Subsequent to an indication of a valid HT-SIG CRC, a PHY-RXSTART.indication(RXVECTOR) shall be issued. The RXVECTOR associated with this primitive includes the parameters specified in Table 20-1. Upon reception of a GF preamble by an HT STA that does not support GF, the FORMAT field of RXVECTOR is set to HT_GF, the remaining fields may be empty, and the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation). If the HT-SIG indicates an unsupported mode or Reserved HT-SIG Indication, the PHY shall issue the error condition PHY-RXEND.indication(UnsupportedRate).



NOTE—This procedure does not describe the operation of optional features, such as LDPC or STBC.

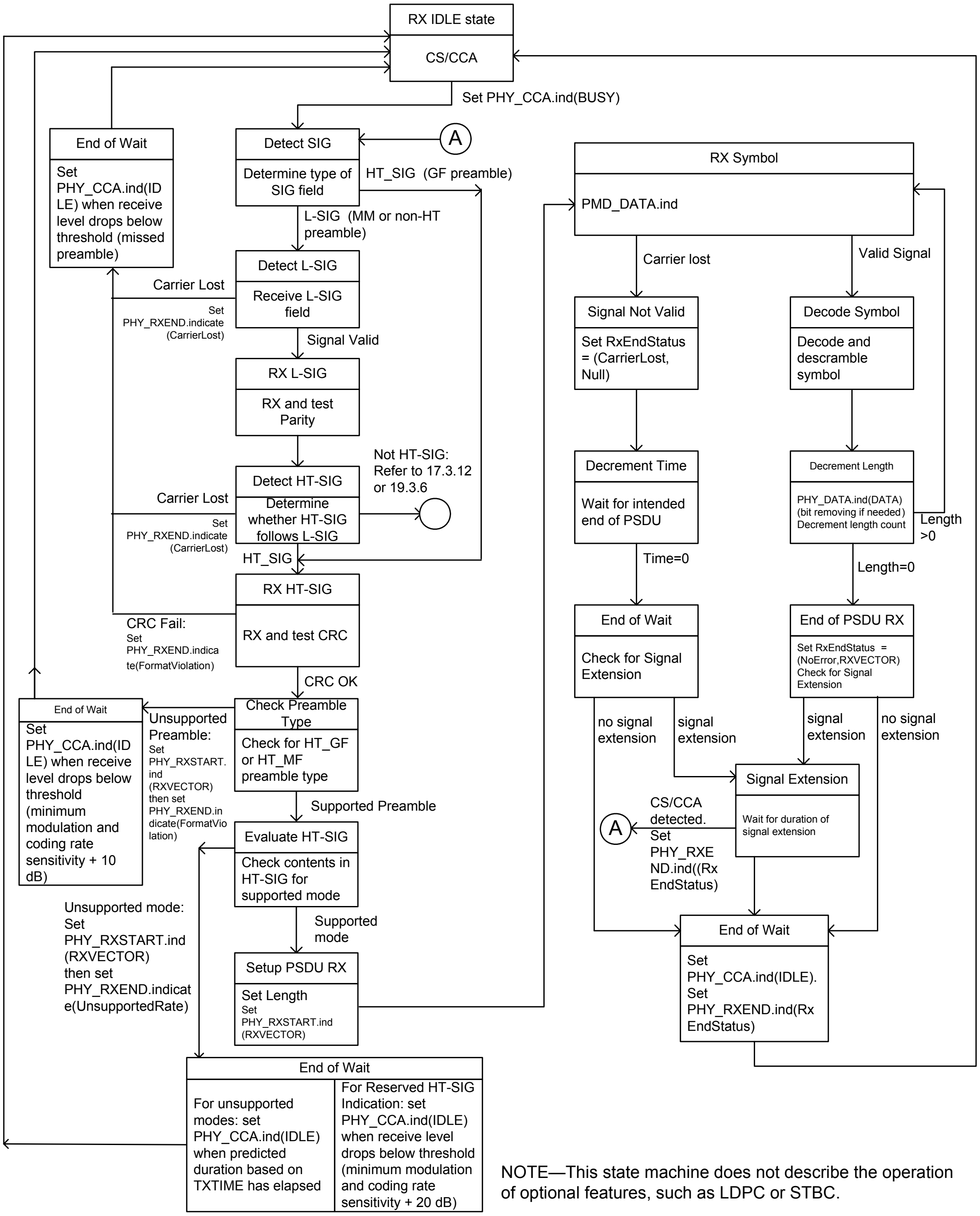
Figure 20-24—PLCP receive procedure for HT-greenfield format PLCP

Following training and SIGNAL fields, the coded PSDU (C-PSDU) (which comprises the coded PLCP SERVICE field and scrambled and coded PSDU) shall be received. If signal loss occurs during reception prior to completion of the PSDU reception, the error condition PHY-RXEND.indication(CarrierLost) shall be reported to the MAC. After waiting for the intended end of the PSDU, if no signal extension is present (as defined in 20.3.2), the PHY shall set PHY-CCA.indication(IDLE) and return to RX IDLE state. Otherwise, the receiver waits for the duration of the signal extension before returning to the RX IDLE state.

The received PSDU bits are assembled into octets, decoded, and presented to the MAC using a series of PHY-DATA.indication(DATA) primitive exchanges. The number of PSDU octets is indicated in the HT Length field of the HT-SIG. The PHY shall proceed with PSDU reception. After the reception of the final bit of the last PSDU octet and possible tail and padding bits, the receiver shall be returned to the RX IDLE state if no signal extension is present (as defined in 20.3.2), as shown in Figure 20-25. Otherwise, the receiver waits for the duration of the signal extension before returning to the RX IDLE state. A PHY-RXEND.indication(NoError) primitive shall be issued on entry to the RX IDLE state.

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

If the binary convolutional code is used, any data received after the indicated data length are considered pad bits (to fill out an OFDM symbol) and should be discarded.



NOTE—This state machine does not describe the operation of optional features, such as LDPC or STBC.

Figure 20-25—PLCP receive state machine

20.4 HT PLME

20.4.1 PLME_SAP sublayer management primitives

Table 20-23 lists the MIB attributes that may be accessed by the PHY entities and the intralayer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 10.4.

20.4.2 PHY MIB

HT PHY MIB attributes are defined in Annex D with specific values defined in Table 20-23. The "Operational semantics" column in Table 20-23 contains two types: static and dynamic.

— Static MIB attributes are fixed and cannot be modified for a given PHY implementation.

— Dynamic MIB attributes are interpreted according to the MAX-ACCESS field of the MIB variable. When MAX-ACCESS is set to read-only, the MIB variable value may be updated by the PLME and read from the MIB variable by management entities. When MAX-ACCESS is set to read-write, the MIB variable may be read and written by management entities.

Table 20-23—HT PHY MIB attributes

Managed object	Default value/range	Operational semantics
dot11PHYOperationTable		
dot11PHYType	HT (X'07')	Static
dot11CurrentRegDomain	Implementation dependent	Dynamic
dot11TempType	Implementation dependent	Static
dot11PHYAntennaTable		
dot11CurrentTxAntenna	Implementation dependent	Dynamic
dot11DiversitySupport	Implementation dependent	Static
dot11CurrentRxAntenna	Implementation dependent	Dynamic
dot11AntennaSelectionOptionImplemented	False/Boolean	Static
dot11TransmitExplicitCSIFeedbackASOptionImplemented	False/Boolean	Static
dot11TransmitIndicesFeedbackASOptionImplemented	False/Boolean	Static
dot11ExplicitCSIFeedbackASOptionImplemented	False/Boolean	Static
dot11TransmitIndicesComputationASOptionImplemented	False/Boolean	Static
dot11ReceiveAntennaSelectionOptionImplemented	False/Boolean	Static
dot11TransmitSoundingPPDUOptionImplemented	False/Boolean	Static

Table 20-23—HT PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11PHYTxPowerTable		
dot11NumberSupportedPowerLevels	Implementation dependent	Static
dot11TxPowerLevel1	Implementation dependent	Static
dot11TxPowerLevel2	Implementation dependent	Static
dot11TxPowerLevel3	Implementation dependent	Static
dot11TxPowerLevel4	Implementation dependent	Static
dot11TxPowerLevel5	Implementation dependent	Static
dot11TxPowerLevel6	Implementation dependent	Static
dot11TxPowerLevel7	Implementation dependent	Static
dot11TxPowerLevel8	Implementation dependent	Static
dot11CurrentTxPowerLevel	Implementation dependent	Dynamic
dot11PhyDSSSTable		
dot11CurrentChannel	Implementation dependent	Dynamic
dot11RegDomainsSupportedTable		
dot11RegDomainsSupported	Implementation dependent	Static
dot11FrequencyBandsSupported	Implementation dependent	Static
dot11PHYAntennasListTable		
dot11SupportedTxAntenna	Implementation dependent	Dynamic
dot11SupportedRxAntenna	Implementation dependent	Static
dot11DiversitySelectionRx	Implementation dependent	Dynamic

Table 20-23—HT PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11SupportedDataRatesTxTable		
dot11SupportedDataratesTxValue	X'02' = 1 Mb/s (2.4) X'04' = 2 Mb/s (2.4) X'0B' = 5.5 Mb/s (2.4) X'16' = 11 Mb/s (2.4) X'0C' = 6 Mb/s X'12' = 9 Mb/s X'18' = 12 Mb/s X'24' = 18 Mb/s X'2C = 22 Mb/s X'30' = 24 Mb/s X'42 = 33 Mb/s X'48' = 36 Mb/s X'60' = 48 Mb/s X'6C' = 54 Mb/s	Static
dot11SupportedDataRatesRxTable		
dot11SupportedDataratesRxValue	X'02' = 1 Mb/s (2.4) X'04' = 2 Mb/s (2.4) X'0B' = 5.5 Mb/s (2.4) X'16' = 11 Mb/s (2.4) X'0C' = 6 Mb/s X'12' = 9 Mb/s X'18' = 12 Mb/s X'24' = 18 Mb/s X'2C = 22 Mb/s X'30' = 24 Mb/s X'42 = 33 Mb/s X'48' = 36 Mb/s X'60' = 48 Mb/s X'6C' = 54 Mb/s	Static
dot11HRDSSSPHYTable		
dot11ShortPreambleOptionImplemented	True	Static
dot11PBCCOptionImplemented	Implementation dependent	Static
dot11ChannelAgilityPresent	False/Boolean	Static
dot11ChannelAgilityEnabled	False/Boolean	Static
dot11PHYOFDMTable		
dot11CurrentFrequency	Implementation dependent	Dynamic
dot11TIThreshold	Implementation dependent	Dynamic
dot11 Channel starting factor	Implementation dependent	Dynamic

Table 20-23—HT PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11PHYERPTable		
dot11ERP-PBCCOptionImplemented	Implementation dependent	Static
dot11DSSS-OFDMOptionImplemented	Implementation dependent	Static
dot11DSSS-OFDMOptionEnabled	Implementation dependent	Dynamic
dot11ShortSlotTimeOptionImplemented	Implementation dependent	Static
dot11ShortSlotTimeOptionEnabled	Implementation dependent	Dynamic
dot11PHYHTTable		
dot11FortyMHzOperationImplemented	False/Boolean	Static
dot11FortyMHzOperationEnabled	False/Boolean	Dynamic
dot11CurrentPrimaryChannel	Implementation dependent	Dynamic
dot11CurrentSecondaryChannel	Implementation dependent	Dynamic
dot11NumberOfSpatialStreamsImplemented	Implementation dependent	Static
dot11NumberOfSpatialStreamsEnabled	Implementation dependent	Dynamic
dot11HTGreenfieldOptionImplemented	False/Boolean	Static
dot11HTGreenfieldOptionEnabled	False/Boolean	Dynamic
dot11ShortGIOptionInTwentyImplemented	False/Boolean	Static
dot11ShortGIOptionInTwentyEnabled	False/Boolean	Dynamic
dot11ShortGIOptionInFortyImplemented	False/Boolean	Static
dot11ShortGIOptionInFortyEnabled	False/Boolean	Dynamic
dot11LDPCCodingOptionImplemented	False/Boolean	Static
dot11LDPCCodingOptionEnabled	False/Boolean	Dynamic
dot11TxSTBCOptionImplemented	False/Boolean	Static
dot11TxSTBCOptionEnabled	False/Boolean	Dynamic
dot11RxSTBCOptionImplemented	False/Boolean	Static
dot11RxSTBCOptionEnabled	False/Boolean	Dynamic
dot11BeamFormingOptionImplemented	False/Boolean	Static
dot11BeamFormingOptionEnabled	False/Boolean	Dynamic

Table 20-23—HT PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11HTSupportedMCSTxTable		
dot11SupportedMCSTxValue	MCS 0–76 for 20 MHz; MCS 0–76 for 40 MHz (MCS 0–7 for 20 MHz mandatory at non-AP STA; MCS 0–15 for 20 MHz mandatory at AP)	Static
dot11HTSupportedMCSRxTable		
dot11SupportedMCSRxValue	MCS 0–76 for 20 MHz; MCS 0–76 for 40 MHz (MCS 0–7 for 20 MHz mandatory at non-AP STA; MCS 0–15 for 20 MHz mandatory at AP)	Static
dot11TransmitBeamformingConfigTable		
dot11ReceiveStaggerSoundingOptionImplemented	False/Boolean	Static
dot11TransmitStaggerSoundingOptionImplemented	False/Boolean	Static
dot11ReceiveNDPOptionImplemented	False/Boolean	Static
dot11TransmitNDPOptionImplemented	False/Boolean	Static
dot11ImplicitTransmitBeamformingOptionImplemented	False/Boolean	Static
dot11CalibrationOptionImplemented	Implementation dependent	Static
dot11ExplicitCSITransmitBeamformingOptionImplemented	False/Boolean	Static
dot11ExplicitNonCompressedBeamformingMatrixOptionImplemented	False/Boolean	Static
dot11ExplicitTransmitBeamformingCSIFeedbackOptionImplemented	Implementation dependent	Static
dot11ExplicitNoncompressedBeamformingFeedbackOptionImplemented	Implementation dependent	Static
dot11ExplicitCompressedBeamformingFeedbackOptionImplemented	Implementation dependent	Static
dot11NumberBeamFormingCSISupportAntenna	Implementation dependent	Static
dot11NumberNonCompressedBeamformingMatrixSupportAntenna	Implementation dependent	Static
dot11NumberCompressedBeamformingMatrixSupportAntenna	Implementation dependent	Static

Table 20-23—HT PHY MIB attributes *(continued)*

Managed object	Default value/range	Operational semantics
dot11TxMCSSetDefined	False/Boolean	Static
dot11TxRxMCSSetNotEqual	False/Boolean	Static
dot11TxMaximumNumberSpatialStreamsSupported	False/Boolean	Static
dot11TxUnequalModulationSupported	False/Boolean	Static

20.4.3 TXTIME calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive or calculated for the PLCP receive procedure shall be calculated for HT-mixed format according to the Equation (20-91) and Equation (20-92) for short and regular GI, respectively, and for HT-greenfield format according to Equation (20-93) and Equation (20-94) for short and regular GI, respectively:

$$\begin{aligned}\text{TXTIME} = {} & T_{LEG\_PREAMBLE} + T_{L\_SIG} + T_{HT\_PREAMBLE} + T_{HT\_SIG} \\ & + T_{SYM} \times \text{Ceiling}\left(\frac{T_{SYMS} \times N_{SYM}}{T_{SYM}}\right) + SignalExtension\end{aligned} \tag{20-91}$$

$$\begin{aligned}\text{TXTIME} = {} & T_{LEG\_PREAMBLE} + T_{L\_SIG} + T_{HT\_PREAMBLE} + T_{HT\_SIG} \\ & + T_{\text{SYM}} \times N_{SYM} + SignalExtension\end{aligned} \tag{20-92}$$

$$\text{TXTIME} = T_{GF\_HT\_PREAMBLE} + T_{HT\_SIG} + T_{SYMS} \times N_{SYM} + SignalExtension \tag{20-93}$$

$$\text{TXTIME} = T_{GF\_HT\_PREAMBLE} + T_{HT\_SIG} + T_{SYM} \times N_{SYM} + SignalExtension \tag{20-94}$$

where

$T_{LEG\_PREAMBLE} = T_{L\text{-}STF} + T_{L\text{-}LTF}$ is the duration of the non-HT preamble

$T_{HT\_PREAMBLE}$ is the duration of the HT preamble in HT-mixed format, given by $T_{HT-STF} + T_{HT-LTF1} + (N_{LTF} - 1)T_{HT-LTFs}$

$T_{GF\_HT\_PREAMBLE}$ is the duration of the preamble in HT-greenfield format, given by $T_{HT-GF-STF} + T_{HT-LTF1} + (N_{LTF} - 1)T_{HT-LTFs}$

T_{SYM}, T_{SYMS}, $T_{HT\text{-}SIG}$, $T_{L\text{-}STF}$, $T_{HT\text{-}STF}$, $T_{HT\text{-}GF\text{-}STF}$, $T_{L\text{-}LTF}$, $T_{HT\text{-}LTF1}$ and $T_{HT\text{-}LTFs}$ are defined in Table 20-5

SignalExtension is 0 µs when TXVECTOR parameter NO_SIG_EXTN is TRUE and is the duration of signal extension as defined by aSignalExtension in Table 20-4 when TXVECTOR parameter NO_SIG_EXTN is FALSE

N_{LTF} is defined in Equation (20-22)

N_{SYM} is the total number of data symbols in the data portion, which may be calculated according to Equation (20-95)

$$N_{SYM} = m_{STBC} \times \mathrm{Ceil}\left(\frac{8 \cdot length + 16 + 6 \cdot N_{ES}}{m_{STBC} \cdot N_{DBPS}}\right) \quad \text{When BCC is used}$$
$$N_{SYM} = \frac{N_{avbits}}{N_{CBPS}} \quad \text{When LDPC is used} \tag{20-95}$$

where

length	is the number of octets in the data portion of the PPDU
m_{STBC}	is equal to 2 when STBC is used, and otherwise 1
N_{ES} and N_{CBPS}	are defined in Table 20-6
N_{DBPS}	is defined in Table 20-28
N_{avbits}	is defined in Equation (20-39)

For non-HT modes of operation, refer to Clause 17 and Clause 19 for TXTIME calculations, except that frames transmitted with a value of NON_HT_DUP_OFDM for the TXVECTOR parameter NON_HT_MODULATION shall use Equation (19-6) for TXTIME calculation.

20.4.4 PHY characteristics

The static HT PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 20-24. The definitions for these characteristics are given in 10.4.

Table 20-24—MIMO PHY characteristics

Characteristics	Value
aRIFSTime	2 µs
aSlotTime	When operating in the 2.4 GHz band: long = 20 µs, short = 9 µs When operating in the 5 GHz band: 9 µs
aSIFSTime	10 µs when operating in the 2.4 GHz band 16 µs when operating in the 5 GHz bands
aSignalExtension	0 µs when operating in the 5 GHz band 6 µs when operating in the 2.4 GHz band
aCCATime	< 4 µs
aPHY-RX-START-Delay	33 µs for both MF and GF
aRxTxTurnaroundTime	< 2 µs
aTxPLCPDelay	Implementation dependent
aRxPLCPDelay	Implementation dependent
aRxTxSwitchTime	<< 1 µs
aTxRampOnTime	Implementation dependent
aTxRampOffTime	Implementation dependent
aTxRFDelay	Implementation dependent

Table 20-24—MIMO PHY characteristics *(continued)*

Characteristics	Value
aRxRFDelay	Implementation dependent
aAirPropagationTime	<< 1 µs
aMACProcessingDelay	< 2 µs
aPreambleLength	16 µs
aSTFOneLength	8 µs
aSTFTwoLength	4 µs
aLTFOneLength	8 µs
aLTFTwoLength	4 µs
aPLCPHeaderLength	4 µs
aPLCPSigTwoLength	8 µs
aPLCPServiceLength	16 bits
aPLCPConvolutionalTailLength	6 bits
aPSDUMaxLength	65 535 octets
aPPDUMaxTime	10 ms
aIUStime	8 µs
aDTT2UTTTime,	32 µs
aCWmin	15
aCWmax	1023
aMaxCSIMatricesReportDelay	250 ms

For non-HT modes of operation, refer to Clause 17 and Clause 19 for PHY characteristics.

20.5 HT PMD sublayer

20.5.1 Scope and field of application

The PMD services provided to the PLCP for the High Throughput (HT) PHY are described in 20.5. Also defined in this subclause are the functional, electrical, and RF characteristics required for interoperability of implementations conforming to this specification. The relationship of this specification to the entire HT PHY is shown in Figure 20-26.

20.5.2 Overview of service

The HT PMD sublayer accepts PLCP sublayer service primitives and provides the actual means by which data are transmitted or received from the medium. The combined function of the HT PMD sublayer primitives and parameters for the receive function results in a data stream, timing information, and associated receive signal parameters being delivered to the PLCP sublayer. A similar functionality is provided for data transmission.

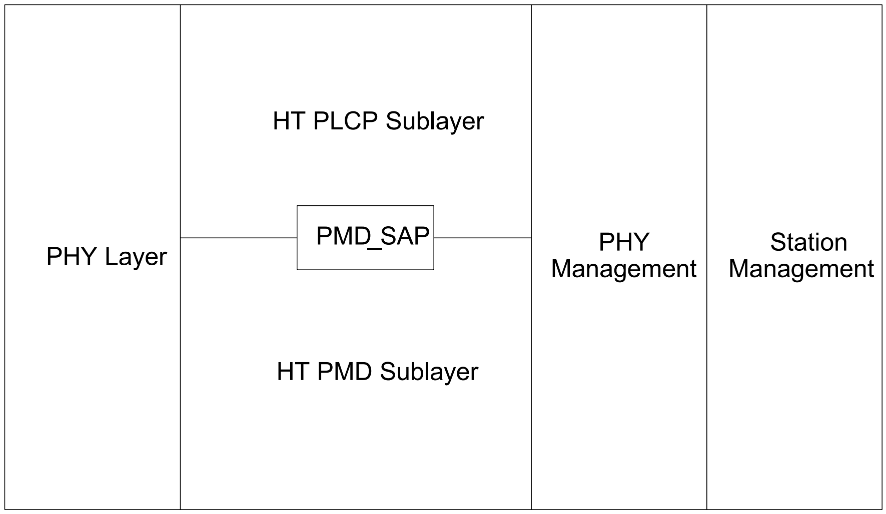


Figure 20-26—PMD layer reference model

20.5.3 Overview of interactions

The primitives provided by the HT PMD fall into two basic categories:

a) Service primitives that support PLCP peer-to-peer interactions
b) Service primitives that have local significance and support sublayer-to-sublayer interactions

20.5.4 Basic service and options

20.5.4.1 Status of service primitives

All of the service primitives described in 20.5.4 are mandatory, unless otherwise specified.

20.5.4.2 PMD_SAP peer-to-peer service primitives

Table 20-25 indicates the primitives for peer-to-peer interactions.

Table 20-25—PMD_SAP peer-to-peer service primitives

Primitive	Request	Indicate	Confirm	Response
PMD_DATA	X	X	—	—

20.5.4.3 PMD_SAP sublayer-to-sublayer service primitives

Table 20-26 indicates the primitives for sublayer-to-sublayer interactions.

Table 20-26—PMD_SAP sublayer-to-sublayer service primitives

Primitive	Request	Indicate	Confirm	Response
PMD_TXSTART	X	—	—	—
PMD_TXEND	X	—	—	—
PMD_TXPWRLVL	X	—	—	—
PMD_TX_PARAMETERS	X	—	—	—
PMD_RSSI	—	X	—	—
PMD_RCPI	—	X	—	—
PMD_CHAN_MAT	—	X	—	—
PMD_FORMAT	—	X	—	—
PMD_CBW_OFFSET	—	X	—	—

20.5.4.4 PMD_SAP service primitive parameters

Table 20-27 shows the parameters used by one or more of the PMD_SAP service primitives.

Table 20-27—List of parameters for PMD primitives

Parameter	Associate primitive	Value
TXD_UNIT	PMD_DATA.request	One OFDM symbol value, N_{DBPS} bits (depending on MCS)
RXD_UNIT	PMD_DATA.indication	Bit, either 0 or 1
TXPWR_LEVEL	PMD_TXPWRLVL.request	1 to 8 (maximum of 8 levels)
MCS	PMD_TX_PARAMETERS.request	0 to 76, MCS index defined in 20.6
CH_BANDWIDTH	PMD_TX_PARAMETERS.request PMD_CBW_OFFSET.indication	The CH_BANDWIDTH parameter indicates whether the packet is transmitted using 40 MHz or 20 MHz channel width. Enumerated type: HT_CBW20, for 20 MHz and for 40 MHz upper and lower modes HT_CBW40, for 40 MHz.
CH_OFFSET	PMD_TX_PARAMETERS.request PMD_CBW_OFFSET.indication	Enumerated type: CH_OFF_20 indicates the use of a 20 MHz channel (that is not part of a 40 MHz channel). CH_OFF_40 indicates the entire 40 MHz channel. CH_OFF_20U indicates the upper 20 MHz of the 40 MHz channel CH_OFF_20L indicates the lower 20 MHz of the 40 MHz channel.

Table 20-27—List of parameters for PMD primitives *(continued)*

Parameter	Associate primitive	Value
STBC	PMD_TX_PARAMETERS.request	Set to a nonzero number indicates the difference between the number of space-time streams N_{STS} and the number of spatial streams N_{SS} indicated by the MCS Set to 00 indicates no STBC (N_{STS}=N_{SS})
GI_TYPE	PMD_TX_PARAMETERS.request	Set to 0 indicates short GI is not used in the packet Set to 1 indicates short GI is used in the packet
ANTENNA_SET	PMD_TX_PARAMETERS.request	Bit field with 8 bits
EXPANSION_MAT	PMD_TX_PARAMETERS.request	$(N_{SD} + N_{SP})$ complex matrices of size $(N_{TX} \times N_{STS})$
EXPANSION_MAT_ TYPE	PMD_TX_PARAMETERS.request	COMPRESSED_SV: EXPANSION_MAT contains a set of compressed beamforming feedback matrices. NON_COMPRESSED_SV: EXPANSION_MAT contains a set of noncompressed beamforming feedback matrices. CSI_MATRICES: EXPANSION_MAT contains a set of CSI matrices
RSSI	PMD_RSSI.indication	0 to 255
RCPI	PMD_RCPI.indication	0 to 255; see 20.3.22.6 for definition of each value.
CHAN_MAT	PMD_CHAN_MAT.indication	$(N_{SD} + N_{SP})$ complex matrices of size $(N_{RX} \times N_{STS})$
FORMAT	PMD_FORMAT.indication	Set to 0 for NON_HT Set to 1 for HT_MF Set to 2 for HT_GF
FEC_CODING	PMD_TX_PARAMETERS.request	Indicates which FEC encoding is used. Enumerated type: BCC_CODING indicates binary convolutional code. LDPC_CODING indicates low-density parity check code.

20.5.5 PMD_SAP detailed service specification

20.5.5.1 Introduction to PMD_SAP service specification

Subclauses 20.5.5.2 through 20.5.5.13 describe the services provided by each PMD primitive.

20.5.5.2 PMD_DATA.request

20.5.5.2.1 Function

This primitive defines the transfer of data from the PLCP sublayer to the PMD entity.

20.5.5.2.2 Semantics of the service primitive

This primitive shall provide the following parameters: PMD_DATA.request (TXD_UNIT)

The TXD_UNIT parameter shall be the *n*-bit combination of 0 and 1 for one symbol of OFDM modulation. If the length of a coded PSDU (C-PSDU) is shorter than *n* bits, 0 bits are added to form an OFDM symbol. This parameter represents a single block of data that, in turn, shall be used by the PHY to be encoded into an OFDM transmitted symbol.

20.5.5.2.3 When generated

This primitive shall be generated by the PLCP sublayer to request transmission of one OFDM symbol.

20.5.5.2.4 Effect of receipt

The PMD performs transmission of the data.

20.5.5.3 PMD_DATA.indication

20.5.5.3.1 Function

This primitive defines the transfer of data from the PMD entity to the PLCP sublayer.

20.5.5.3.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_DATA.indication(RXD_UNIT)

The RXD_UNIT parameter shall be 0 or 1 and shall represent either a SIGNAL field bit or a data field bit after the decoding of the FEC by the PMD entity.

20.5.5.3.3 When generated

This primitive, generated by the PMD entity, forwards received data to the PLCP sublayer.

20.5.5.3.4 Effect of receipt

The PLCP sublayer decodes the bits that it receives from the PMD and either interprets them as part of its own signaling or passes them to the MAC sublayer as part of the PSDU after any necessary additional processing (e.g., descrambling).

20.5.5.4 PMD_TXSTART.request

20.5.5.4.1 Function

This primitive, generated by the PHY PLCP sublayer, initiates PPDU transmission by the PMD layer.

20.5.5.4.2 Semantics of the service primitive

This primitive has no parameters.

20.5.5.4.3 When generated

This primitive shall be generated by the PLCP sublayer to initiate the PMD layer transmission of the PPDU. The PHY-TXSTART.request primitive shall be provided to the PLCP sublayer prior to issuing the PMD_TXSTART command.

20.5.5.4.4 Effect of receipt

PMD_TXSTART initiates transmission of a PPDU by the PMD sublayer.

20.5.5.5 PMD_TXEND.request

20.5.5.5.1 Function

This primitive, generated by the PHY PLCP sublayer, ends PPDU transmission by the PMD layer.

20.5.5.5.2 Semantics of the service primitive

This primitive has no parameters.

20.5.5.5.3 When generated

This primitive shall be generated by the PLCP sublayer to terminate the PMD layer transmission of the PPDU.

20.5.5.5.4 Effect of receipt

PMD_TXEND terminates transmission of a PPDU by the PMD sublayer.

20.5.5.6 PMD_TXEND.confirm

20.5.5.6.1 Function

This primitive, generated by the PMD entity, indicates the end of PPDU transmission by the PMD layer. It is generated at the 4 µs boundary following the trailing boundary of the last symbol transmitted.

20.5.5.6.2 Semantics of the service primitive

This primitive has no parameters.

20.5.5.6.3 When generated

This primitive shall be generated by the PMD entity at the 4 µs boundary following the trailing boundary of the last symbol transmitted.

20.5.5.6.4 Effect of receipt

The PLCP sublayer determines that transmission of the last symbol of the PPDU is complete. This completion is used as a timing reference in the PLCP state machines. See 20.3.23.

20.5.5.7 PMD_TXPWRLVL.request

20.5.5.7.1 Function

This primitive, generated by the PHY PLCP sublayer, selects the power level used by the PHY for transmission.

20.5.5.7.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_TXPWRLVL.request (TXPWR_LEVEL)

TXPWR_LEVEL selects which of the transmit power levels should be used for the current packet transmission. The number of available power levels shall be determined by the MIB parameter aNumberSupportedPowerLevels. See 20.3.21.3 for further information on the OFDM PHY power level control capabilities.

20.5.5.7.3 When generated

This primitive shall be generated by the PLCP sublayer to select a specific transmit power. This primitive shall be applied prior to setting PMD_TXSTART into the transmit state.

20.5.5.7.4 Effect of receipt

PMD_TXPWRLVL immediately sets the transmit power level to the level given by TXPWR_LEVEL.

20.5.5.8 PMD_RSSI.indication

20.5.5.8.1 Function

This primitive, generated by the PMD sublayer, provides the receive signal strength to the PLCP and MAC entity.

20.5.5.8.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_RSSI.indication (RSSI)

The RSSI shall be a measure of the RF energy received by the HT PHY. RSSI indications of up to 8 bits (256 levels) are supported.

20.5.5.8.3 When generated

This primitive shall be generated by the PMD after the reception of the HT training fields.

20.5.5.8.4 Effect of receipt

This parameter shall be provided to the PLCP layer for information only. The RSSI may be used as part of a CCA scheme.

20.5.5.9 PMD_RCPI.indication

20.5.5.9.1 Function

This primitive, generated by the PMD sublayer, provides the received channel power indicator to the PLCP and MAC entity.

20.5.5.9.2 Semantics of the service primitive

The primitive shall provide the following parameter: PMD_RCPI.indication(RCPI).

The RCPI is a measure of the channel power received by the OFDM PHY. RCPI measurement and parameter values are defined in 20.3.22.6.

20.5.5.9.3 When generated

This primitive shall be generated by the PMD when the OFDM PHY is in the receive state. It is generated at the end of the last received symbol.

20.5.5.9.4 Effect of receipt

This parameter shall be provided to the PLCP layer for information only. The RCPI may be used in conjunction with RSSI to measure input signal quality.

20.5.5.10 PMD_TX_PARAMETERS.request

20.5.5.10.1 Function

This primitive, generated by the PHY PLCP sublayer, selects the related parameters used by the PHY for transmission.

20.5.5.10.2 Semantics of the service primitive

This primitive shall provide the following parameters:

PMD_TX_PARAMETERS.request (MCS, CH_BANDWIDTH, CH_OFFSET, STBC, GI_TYPE, ANTENNA_SET, FEC_CODING, PMD_EXPANSIONS_MAT, PMD_EXPANSIONS_MAT_TYPE)

20.5.5.10.3 When generated

This primitive shall be generated by the PLCP sublayer to select a specific transmit parameter. This primitive shall be applied prior to setting PMD_TXSTART into the transmit state.

20.5.5.10.4 Effect of receipt

PMD_TX_PARAMETERS immediately sets the transmit parameters. The receipt of these parameters selects the values that shall be used for all subsequent PPDU transmissions

20.5.5.11 PMD_CBW_OFFSET.indication

20.5.5.11.1 Function

This primitive, generated by the PMD sublayer, provides the bandwidth and channel offset of the received frame to the PLCP and MAC entity.

20.5.5.11.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_CBW_OFFSET.indication (CH_BANDWIDTH, CH_OFFSET)

CH_BANDWIDTH represents channel width (20 MHz or 40 MHz) in which the data are transmitted and the transmission format (non-HT duplicate or MCS 32). CH_OFFSET indicates in a 20 MHz bandwidth, in a 20 MHz subchannel of the 40 MHz channel (upper or lower), or in the entire 40 MHz channel.

20.5.5.11.3 When generated

This primitive shall be generated by the PMD when the OFDM PHY is in the receive state. It shall be available continuously to the PLCP that, in turn, shall provide the parameter to the MAC entity.

20.5.5.11.4 Effect of receipt

The PLCP sublayer passes the data to the MAC sublayer as part of the RXVECTOR.

20.5.5.12 PMD_CHAN_MAT.indication

20.5.5.12.1 Function

This primitive, generated by the PMD sublayer, provides the channel response matrices to the PLCP and MAC entity.

20.5.5.12.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_CHAN_MAT.indication (CHAN_MAT)

The CHAN_MAT parameter contains the channel response matrices that were measured during the reception of the current frame.

20.5.5.12.3 When generated

This primitive shall be generated by the PMD when the OFDM PHY is in the receive state. It shall be available continuously to the PLCP that, in turn, shall provide the parameter to the MAC entity.

20.5.5.12.4 Effect of receipt

The PLCP sublayer passes the data to the MAC sublayer as part of the RXVECTOR.

20.5.5.13 PMD_FORMAT.indication

20.5.5.13.1 Function

This primitive, generated by the PMD sublayer, provides the format of the received frame to the PLCP and MAC entity.

20.5.5.13.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_FORMAT.indication (FORMAT).

The format indicates one of the PPDU formats: non HT, HT-mixed format, or HT-greenfield format.

20.5.5.13.3 When generated

This primitive shall be generated by the PMD after the reception of the HT training fields.

20.5.5.13.4 Effect of receipt

The PLCP sublayer passes the data to the MAC sublayer as part of the RXVECTOR.

20.6 Parameters for HT MCSs

Table 20-28 defines the symbols used in the rate-dependent parameter tables.

Table 20-28—Symbols used in MCS parameter tables

Symbol	Explanation
N_{SS}	Number of spatial streams
R	Coding rate
N_{BPSC}	Number of coded bits per single carrier (total across spatial streams)
$N_{BPSCS}(i_{SS})$	Number of coded bits per single carrier for each spatial stream, $i_{SS} = 1,...,N_{SS}$
N_{SD}	Number of complex data numbers per spatial stream per OFDM symbol
N_{SP}	Number of pilot values per OFDM symbol
N_{CBPS}	Number of coded bits per OFDM symbol
N_{DBPS}	Number of data bits per OFDM symbol
N_{ES}	Number of BCC encoders for the DATA field
N_{TBPS}	Total bits per subcarrier

The rate-dependent parameters for mandatory 20 MHz, N_{SS} = 1 MCSs with N_{ES} = 1 shall be as shown in Table 20-29.

Table 20-29—MCS parameters for mandatory 20 MHz, N_{SS} = 1, N_{ES} = 1

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
								800 ns GI	400 ns GI (see NOTE)
0	BPSK	1/2	1	52	4	52	26	6.5	7.2
1	QPSK	1/2	2	52	4	104	52	13.0	14.4
2	QPSK	3/4	2	52	4	104	78	19.5	21.7
3	16-QAM	1/2	4	52	4	208	104	26.0	28.9
4	16-QAM	3/4	4	52	4	208	156	39.0	43.3
5	64-QAM	2/3	6	52	4	312	208	52.0	57.8
6	64-QAM	3/4	6	52	4	312	234	58.5	65.0
7	64-QAM	5/6	6	52	4	312	260	65.0	72.2
NOTE—Support of 400 ns GI is optional on transmit and receive.									

The rate-dependent parameters for optional 20 MHz, N_{SS} = 2 MCSs with N_{ES} = 1 and EQM of the spatial streams shall be as shown in Table 20-30.

Table 20-30—MCS parameters for optional 20 MHz, N_{SS} = 2, N_{ES} = 1, EQM

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
								800 ns GI	400 ns GI (see NOTE)
8	BPSK	1/2	1	52	4	104	52	13.0	14.4
9	QPSK	1/2	2	52	4	208	104	26.0	28.9
10	QPSK	3/4	2	52	4	208	156	39.0	43.3
11	16-QAM	1/2	4	52	4	416	208	52.0	57.8
12	16-QAM	3/4	4	52	4	416	312	78.0	86.7
13	64-QAM	2/3	6	52	4	624	416	104.0	115.6
14	64-QAM	3/4	6	52	4	624	468	117.0	130.0
15	64-QAM	5/6	6	52	4	624	520	130.0	144.4
NOTE—The 400 ns GI rate values are rounded to 1 decimal place.									

The rate-dependent parameters for optional 20 MHz, N_{SS} = 3 MCSs with N_{ES} = 1 and EQM of the spatial streams shall be as shown in Table 20-31.

Table 20-31—MCS parameters for optional 20 MHz, N_{SS} = 3, N_{ES} = 1, EQM

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
								800 ns GI	400 ns GI
16	BPSK	1/2	1	52	4	156	78	19.5	21.7
17	QPSK	1/2	2	52	4	312	156	39.0	43.3
18	QPSK	3/4	2	52	4	312	234	58.5	65.0
19	16-QAM	1/2	4	52	4	624	312	78.0	86.7
20	16-QAM	3/4	4	52	4	624	468	117.0	130.0
21	64-QAM	2/3	6	52	4	936	624	156.0	173.3
22	64-QAM	3/4	6	52	4	936	702	175.5	195.0
23	64-QAM	5/6	6	52	4	936	780	195.0	216.7

The rate-dependent parameters for optional 20 MHz, N_{SS} = 4 MCSs with N_{ES} = 1 and EQM of the spatial streams shall be as shown in Table 20-32.

Table 20-32—MCS parameters for optional 20 MHz, N_{SS} = 4, N_{ES} = 1, EQM

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
								800 ns GI	400 ns GI
24	BPSK	1/2	1	52	4	208	104	26.0	28.9
25	QPSK	1/2	2	52	4	416	208	52.0	57.8
26	QPSK	3/4	2	52	4	416	312	78.0	86.7
27	16-QAM	1/2	4	52	4	832	416	104.0	115.6
28	16-QAM	3/4	4	52	4	832	624	156.0	173.3
29	64-QAM	2/3	6	52	4	1248	832	208.0	231.1
30	64-QAM	3/4	6	52	4	1248	936	234.0	260.0
31	64-QAM	5/6	6	52	4	1248	1040	260.0	288.9

The rate-dependent parameters for optional 40 MHz, N_{SS} = 1 MCSs with N_{ES} = 1 shall be as shown in Table 20-33.

Table 20-33—MCS parameters for optional 40 MHz, N_{SS} = 1, N_{ES} = 1

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
								800 ns GI	400 ns GI
0	BPSK	1/2	1	108	6	108	54	13.5	15.0
1	QPSK	1/2	2	108	6	216	108	27.0	30.0
2	QPSK	3/4	2	108	6	216	162	40.5	45.0
3	16-QAM	1/2	4	108	6	432	216	54.0	60.0
4	16-QAM	3/4	4	108	6	432	324	81.0	90.0
5	64-QAM	2/3	6	108	6	648	432	108.0	120.0
6	64-QAM	3/4	6	108	6	648	486	121.5	135.0
7	64-QAM	5/6	6	108	6	648	540	135.0	150.0

The rate-dependent parameters for optional 40 MHz, N_{SS} = 2 MCSs with N_{ES} = 1 and EQM of the spatial streams shall be as shown in Table 20-34.

Table 20-34—MCS parameters for optional 40 MHz, N_{SS} = 2, N_{ES} = 1, EQM

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
								800 ns GI	400 ns GI
8	BPSK	1/2	1	108	6	216	108	27.0	30.0
9	QPSK	1/2	2	108	6	432	216	54.0	60.0
10	QPSK	3/4	2	108	6	432	324	81.0	90.0
11	16-QAM	1/2	4	108	6	864	432	108.0	120.0
12	16-QAM	3/4	4	108	6	864	648	162.0	180.0
13	64-QAM	2/3	6	108	6	1296	864	216.0	240.0
14	64-QAM	3/4	6	108	6	1296	972	243.0	270.0
15	64-QAM	5/6	6	108	6	1296	1080	270.0	300.0

The rate-dependent parameters for optional 40 MHz, N_{SS} = 3 MCSs, with EQM of the spatial streams shall be as shown in Table 20-35.

Table 20-35—MCS parameters for optional 40 MHz, N_{SS} = 3, EQM

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)	
									800 ns GI	400 ns GI
16	BPSK	1/2	1	108	6	324	162	1	40.5	45.0
17	QPSK	1/2	2	108	6	648	324	1	81.0	90.0
18	QPSK	3/4	2	108	6	648	486	1	121.5	135.0
19	16-QAM	1/2	4	108	6	1296	648	1	162.0	180.0
20	16-QAM	3/4	4	108	6	1296	972	1	243.0	270.0
21	64-QAM	2/3	6	108	6	1944	1296	2	324.0	360.0
22	64-QAM	3/4	6	108	6	1944	1458	2	364.5	405.0
23	64-QAM	5/6	6	108	6	1944	1620	2	405.0	450.0

The rate-dependent parameters for optional 40 MHz, N_{SS} = 4 MCSs, with EQM of the spatial streams shall be as shown in Table 20-36.

Table 20-36—MCS parameters for optional 40 MHz, N_{SS} = 4, EQM

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)	
									800 ns GI	400 ns GI
24	BPSK	1/2	1	108	6	432	216	1	54.0	60.0
25	QPSK	1/2	2	108	6	864	432	1	108.0	120.0
26	QPSK	3/4	2	108	6	864	648	1	162.0	180.0
27	16-QAM	1/2	4	108	6	1728	864	1	216.0	240.0
28	16-QAM	3/4	4	108	6	1728	1296	2	324.0	360.0
29	64-QAM	2/3	6	108	6	2592	1728	2	432.0	480.0
30	64-QAM	3/4	6	108	6	2592	1944	2	486.0	540.0
31	64-QAM	5/6	6	108	6	2592	2160	2	540.0	600.0

The rate-dependent parameters for optional 40 MHz MCS 32 format with N_{SS} = 1 and N_{ES} = 1 shall be shall be as shown in Table 20-37.

Table 20-37—MCS parameters for optional 40 MHz MCS 32 format, N_{SS} = 1, N_{ES} = 1

MCS Index	Modulation	R	$N_{BPSCS}(i_{SS})$	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
								800 ns GI	400 ns GI
32	BPSK	1/2	1	48	4	48	24	6.0	6.7

The rate-dependent parameters for optional 20 MHz, N_{SS} = 2 MCSs with N_{ES} = 1 and UEQM of the spatial streams shall be as shown in Table 20-38.

Table 20-38—MCS parameters for optional 20 MHz, N_{SS} = 2, N_{ES} = 1, UEQM

MCS Index	Modulation		R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
	Stream 1	Stream 2							800 ns GI	400 ns GI
33	16-QAM	QPSK	1/2	6	52	4	312	156	39	43.3
34	64-QAM	QPSK	1/2	8	52	4	416	208	52	57.8
35	64-QAM	16-QAM	1/2	10	52	4	520	260	65	72.2
36	16-QAM	QPSK	3/4	6	52	4	312	234	58.5	65.0
37	64-QAM	QPSK	3/4	8	52	4	416	312	78	86.7
38	64-QAM	16-QAM	3/4	10	52	4	520	390	97.5	108.3

The rate-dependent parameters for optional 20 MHz, N_{SS} = 3 MCSs with N_{ES} = 1 and UEQM of the spatial streams shall be as shown in Table 20-39.

Table 20-39—MCS parameters for optional 20 MHz, N_{SS} = 3, N_{ES} = 1, UEQM

MCS Index	Modulation			R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
	Stream 1	Stream 2	Stream 3							800 ns GI	400 ns GI
39	16-QAM	QPSK	QPSK	1/2	8	52	4	416	208	52	57.8
40	16-QAM	16-QAM	QPSK	1/2	10	52	4	520	260	65	72.2
41	64-QAM	QPSK	QPSK	1/2	10	52	4	520	260	65	72.2
42	64-QAM	16-QAM	QPSK	1/2	12	52	4	624	312	78	86.7
43	64-QAM	16-QAM	16-QAM	1/2	14	52	4	728	364	91	101.1
44	64-QAM	64-QAM	QPSK	1/2	14	52	4	728	364	91	101.1
45	64-QAM	64-QAM	16-QAM	1/2	16	52	4	832	416	104	115.6
46	16-QAM	QPSK	QPSK	3/4	8	52	4	416	312	78	86.7
47	16-QAM	16-QAM	QPSK	3/4	10	52	4	520	390	97.5	108.3
48	64-QAM	QPSK	QPSK	3/4	10	52	4	520	390	97.5	108.3
49	64-QAM	16-QAM	QPSK	3/4	12	52	4	624	468	117	130.0
50	64-QAM	16-QAM	16-QAM	3/4	14	52	4	728	546	136.5	151.7
51	64-QAM	64-QAM	QPSK	3/4	14	52	4	728	546	136.5	151.7
52	64-QAM	64-QAM	16-QAM	3/4	16	52	4	832	624	156	173.3

The rate-dependent parameters for optional 20 MHz, N_{SS} = 4 MCSs with N_{ES} = 1 and UEQM in the spatial streams shall be as shown in Table 20-40.

Table 20-40—MCS parameters for optional 20 MHz, N_{SS} = 4, N_{ES} = 1, UEQM

MCS Index	Modulation				R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
	Stream 1	Stream 2	Stream 3	Stream 4							800 ns GI	400 ns GI
53	16-QAM	QPSK	QPSK	QPSK	1/2	10	52	4	520	260	65	72.2
54	16-QAM	16-QAM	QPSK	QPSK	1/2	12	52	4	624	312	78	86.7
55	16-QAM	16-QAM	16-QAM	QPSK	1/2	14	52	4	728	364	91	101.1
56	64-QAM	QPSK	QPSK	QPSK	1/2	12	52	4	624	312	78	86.7
57	64-QAM	16-QAM	QPSK	QPSK	1/2	14	52	4	728	364	91	101.1
58	64-QAM	16-QAM	16-QAM	QPSK	1/2	16	52	4	832	416	104	115.6
59	64-QAM	16-QAM	16-QAM	16-QAM	1/2	18	52	4	936	468	117	130.0
60	64-QAM	64-QAM	QPSK	QPSK	1/2	16	52	4	832	416	104	115.6
61	64-QAM	64-QAM	16-QAM	QPSK	1/2	18	52	4	936	468	117	130.0
62	64-QAM	64-QAM	16-QAM	16-QAM	1/2	20	52	4	1040	520	130	144.4
63	64-QAM	64-QAM	64-QAM	QPSK	1/2	20	52	4	1040	520	130	144.4
64	64-QAM	64-QAM	64-QAM	16-QAM	1/2	22	52	4	1144	572	143	158.9
65	16-QAM	QPSK	QPSK	QPSK	3/4	10	52	4	520	390	97.5	108.3
66	16-QAM	16-QAM	QPSK	QPSK	3/4	12	52	4	624	468	117	130.0
67	16-QAM	16-QAM	16-QAM	QPSK	3/4	14	52	4	728	546	136.5	151.7
68	64-QAM	QPSK	QPSK	QPSK	3/4	12	52	4	624	468	117	130.0
69	64-QAM	16-QAM	QPSK	QPSK	3/4	14	52	4	728	546	136.5	151.7
70	64-QAM	16-QAM	16-QAM	QPSK	3/4	16	52	4	832	624	156	173.3
71	64-QAM	16-QAM	16-QAM	16-QAM	3/4	18	52	4	936	702	175.5	195.0
72	64-QAM	64-QAM	QPSK	QPSK	3/4	16	52	4	832	624	156	173.3
73	64-QAM	64-QAM	16-QAM	QPSK	3/4	18	52	4	936	702	175.5	195.0
74	64-QAM	64-QAM	16-QAM	16-QAM	3/4	20	52	4	1040	780	195	216.7
75	64-QAM	64-QAM	64-QAM	QPSK	3/4	20	52	4	1040	780	195	216.7
76	64-QAM	64-QAM	64-QAM	16-QAM	3/4	22	52	4	1144	858	214.5	238.3

The rate-dependent parameters for optional 40 MHz, N_{SS} = 2 MCSs with N_{ES} = 1 and UEQM of the spatial streams shall be as shown in Table 20-41.

Table 20-41—MCS parameters for optional 40 MHz, N_{SS} = 2, N_{ES} = 1, UEQM

MCS Index	Modulation		R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
	Stream 1	Stream 2							800 ns GI	400 ns GI
33	16-QAM	QPSK	1/2	6	108	6	648	324	81	90
34	64-QAM	QPSK	1/2	8	108	6	864	432	108	120
35	64-QAM	16-QAM	1/2	10	108	6	1080	540	135	150
36	16-QAM	QPSK	3/4	6	108	6	648	486	121.5	135
37	64-QAM	QPSK	3/4	8	108	6	864	648	162	180
38	64-QAM	16-QAM	3/4	10	108	6	1080	810	202.5	225

The rate-dependent parameters for optional 40 MHz, N_{SS} = 3 MCSs, with UEQM of the spatial streams shall be as shown in Table 20-42.

Table 20-42—MCS parameters for optional 40 MHz, N_{SS} = 3, UEQM

MCS Index	Modulation			R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)	
	Stream 1	Stream 2	Stream 3								800 ns GI	400 ns GI
39	16-QAM	QPSK	QPSK	1/2	8	108	6	864	432	1	108	120
40	16-QAM	16-QAM	QPSK	1/2	10	108	6	1080	540	1	135	150
41	64-QAM	QPSK	QPSK	1/2	10	108	6	1080	540	1	135	150
42	64-QAM	16-QAM	QPSK	1/2	12	108	6	1296	648	1	162	180
43	64-QAM	16-QAM	16-QAM	1/2	14	108	6	1512	756	1	189	210
44	64-QAM	64-QAM	QPSK	1/2	14	108	6	1512	756	1	189	210
45	64-QAM	64-QAM	16-QAM	1/2	16	108	6	1728	864	1	216	240
46	16-QAM	QPSK	QPSK	3/4	8	108	6	864	648	1	162	180
47	16-QAM	16-QAM	QPSK	3/4	10	108	6	1080	810	1	202.5	225
48	64-QAM	QPSK	QPSK	3/4	10	108	6	1080	810	1	202.5	225
49	64-QAM	16-QAM	QPSK	3/4	12	108	6	1296	972	1	243	270
50	64-QAM	16-QAM	16-QAM	3/4	14	108	6	1512	1134	1	283.5	315
51	64-QAM	64-QAM	QPSK	3/4	14	108	6	1512	1134	1	283.5	315
52	64-QAM	64-QAM	16-QAM	3/4	16	108	6	1728	1296	2	324	360

The rate-dependent parameters for optional 40 MHz, N_{SS} = 4 MCSs, with UEQM of the spatial streams shall be as shown in Table 20-43.

Table 20-43—MCS parameters for optional 40 MHz, N_{SS} = 4, UEQM

MCS Index	Modulation				R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)	
	Stream 1	Stream 2	Stream 3	Stream 4								800 ns GI	400 ns GI
53	16-QAM	QPSK	QPSK	QPSK	1/2	10	108	6	1080	540	1	135	150
54	16-QAM	16-QAM	QPSK	QPSK	1/2	12	108	6	1296	648	1	162	180
55	16-QAM	16-QAM	16-QAM	QPSK	1/2	14	108	6	1512	756	1	189	210
56	64-QAM	QPSK	QPSK	QPSK	1/2	12	108	6	1296	648	1	162	180
57	64-QAM	16-QAM	QPSK	QPSK	1/2	14	108	6	1512	756	1	189	210
58	64-QAM	16-QAM	16-QAM	QPSK	1/2	16	108	6	1728	864	1	216	240
59	64-QAM	16-QAM	16-QAM	16-QAM	1/2	18	108	6	1944	972	1	243	270
60	64-QAM	64-QAM	QPSK	QPSK	1/2	16	108	6	1728	864	1	216	240
61	64-QAM	64-QAM	16-QAM	QPSK	1/2	18	108	6	1944	972	1	243	270
62	64-QAM	64-QAM	16-QAM	16-QAM	1/2	20	108	6	2160	1080	1	270	300
63	64-QAM	64-QAM	64-QAM	QPSK	1/2	20	108	6	2160	1080	1	270	300
64	64-QAM	64-QAM	64-QAM	16-QAM	1/2	22	108	6	2376	1188	1	297	330
65	16-QAM	QPSK	QPSK	QPSK	3/4	10	108	6	1080	810	1	202.5	225
66	16-QAM	16-QAM	QPSK	QPSK	3/4	12	108	6	1296	972	1	243	270
67	16-QAM	16-QAM	16-QAM	QPSK	3/4	14	108	6	1512	1134	1	283.5	315
68	64-QAM	QPSK	QPSK	QPSK	3/4	12	108	6	1296	972	1	243	270
69	64-QAM	16-QAM	QPSK	QPSK	3/4	14	108	6	1512	1134	1	283.5	315
70	64-QAM	16-QAM	16-QAM	QPSK	3/4	16	108	6	1728	1296	2	324	360

Table 20-43—MCS parameters for optional 40 MHz, N_{SS} = 4, UEQM *(continued)*

MCS Index	Modulation				*R*	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)	
	Stream 1	Stream 2	Stream 3	Stream 4								800 ns GI	400 ns GI
71	64-QAM	16-QAM	16-QAM	16-QAM	3/4	18	108	6	1944	1458	2	364.5	405
72	64-QAM	64-QAM	QPSK	QPSK	3/4	16	108	6	1728	1296	2	324	360
73	64-QAM	64-QAM	16-QAM	QPSK	3/4	18	108	6	1944	1458	2	364.5	405
74	64-QAM	64-QAM	16-QAM	16-QAM	3/4	20	108	6	2160	1620	2	405	450
75	64-QAM	64-QAM	64-QAM	QPSK	3/4	20	108	6	2160	1620	2	405	450
76	64-QAM	64-QAM	64-QAM	16-QAM	3/4	22	108	6	2376	1782	2	445.5	495

Annex A

(normative)

Protocol Implementation Conformance Statement (PICS) proforma

A.4 PICS proforma–IEEE Std 802.11-2007

A.4.3 IUT configuration

Change the rows for CF10, CF11, and CF12 and insert a CF16 row at the end of the table in A.4.3 as follows:

Item	IUT configuration	References	Status	Support
*CF10	Is spectrum management operation supported?	7.3.1.4, 11.6	(CF6 OR CF16): O	Yes ☐ No ☐
*CF11	Is regulatory classes capability implemented?	7.3.2.12, 17.3.8.3.2, 17.3.8.6, 17.4.2, Annex I, Annex J	(CF6 OR CF16) &CF8&CF10: O	Yes ☐ No ☐ N/A ☐
*CF12	Quality of service (QoS) supported	9.9, 9.10, 5.2.9	O CF16:M	Yes ☐ No ☐ N/A ☐
*CF16	High-throughput (HT) features	7.3.2.56	O	Yes ☐ No ☐

A.4.4 MAC protocol

A.4.4.1 MAC protocol capabilities

Change the rows for PC31, PC32, and PC34 and insert the new rows (PC37 through PC37.6) at the end of the table in A.4.4.1 as follows:

Item	Protocol capability	References	Status	Support
PC31	Support transmission of CTS-to-self sequence as described in the reference~~s~~	9.2.11~~, 9.12~~	CF9:O	Yes ☐ No ☐ N/A ☐
PC32	Support reception of CTS-to-self sequence as described in the reference~~s~~	9.2.11~~, 9.12~~	CF9:M	Yes ☐ No ☐ N/A ☐
*PC34	Robust security network association (RSNA)	7.2.2.1, 7.3.1.4, 5.4.3.3, 8.7.2.1, 8.7.2.2, 8.7.2.3, 8.7.2.4, 11.3.1, 11.3.2, 8.3.3	O	Yes ☐ No ☐
*PC37	Power save multi-poll (PSMP)	7.4.10.4, 9.16	O	Yes ☐ No ☐
*PC37.1	Scheduled PSMP	7.3.2.30, 11.4.4b	PC36:M	Yes ☐ No ☐ N/A ☐
PC37.1.1	PSMP additions to TSPEC	7.3.2.30	PC36.1:M	Yes ☐ No ☐ N/A ☐
PC37.1.2	AP role in scheduled PSMP sequence	9.16.1.2, 9.16.1.3	(PC36.1 and CF1):M	Yes ☐ No ☐ N/A ☐
PC37.1.3	STA role in scheduled PSMP sequence	9.16.1.2, 9.16.1.3	(PC36.1 and CF2):M	Yes ☐ No ☐ N/A ☐
*PC37.2	Unscheduled PSMP	9.16.3	PC36:M	Yes ☐ No ☐ N/A ☐
PC37.2.1	PSMP additions to TSPEC	7.3.2.30	(CF1 and PC36.2):M (CF2 and PC36.2):O	Yes ☐ No ☐ N/A ☐
PC37.3	Creation, scheduling, and transmission of PSMP Action frame	7.4.10.4, 9.16.1.1	(PC36 and CF1):M	Yes ☐ No ☐ N/A ☐
PC37.4	Reception and interpretation of PSMP Action frame	7.4.10.4	(PC36 and CF2):M	Yes ☐ No ☐ N/A ☐
PC37.5	Multi-TID Block Ack rules in PSMP sequence	7.2.1.7.4, 7.2.1.8.4, 9.16.1.7, 11.5.2	PC36: M	Yes ☐ No ☐ N/A ☐
PC37.6	Multi-phase PSMP	9.16.1.5	PC36:M	Yes ☐ No ☐ N/A ☐

A.4.4.3 Frame exchange sequences

Change the rows for FS1 and FS2 in A.4.4.3 as follows:

Item	Frame exchange sequence	References	Status	Support
	Are the following frame sequences supported?			
FS1	Basic frame sequences	~~9.12, Annex C~~ 9.2.5.6, 9.2.5.7, 9.2.6, 9.2.7, 9.2.8, 9.2.9	M	Yes ☐ No ☐
FS2	CF-Frame sequences	~~9.12, Annex C~~ 9.3.2, 9.3.3	(PC4 OR PC5):M	Yes ☐ No ☐ N/A ☐

A.4.4.4 MAC addressing functions

Change the row for AD3 in A.4.4.4 as follows:

Item	MAC Address function	References	Status	Support
AD3	Receive address matching	7.1.3.3, 7.2.2.1, Annex C	M	Yes ☐ No ☐ N/A ☐

A.4.14 QoS base functionality

Change the rows for QB1, and QB4 and insert the new rows (QB4.1 through QB4.4) after the QB4 row in A.4.14 as follows:

Item	Protocol capability	References	Status	Support
QB1	QoS frame format	7.2.1.1–7.2.1.3, 7.2.2.1, 7.2.3.1, 7.2.3.4–7.2.3.7, 7.2.3.9, 7.2.3.12	CF12:M	Yes ☐ No ☐ N/A ☐
QB4	Block Acknowledgments (Block Acks)	~~7.2.1.7, 7.2.1.8, 7.4.4, 9.10, 11.5~~	~~CF12:O~~	~~Yes ☐ No ☐ N/A ☐~~
QB4.1	Immediate Block Ack	7.2.1.7.1, 7.2.1.7.2, 7.2.1.8.1, 7.2.1.8.2, 7.4.4, 9.10 (except 9.10.7 and 9.10.8), 11.5	CF12:O CF16:M	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
*QB4.2	Delayed Block Ack	7.2.1.7.1, 7.2.1.7.2, 7.2.1.8.1, 7.2.1.8.2, 7.4.4, 9.10 (except 9.10.7 and 9.10.8), 11.5	CF12:O	Yes ☐ No ☐ N/A ☐
QB4.3	Compressed Block Ack	7.2.1.7.3	CF12:O CF16:M	Yes ☐ No ☐ N/A ☐
QB4.4	MultiTID Block Ack	7.2.1.7.4	CF12:O CF16:M	Yes ☐ No ☐ N/A ☐

A.4.16 QoS hybrid coordination function (HCF) controlled channel access (HCCA)

Change the row for QP4 in A.4.16 as follows:

Item	Protocol capability	References	Status	Support
QP4	HCF frame exchange sequences	~~9.12~~ 9.9.1, 9.3.2	CF12:M	Yes ☐ No ☐ N/A ☐

Insert the following subclauses (A.4.19 through A.4.19.2) after A.4.18:

A.4.19 High-throughput (HT) features

A.4.19.1 HT MAC features

Item	Protocol capability	References	Status	Support
	Are the following MAC protocol features supported?			
HTM1	HT capabilities signaling			
HTM1.1	HT capabilities element	7.3.2.56.1	CF16:M	Yes ☐ No ☐ N/A ☐
HTM1.2	Signaling of STA capabilities in Probe Request, (Re)Association Request frames	7.3.2.56, 7.2.3.8, 7.2.3.4, 7.2.3.6	(CF16 and CF2):M	Yes ☐ No ☐ N/A ☐
HTM1.3	Signaling of STA and BSS capabilities in Beacon, Probe Response, (Re)Association Response frames	7.3.2.56, 7.2.3.1, 7.2.3.9, 7.2.3.5, 7.2.3.7	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTM2	Signaling of HT operation	7.3.2.57	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTM3	MPDU aggregation			

Item	Protocol capability	References	Status	Support
HTM3.1	Reception of A-MPDU	7.3.2.56.3, 8.3, 9.7d.2	CF16:M	Yes ☐ No ☐ N/A ☐
HTM3.2	A-MPDU format	7.4a.1	CF16:M	Yes ☐ No ☐ N/A ☐
HTM3.3	A-MPDU contents	7.4a.3	CF16:M	Yes ☐ No ☐ N/A ☐
HTM3.4	A-MPDU frame exchange sequences	9.9.1.4	CF16:M	Yes ☐ No ☐ N/A ☐
HTM3.5	Transmission of A-MPDU	7.3.2.56.3, 8.3	CF16:O	Yes ☐ No ☐ N/A ☐
HTM4	MSDU aggregation			
HTM4.1	Reception of A-MSDUs	7.1.3.5, 7.2.2.2	CF16:M	Yes ☐ No ☐ N/A ☐
HTM4.2	A-MSDU format	7.2.2.2	CF16:M	Yes ☐ No ☐ N/A ☐
HTM4.3	A-MSDU content	7.2.2.2	CF16:M	Yes ☐ No ☐ N/A ☐
HTM4.4	Transmission of A-MSDUs	7.2.2.2, 7.1.3.5	CF16:O	Yes ☐ No ☐ N/A ☐
HTM5	Block Ack			
HTM5.1	Block Ack mechanism	7.2.1.7, 7.2.1.8, 7.3.1.14, 9.10,11.5	CF16:M	Yes ☐ No ☐ N/A ☐
HTM5.2	Use of compressed bitmap between HT STAs	7.2.1.8.3, 9.10.6,	CF16:M	Yes ☐ No ☐ N/A ☐
HTM5.3	HT-immediate Block Ack extensions	9.10.7	CF16:M	Yes ☐ No ☐ N/A ☐
HTM5.4	HT-delayed Block Ack extensions	9.10.8	CF16 and QB4.2:M	Yes ☐ No ☐ N/A ☐
HTM5.5	Multiple TID Block Ack	7.2.1.7.4, 7.2.1.8.4, 9.16.1.7	HTM12:M	Yes ☐ No ☐ N/A ☐
HTM6	Protection mechanisms for different HT PHY options			
HTM6.1	Protection of RIFS PPDUs in the presence of non-HT STAs	9.13.3.3	CF16:M	Yes ☐ No ☐ N/A ☐
HTM6.1a	Protection of RIFS PPDUs in an IBSS	9.13.3.3	CF16:M	Yes ☐ No ☐ N/A ☐
HTM6.2	Protection of HT-greenfield PPDUs in the presence of non-HT STAs	9.13.3.1	HTP1.3:M	Yes ☐ No ☐ N/A ☐
HTM6.2a	Protection of HT-greenfield PPDUs in an IBSS	9.13.3.1	CF16:M	Yes ☐ No ☐ N/A ☐
*HTM7	L-SIG TXOP protection mechanism	9.13.5	CF16:O	Yes ☐ No ☐ N/A ☐
HTM7.1	Update NAV according to L-SIG	9.13.5.4	HTM7:M	Yes ☐ No ☐ N/A ☐
HTM8	Duration/ID rules for A-MPDU and TXOP	7.1.3.2	CF16:O	Yes ☐ No ☐ N/A ☐
HTM9	Truncation of TXOP as TXOP holder	9.9.1.7	CF16:O	Yes ☐ No ☐ N/A ☐
HTM10	Reception of +HTC frames	7.1.3.1.9, 7.3.2.56.5, 9.7a	CF16:O	Yes ☐ No ☐ N/A ☐
*HTM11	Reverse direction (RD) aggregation exchanges	9.15	CF16:O	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
HTM11.1	Constraints regarding responses	9.15.4	HTM11:M	Yes ☐ No ☐ N/A ☐
HTM12	Link adaptation			
HTM12.1	Use of the HT Control field for link adaptation in immediate response exchange.	7.1.3.5a, 7.2.3.13, 9.18.2	CF16:O	Yes ☐ No ☐ N/A ☐
HTM12.2	Link adaptation using explicit feedback mechanism	7.2.3.13, 9.19.3	CF16:O	Yes ☐ No ☐ N/A ☐
HTM13	Transmit beamforming			
*HTM13.1	Transmission of beamformed PPDUs	9.19	CF16:O	Yes ☐ No ☐ N/A ☐
*HTM13.2	Reception of beamformed PPDUs	9.19	CF16:O	Yes ☐ No ☐ N/A ☐
*HTM13.3	Initiate transmit beamforming frame exchange with implicit feedback	9.19.2	HTM13.1:O	Yes ☐ No ☐ N/A ☐
HTM13.3.1	Reception of sounding PPDUs	9.19.2	HTM13.3:M	Yes ☐ No ☐ N/A ☐
*HTM13.4	Response to transmit beamforming frame exchange with implicit feedback	9.19.2	HTM13.2:O	Yes ☐ No ☐ N/A ☐
HTM13.4.1	Transmission of sounding PPDUs	9.19.2	HTM13.4:M	Yes ☐ No ☐ N/A ☐
*HTM13.5	Initiate transmit beamforming frame exchange with explicit feedback	7.4.10.6, 9.19.3	HTM13.1:O	Yes ☐ No ☐ N/A ☐
HTM13.5.1	Transmission of sounding PPDUs	9.19.3	HTM13.5:M	Yes ☐ No ☐ N/A ☐
*HTM13.6	Respond to transmit beamforming frame exchange with explicit feedback	9.19.3	HTM13.2:O	Yes ☐ No ☐ N/A ☐
HTM13.6.1	Transmission of Action No Ack +HTC frame including Action payload of type CSI	9.19.3, 7.4.10.6	HTM13.6:O.1	Yes ☐ No ☐ N/A ☐
HTM13.6.2	Transmission of Action No Ack +HTC frame including Action payload of type “noncompressed beamforming”	9.19.3, 7.4.10.7	HTM13.6:O.1	Yes ☐ No ☐ N/A ☐
HTM13.6.3	Transmission of Action No Ack +HTC frame including Action payload of type “Compressed beamforming”	9.19.3, 7.4.10.8	HTM13.6:O.1	Yes ☐ No ☐ N/A ☐
*HTM13.7	Calibration procedure	7.2.3.13, 9.19.2.4	HTM13:O	Yes ☐ No ☐ N/A ☐
HTM14	Antenna selection (ASEL)	7.1.3.5a, 7.3.2.56.7, 7.4.10.9, 9.20	CF16:O	Yes ☐ No ☐ N/A ☐
*HTM15	Null data packet (NDP)	9.21	CF16:O	Yes ☐ No ☐ N/A ☐
HTM16	Space-time block coding (STBC) support			
HTM16.1	STBC beacon transmission	11.1.2.1	HTP2.11:O	Yes ☐ No ☐ N/A ☐
HTM16.2	Dual CTS protection	9.2.5.5a	HTP2.11:O	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
HTM17	SM power save support			
*HTM17.1	AP support for dynamic and static SM power save mode	11.2.3	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
*HTM17.2	STA support for dynamic and static SM power save mode	11.2.3	(CF16 and CF2):O	Yes ☐ No ☐ N/A ☐
HTM17.3	Transmit SM Power Save state information using HT capabilities, or SM Power Save Action frame	7.4.10.3, 11.2.3	(HTM17.1 OR HTM17.2):M	Yes ☐ No ☐ N/A ☐
HTM17.4	Receive SM Power Save state information and support frame exchanges with SM Power Save STAs	11.2.3	CF16:M	Yes ☐ No ☐ N/A ☐
HTM18	Mechanisms for coexistence of 20 MHz and 40 MHz channels	11.14	CF16:M	Yes ☐ No ☐ N/A ☐
HTM19	Channel selection methods for 20/40 MHz operation	11.14.3	(HTP2.3.4 and CF1):M	Yes ☐ No ☐ N/A ☐
HTM20	20/40 MHz operation	11.14	HTP2.3.4:M	Yes ☐ No ☐ N/A ☐
HTM21	Phased coexistence operation (PCO)			
*HTM21.1	PCO capability at AP	11.15	(CF16 and CF1):O	Yes ☐ No ☐ N/A ☐
HTM21.1.1	Rules for operation at a PCO active AP	7.4.10.5, 11.15.2	HTM21.1:M	Yes ☐ No ☐ N/A ☐
*HTM21.2	STA support for PCO mode	11.15	(CF16 and CF2):O	Yes ☐ No ☐ N/A ☐
HTM21.2.1	Rules for operation at PCO active STA	7.4.10.5, 11.15.3	HTM21.2:M	Yes ☐ No ☐ N/A ☐
HTM22	Management information base (MIB)			
HTM22.1	dot11PhyHTComplianceGroup	Annex D	CF16:M	Yes ☐ No ☐ N/A ☐
HTM22.2	dot11PhyMCSGroup	Annex D	CF16:M	Yes ☐ No ☐ N/A ☐

A.4.19.2 HT PHY features

Item	Protocol capability	References	Status	Support
	Are the following PHY protocol features supported?			
HTP1	PHY operating modes			
HTP1.1	Operation according to Clause 17 and/or Clause 19	20.1.4	CF16:M	Yes ☐ No ☐ N/A ☐
HTP1.2	HT-mixed format	20.1.4	CF16:M	Yes ☐ No ☐ N/A ☐
*HTP1.3	HT-greenfield format	20.1.4	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2	PLCP frame format			
HTP2.1	HT-mixed format PLCP format	20.3.2	CF16:M	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
HTP2.2	HT-greenfield PLCP format	20.3.2	HTP1.3:M	Yes ☐ No ☐ N/A ☐
HTP2.3	Modulation and coding schemes (MCS)			
HTP2.3.1	MCS 0 through MCS 7 in 20 MHz with 800 ns guard interval (GI)			
HTP2.3.1.1	Support for 20 MHz with 800 ns GI MCS index 0	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.1.2	Support for 20 MHz with 800 ns GI MCS index 1	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.1.3	Support for 20 MHz with 800 ns GI MCS index 2	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.1.4	Support for 20 MHz with 800 ns GI MCS index 3	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.1.5	Support for 20 MHz with 800 ns GI MCS index 4	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.1.6	Support for 20 MHz with 800 ns GI MCS index 5	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.1.7	Support for 20 MHz with 800 ns GI MCS index 6	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.1.8	Support for 20 MHz with 800 ns GI MCS index 7	20.3.5, 20.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.3.2	MCS 8 through MCS 15 in 20 MHz with 800 ns GI			
HTP2.3.2.1	Support for 20 MHz with 800 ns GI MCS index 8	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.2.2	Support for 20 MHz with 800 ns GI MCS index 9	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.2.3	Support for 20 MHz with 800 ns GI MCS index 10	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.2.4	Support for 20 MHz with 800 ns GI MCS index 11	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.2.5	Support for 20 MHz with 800 ns GI MCS index 12	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.2.6	Support for 20 MHz with 800 ns GI MCS index 13	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.2.7	Support for 20 MHz with 800 ns GI MCS index 14	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.2.8	Support for 20 MHz with 800 ns GI MCS index 15	20.3.5, 20.6	(CF16 and CF1):M	Yes ☐ No ☐ N/A ☐
HTP2.3.3	Transmit and receive support for 400 ns GI	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
*HTP2.3.4	Operation at 40 MHz	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5	Support for MCS with indices 16 through 76			

Item	Protocol capability	References	Status	Support
HTP2.3.5.1	Support for MCS with index 16	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.2	Support for MCS with index 17	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.3	Support for MCS with index 18	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.4	Support for MCS with index 19	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.5	Support for MCS with index 20	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.6	Support for MCS with index 21	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.7	Support for MCS with index 22	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.8	Support for MCS with index 23	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.9	Support for MCS with index 24	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.10	Support for MCS with index 25	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.11	Support for MCS with index 26	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.12	Support for MCS with index 27	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.13	Support for MCS with index 28	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.14	Support for MCS with index 29	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.15	Support for MCS with index 30	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.16	Support for MCS with index 31	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.17	Support for MCS with index 32	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.18	Support for MCS with index 33	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.19	Support for MCS with index 34	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.20	Support for MCS with index 35	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.21	Support for MCS with index 36	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.22	Support for MCS with index 37	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.23	Support for MCS with index 38	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.24	Support for MCS with index 39	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.25	Support for MCS with index 40	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.26	Support for MCS with index 41	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.27	Support for MCS with index 42	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.28	Support for MCS with index 43	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.29	Support for MCS with index 44	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.30	Support for MCS with index 45	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.31	Support for MCS with index 46	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.32	Support for MCS with index 47	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.33	Support for MCS with index 48	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.34	Support for MCS with index 49	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
HTP2.3.5.35	Support for MCS with index 50	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.36	Support for MCS with index 51	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.37	Support for MCS with index 52	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.38	Support for MCS with index 53	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.39	Support for MCS with index 54	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.40	Support for MCS with index 55	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.41	Support for MCS with index 56	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.42	Support for MCS with index 57	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.43	Support for MCS with index 58	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.44	Support for MCS with index 59	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.45	Support for MCS with index 60	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.46	Support for MCS with index 61	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.47	Support for MCS with index 62	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.48	Support for MCS with index 63	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.49	Support for MCS with index 64	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.50	Support for MCS with index 65	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.51	Support for MCS with index 66	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.52	Support for MCS with index 67	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.53	Support for MCS with index 68	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.54	Support for MCS with index 69	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.55	Support for MCS with index 70	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.56	Support for MCS with index 71	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.57	Support for MCS with index 72	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.58	Support for MCS with index 73	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.59	Support for MCS with index 74	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.60	Support for MCS with index 75	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.3.5.61	Support for MCS with index 76	20.3.5, 20.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.4	PHY timing parameters			
HTP2.4.1	Values in non-HT 20 MHz channel	20.3.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.4.2	Values in 20 MHz HT channel	20.3.6	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.4.3	Values in 40 MHz channel	20.3.6	HTP2.3.4:M	Yes ☐ No ☐ N/A ☐
HTP2.5	HT Preamble field definition and coding			
HTP2.5.1	HT-mixed format preamble	20.3.9.2	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.5.2	HT-greenfield preamble	20.3.9.5	HTP1.3:M	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
HTP2.5.3	Extension HT Long Training fields (HT-ELTFs)	20.3.9.4.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.6	HT Data field definition and coding	20.3.11	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.6.1	Use of LDPC codes	20.3.11.6	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.7	Beamforming	20.3.12	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.8	Sounding PPDUs			
HTP2.8.1	HT preamble format for sounding PPDUs	20.3.13	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.8.2	Sounding with an NDP	20.3.13.1	HTM15:O	Yes ☐ No ☐ N/A ☐
HTP2.8.3	Sounding PPDU for calibration	20.3.13.2	HTM14.7:M	Yes ☐ No ☐ N/A ☐
HTP2.9	Channel numbering and channelization			
HTP2.9.1	Channel allocation for 20 MHz channels at 5 GHz	17.3.8.3	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.9.2	Channel allocation for 20 MHz channels at 2.4 GHz	19.4.2	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.9.3	Channel allocation for 40 MHz channels at 5 GHz	20.3.15.2	HTP2.3.4:M	Yes ☐ No ☐ N/A ☐
HTP2.9.4	Channel allocation for 40 MHz channels at 2.4 GHz	20.3.15.1	HTP2.3.4:M	Yes ☐ No ☐ N/A ☐
HTP2.10	PMD transmit specification			
HTP2.10.1	PMD transmit specification for 20 MHz channel	20.3.21	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.10.2	PMD transmit specification for 40 MHz channel	20.3.21	HTP2.3.4:M	Yes ☐ No ☐ N/A ☐
*HTP2.11	Space-time block coding (STBC)	20.3.11.8.1	CF16:O	Yes ☐ No ☐ N/A ☐
HTP2.12	PMD receive specification			
HTP2.12.1	PMD receive specification for 20 MHz channel	20.3.22	CF16:M	Yes ☐ No ☐ N/A ☐
HTP2.12.2	PMD receive specification for 40 MHz channel	20.3.22	HTP2.3.4:M	Yes ☐ No ☐ N/A ☐
HTP2.13	PPDU reception with RIFS	20.3.22.7	CF16:M	Yes ☐ No ☐ N/A ☐

Annex C

(informative)

Formal description of a subset of MAC operation

C.3 State machines for MAC STAs

Insert the following paragraph after the fourth paragraph of C.3:

This clause does not describe the behavior of an HT STA.

Annex D

(normative)

ASN.1 encoding of the MAC and PHY MIB

Change the list of imports at the beginning of Annex D as follows:

```
IEEE802dot11-MIB DEFINITIONS ::= BEGIN
          IMPORTS
               MODULE-IDENTITY, OBJECT-TYPE,
               NOTIFICATION-TYPE,Integer32, Counter32, Counter64,
               Unsigned32                   FROM SNMPv2-SMI
               DisplayString , MacAddress, RowStatus,
               TruthValue                   FROM SNMPv2-TC
               MODULE-COMPLIANCE, OBJECT-GROUP,
               NOTIFICATION-GROUP           FROM SNMPv2-CONF
               ifIndex                      FROM RFC1213-MIB;
```

Change the "Station Management (SMT) Attributes" in the "Major sections" part of Annex D as follows:

```
--**********************************************************************
--* Major sections
--**********************************************************************
--
-- Station Management (SMT) Attributes
-- DEFINED AS "The SMT object class provides the necessary support
-- at the station to manage the processes in the station such that
-- the station may work cooperatively as part of the IEEE 802.11
-- network.

dot11smt OBJECT IDENTIFIER ::= { ieee802dot11 1 }
-- dot11 SMT GROUPS
   -- dot11StationConfigTable                      ::= { dot11smt 1 }
   -- dot11AuthenticationAlgorithmTable            ::= { dot11smt 2 }
   -- dot11WEPDefaultKeysTable                     ::= { dot11smt 3 }
   -- dot11WEPKEYMappingsTable                     ::= { dot11smt 4 }
   -- dot11PrivacyTable                            ::= { dot11smt 5 }
   -- dot11SMTnotification                         ::= { dot11smt 6 }
   -- dot11MultiDomainCapabilityTable              ::= { dot11smt 7 }
   -- dot11SpectrumManagementTable                 ::= { dot11smt 8 }
   -- dot11RSNAConfigTable                         ::= { dot11smt 9 }
   -- dot11RSNAConfigPairwiseCiphersTable          ::= { dot11smt 10 }
   -- dot11RSNAConfigAuthenticationSuitesTable     ::= { dot11smt 11 }
   -- dot11RSNAStatsTable                          ::= { dot11smt 12 }
   -- dot11RegulatoryClassesTable                  ::= { dot11smt 13 }
   -- dot11RadioResourceManagement                 ::= { dot11smt 14 }
   -- dot11FastBSSTransitionConfigTable            ::= { dot11smt 15 }
```

```
   -- dot11LCIDSETable                              ::= { dot11smt 16 }
   -- dot11HTStationConfigTable                     ::= { dot11smt 17 }
```

Change the "PHY Attributes" in the "Major sections" part of Annex D as follows:

```
--
-- PHY Attributes
-- DEFINED AS "The PHY object class provides the necessary support
-- for required PHY operational information that may vary from PHY
-- to PHY and from STA to STA to be communicated to upper layers."

dot11phy OBJECT IDENTIFIER ::= { ieee802dot11 4 }
-- PHY GROUPS
   -- dot11PhyOperationTable                  ::= { dot11phy 1 }
   -- dot11PhyAntennaTable                    ::= { dot11phy 2 }
   -- dot11PhyTxPowerTable                    ::= { dot11phy 3 }
   -- dot11PhyFHSSTable                       ::= { dot11phy 4 }
   -- dot11PhyDSSSTable                       ::= { dot11phy 5 }
   -- dot11PhyIRTable                         ::= { dot11phy 6 }
   -- dot11RegDomainsSupportedTable           ::= { dot11phy 7 }
   -- dot11AntennasListTable                  ::= { dot11phy 8 }
   -- dot11SupportedDataRatesTxTable          ::= { dot11phy 9 }
   -- dot11SupportedDataRatesRxTable          ::= { dot11phy 10 }
   -- dot11PhyOFDMTable                       ::= { dot11phy 11 }
   -- dot11PhyHRDSSSTable                     ::= { dot11phy 12 }
   -- dot11EHCCHoppingPatternTable            ::= { dot11phy 13 }
   -- dot11PhyERPTable                        ::= { dot11phy 14 }
   -- dot11PhyHTTable                         ::= { dot11phy 15 }
   -- dot11HTSupportedMCSTxTable              ::= { dot11phy 16 }
   -- dot11HTSupportedMCSRxTable              ::= { dot11phy 17 }
   -- dot11TransmitBeamformingConfigTable     ::= { dot11phy 18 }
```

Change the "Dot11StationConfigEntry" sequence list of the "dotStationConfig TABLE" in Annex D as follows:

```
Dot11StationConfigEntry ::=
SEQUENCE {
          dot11StationID                              MacAddress,
          dot11MediumOccupancyLimit                   INTEGER,
          dot11CFPollable                             TruthValue,
          dot11CFPeriod                               INTEGER,
          dot11CFPMaxDuration                         INTEGER,
          dot11AuthenticationResponseTimeOut          Unsigned32,
          dot11PrivacyOptionImplemented               TruthValue,
          dot11PowerManagementMode                    INTEGER,
          dot11DesiredSSID                            OCTET STRING,
          dot11DesiredBSSType                         INTEGER,
          dot11OperationalRateSet                     OCTET STRING,
          dot11BeaconPeriod                           INTEGER,
```



```
dot11DTIMPeriod                                INTEGER,
dot11AssociationResponseTimeOut                Unsigned32,
dot11DisassociateReason                        INTEGER,
dot11DisassociateStation                       MacAddress,
dot11DeauthenticateReason                      INTEGER,
dot11DeauthenticateStation                     MacAddress,
dot11AuthenticateFailStatus                    INTEGER,
dot11AuthenticateFailStation                   MacAddress,
dot11MultiDomainCapabilityImplemented          TruthValue,
dot11MultiDomainCapabilityEnabled              TruthValue,
dot11CountryString                             OCTET STRING,
dot11SpectrumManagementImplemented             TruthValue,
dot11SpectrumManagementRequired                TruthValue,
dot11RSNAOptionImplemented                     TruthValue,
dot11RSNAPreauthenticationImplemented          TruthValue,
dot11RegulatoryClassesImplemented              TruthValue,
dot11RegulatoryClassesRequired                 TruthValue,
dot11QosOptionImplemented                      TruthValue,
dot11ImmediateBlockAckOptionImplemented        TruthValue,
dot11DelayedBlockAckOptionImplemented          TruthValue,
dot11DirectOptionImplemented                   TruthValue,
dot11APSDOptionImplemented                     TruthValue,
dot11QAckOptionImplemented                     TruthValue,
dot11QBSSLoadOptionImplemented                 TruthValue,
dot11QueueRequestOptionImplemented             TruthValue,
dot11TXOPRequestOptionImplemented              TruthValue,
dot11MoreDataAckOptionImplemented              TruthValue,
dot11AssociatedinNQBSS                         TruthValue,
dot11DLSAllowdInQBSS                           TruthValue,
dot11DLSAllowed                                TruthValue,
dot11AssociateStation                          MacAddress,
dot11AssociateID                               INTEGER,
dot11AssociateFailStation                      MacAddress,
dot11AssociateFailStatus                       INTEGER,
dot11ReassociateStation                        MacAddress,
dot11ReassociateID                             INTEGER,
dot11ReassociateFailStation                    MacAddress,
dot11ReassociateFailStatus                     INTEGER,
dot11RadioMeasurementCapable                   TruthValue,
dot11RadioMeasurementEnabled                   TruthValue,
dot11RRMMeasurementProbeDelay                  INTEGER,
dot11RRMMeasurementPilotPeriod                 INTEGER,
dot11RRMLinkMeasurementEnabled                 TruthValue,
dot11RRMNeighborReportEnabled                  TruthValue,
dot11RRMParallelMeasurementsEnabled            TruthValue,
dot11RRMRepeatedMeasurementsEnabled            TruthValue,
dot11RRMBeaconPassiveMeasurementEnabled        TruthValue,
dot11RRMBeaconActiveMeasurementEnabled         TruthValue,
dot11RRMBeaconTableMeasurementEnabled          TruthValue,
dot11RRMBeaconMeasurementReportingConditionsEnabled TruthValue,
```

```
dot11RRMFrameMeasurementEnabled                  TruthValue,
dot11RRMChannelLoadMeasurementEnabled            TruthValue,
dot11RRMNoiseHistogramMeasurementEnabled         TruthValue
dot11RRMStatisticsMeasaurementEnabled            TruthValue,
dot11RRMLCIMeasurementEnabled                    TruthValue,
dot11RRMLCIAzimuthEnabled                        TruthValue,
dot11RRMTransmitStreamCategoryMeasurementEnabled TruthValue,
dot11RRMTriggeredTransmitStreamCategoryMeasurementEnabled
                                                 TruthValue,
dot11RRMAPChannelReportEnabled                   TruthValue,
dot11RRMMIBEnabled                               TruthValue,
dot11RRMMaxMeasurementDuration                   Unsigned32,
dot11RRMNonOperatingChannelMaxMeasurementDuration Unsigned32,
dot11RRMMeasurementPilotTransmissionInformationEnabled
                                                 TruthValue,
dot11RRMMeasurementPilotCapability               Unsigned32,
dot11RRMNeighborReportTSFOffsetEnabled           TruthValue,
dot11RRMRCPIMeasurementEnabled                   TruthValue,
dot11RRMRSNIMeasurementEnabled                   TruthValue,
dot11RRMBSSAverageAccessDelayEnabled             TruthValue,
dot11RRMBSSAvailableAdmissionCapacityEnabled     TruthValue,
dot11RRMAntennaInformationEnabled                TruthValue,
dot11FastBSSTransitionImplemented                TruthValue
dot11LCIDSEImplemented                           TruthValue,
dot11LCIDSERequired                              TruthValue,
dot11DSERequired                                 TruthValue,
dot11ExtendedChannelSwitchEnabled                TruthValue,
dot11RSNAProtectedManagementFramesEnabled        TruthValue,
dot11RSNAUnprotectedManagementFramesAllowed      TruthValue,
dot11AssociationSAQueryMaximumTimeout            Unsigned32,
dot11AssociationSAQueryRetryTimeout              INTEGER,
dot11HighThroughputOptionImplemented             TruthValue,
dot11RSNAPBACRequired                            TruthValue,
dot11PSMPOptionImplemented                       TruthValue}
```

Change attribute dot11OperationalRateSet { dot11StationConfigEntry 11 } in the "dotStationConfig TABLE" in Annex D as follows:

```
dot11OperationalRateSet OBJECT-TYPE
SYNTAX OCTET STRING (SIZE(1..126))
MAX-ACCESS read-write
STATUS current
DESCRIPTION
        "This attribute shall specify the set of non-HT data rates at which
the station may transmit data. The attribute that specifies the set of HT
data rates is dot11HTOperationalMCSSet. Each octet contains a value
representing a rate. Each rate shall be within the range from 2 to 127,
corresponding to data rates in increments of 500 kbit/s from 1 Mb/s to 63.5
Mb/s, and shall be supported (as indicated in the supported rates table) for
receiving data. This value is reported in transmitted Beacon, Probe Request,
Probe Response, Association Request, Association Response, Reassociation
```



```
Request, and Reassociation Response frames, and is used to determine whether
a BSS with which the station desires to synchronize is suitable. It is also
used when starting a BSS, as specified in 10.3."
::= { dot11StationConfigEntry 11 }
```

Insert the following attribute descriptions (92 through 94) into the "dotStationConfig TABLE" in Annex D after attribute dot11AssociationSAQueryRetryTimeout { dot11StationConfigEntry 91 }:

```
dot11HighThroughputOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
          "This attribute indicates whether the entity is HT Capable."
::= { dot11StationConfigEntry 92}

dot11RSNAPBACRequired OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
          "This variable indicates whether this STA requires the Protection
of Block Ack agreements."
               DEFAULT { FALSE }
::= { dot11StationConfigEntry 93}

dot11PSMPOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the station
implementation is capable of supporting PSMP. "
          DEFVAL { false }
::= { dot11StationConfigEntry 94 }
```

Insert the following table ("dot11HTStationConfig TABLE") after the "dot11LCIDSE TABLE" in Annex D:

```
-- **********************************************************************
-- * dot11HTStationConfig TABLE
-- **********************************************************************

dot11HTStationConfigTable OBJECT-TYPE
          SYNTAX SEQUENCE OF Dot11HTStationConfigEntry
          MAX-ACCESS not-accessible
          STATUS current
          DESCRIPTION
```

```
                "Station Configuration attributes. In tabular form to allow
for multiple instances on an agent."
          ::= { dot11smt 17 }

dot11HTStationConfigEntry OBJECT-TYPE
          SYNTAX Dot11HTStationConfigEntry
          MAX-ACCESS not-accessible
          STATUS current
          DESCRIPTION
               "An entry (conceptual row) in the dot11HTStationConfig Table.

               ifIndex - Each IEEE 802.11 interface is represented by an
ifEntry. Interface tables in this MIB module are indexed by ifIndex."
          INDEX { ifIndex }
          ::= { dot11HTStationConfigTable 1 }

Dot11HTStationConfigEntry ::=
          SEQUENCE {
          dot11HTOperationalMCSSet                    OCTET STRING,
          dot11MIMOPowerSave                          INTEGER,
          dot11NDelayedBlockAckOptionImplemented      TruthValue,
          dot11MaxAMSDULength                         INTEGER,
          dot11STBCControlFrameOptionImplemented      TruthValue,
          dot11LsigTxopProtectionOptionImplemented    TruthValue,
          dot11MaxRxAMPDUFactor                       INTEGER,
          dot11MinimumMPDUStartSpacing                INTEGER,
          dot11PCOOptionImplemented                   TruthValue,
          dot11TransitionTime                         INTEGER,
          dot11MCSFeedbackOptionImplemented           INTEGER,
          dot11HTControlFieldSupported                TruthValue,
          dot11RDResponderOptionImplemented           TruthValue,
          dot11SPPAMSDUCapable                        TruthValue,
          dot11SPPAMSDURequired                       TruthValue,
          dot11FortyMHzOptionImplemented              TruthValue
          }

dot11HTOperationalMCSSet OBJECT-TYPE
               SYNTAX OCTET STRING (SIZE(1..127))
               MAX-ACCESS read-write
               STATUS current
               DESCRIPTION
               "This attribute shall specify the set of MCS at which the
station may transmit data. Each octet contains a value representing a rate.
Each MCS shall be within the range from 1 to 127, and shall be supported for
receiving data. This value is reported in transmitted Beacon, Probe Request,
Probe Response, Association Request, Association Response, Reassociation
Request, and Reassociation Response frames, and is used to determine whether
a BSS with which the station desires to synchronize is suitable. It is also
used when starting a BSS, as specified in 10.3."
::= { dot11HTStationConfigEntry 1 }
```



```
dot11MIMOPowerSave OBJECT-TYPE
         SYNTAX INTEGER { static(1), dynamic(2), mimo(3) }
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This is an 8-bit integer value that identifies the configured
power save state of MIMO."
::= { dot11HTStationConfigEntry 2 }

dot11NDelayedBlockAckOptionImplemented OBJECT-TYPE
         SYNTAX TruthValue
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This attribute, when TRUE, indicates that the station
implementation is capable of supporting the No Ack option of the Delayed
Block Ack. "
         DEFVAL { false }
::= { dot11HTStationConfigEntry 3 }

dot11MaxAMSDULength OBJECT-TYPE
         SYNTAX INTEGER { 3839, 7935 }
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This attribute indicates the supported maximum size of A-
MSDU."
         DEFVAL { 3839}
::= { dot11HTStationConfigEntry 4 }

dot11STBCControlFrameOptionImplemented OBJECT-TYPE
         SYNTAX TruthValue
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This attribute, when TRUE, indicates that the station
implementation is capable of processing the received control frames that are
STBC frames. "
         DEFVAL { false }
::= { dot11HTStationConfigEntry 5 }

dot11LsigTxopProtectionOptionImplemented OBJECT-TYPE
         SYNTAX TruthValue
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This attribute, when TRUE, indicates that the station
implementation is capable of supporting L-SIG TXOP protection option."
         DEFVAL { false }
::= { dot11HTStationConfigEntry 6 }
```



```
dot11MaxRxAMPDUFactor OBJECT-TYPE
          SYNTAX INTEGER (0..3)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the maximum length of A-MPDU that
the STA can receive. The Maximum Rx A-MPDU defined by this field is equal to
2^(13+dot11MaxRxAMPDUFactor) -1 octets."
          DEFVAL { 0 }
::= { dot11HTStationConfigEntry 7 }

dot11MinimumMPDUStartSpacing OBJECT-TYPE
          SYNTAX INTEGER (0..7)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the minimum time between the start
of adjacent MPDUs within an A-MPDU. This time is measured at the PHY-SAP; the
number of octets between the start of two consecutive MPDUs in A-MPDU shall
be equal or greater than (dot11MinimumMPDUStartSpacing*PHY-bit-rate)/8. The
encoding of the minimum time to this attribute is:
               0    no restriction
               1    1/4 µs
               2    1/2 µs
               3    1 µs
               4    2 µs
               5    4 µs
               6    8 µs
               7    16 µs "
          DEFVAL { 0 }
::= { dot11HTStationConfigEntry 8 }

dot11PCOOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the station
implementation is capable of supporting PCO."
          DEFVAL { false }
::= { dot11HTStationConfigEntry 9 }

dot11TransitionTime OBJECT-TYPE
          SYNTAX INTEGER (0..3)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates that the maximum transition time
within which the STA can switch between 20 MHz channel width and 40 MHz
channel width with a high probability. The encoding of the transition time to
this attribute is:
```

```
          0    no transition
          1    400 µs
          2    1500 µs
          3    5000 µs "
          DEFVAL { 2 }
::= { dot11HTStationConfigEntry 10 }

dot11MCSFeedbackOptionImplemented OBJECT-TYPE
          SYNTAX INTEGER { none(0), unsolicited (2), both (3) }
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the MCS feed back capability
supported by the station implementation."
          DEFVAL { 0 }
::= { dot11HTStationConfigEntry 11 }

dot11HTControlFieldSupported OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the station
implementation is capable of receiving HT Control field."
          DEFVAL { false }
::= { dot11HTStationConfigEntry 12 }

dot11RDResponderOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the station
implementation is capable operating as an RD responder."
          DEFVAL { false }
::= { dot11HTStationConfigEntry 13 }

dot11SPPAMSDUCapable OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the STA
implementation is capable of protecting the A-MSDU bit (Bit 7) in the QoS
Control field when dot11RSNAEnabled is TRUE."
          DEFVAL { false }
          ::= { dot11HTStationConfigEntry 14 }

dot11SPPAMSDURequired OBJECT-TYPE
          SYNTAX TruthValue
```

```
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the STA is
configured to disallow (not to send or receive) of PP A-MSDUs when
dot11RSNAEnabled is TRUE."
          DEFVAL { false }
          ::= { dot11HTStationConfigEntry 15 }

dot11FortyMHzOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the STA is capable
of transmitting and receiving on a 40 MHz channel using a 40 MHz mask."
          DEFVAL ( false }
          ::= { dot11HTStationConfigEntry 16 }

-- **********************************************************************
-- * End of dot11HTStationConfig TABLE
-- **********************************************************************
```

Change the "Dot11OperationEntry" sequence list in the "dot11Operation TABLE" in Annex D as follows:

```
Dot11OperationEntry ::=
          SEQUENCE {
          dot11MACAddress                             MacAddress,
          dot11RTSThreshold                           INTEGER,
          dot11ShortRetryLimit                        INTEGER,
          dot11LongRetryLimit                         INTEGER,
          dot11FragmentationThreshold                 INTEGER,
          dot11MaxTransmitMSDULifetime                Unsigned32,
          dot11MaxReceiveLifetime                     Unsigned32,
          dot11ManufacturerID                         DisplayString,
          dot11ProductID                              DisplayString,
          dot11CAPLimit                               INTEGER,
          dot11HCCWmin                                INTEGER,
          dot11HCCWmax                                INTEGER,
          dot11HCCAIFSN                               INTEGER,
          dot11ADDBAResponseTimeout                   INTEGER,
          dot11ADDTSResponseTimeout                   INTEGER,
          dot11ChannelUtilizationBeaconInterval       INTEGER,
          dot11ScheduleTimeout                        INTEGER,
          dot11DLSResponseTimeout                     INTEGER,
          dot11QAPMissingAckRetryLimit                INTEGER,
          dot11EDCAAveragingPeriod                    INTEGER,
          dot11HTProtection                           INTEGER,
```



```
        dot11RIFSMode                               TruthValue,
        dot11PSMPControlledAccess                   TruthValue,
        dot11ServiceIntervalGranularity             INTEGER,
        dot11DualCTSProtection                      TruthValue,
        dot11LSIGTXOPFullProtectionEnabled          TruthValue,
        dot11NonGFEntitiesPresent                   TruthValue,
        dot11PCOActivated                           TruthValue,
        dot11PCOFortyMaxDuration                    INTEGER,
        dot11PCOTwentyMaxDuration                   INTEGER,
        dot11PCOFortyMinDuration                    INTEGER,
        dot11PCOTwentyMinDuration                   INTEGER,
        dot11FortyMHzIntolerant                     TruthValue,
        dot11BSSWidthTriggerScanInterval            INTEGER,
        dot11BSSWidthChannelTransitionDelayFactor   INTEGER,
        dot11OBSSScanPassiveDwell                   INTEGER,
        dot11OBSSScanActiveDwell                    INTEGER,
        dot11OBSSScanPassiveTotalPerChannel         INTEGER,
        dot11OBSSScanActiveTotalPerChannel          INTEGER,
        dot112040BSSCoexistenceManagementSupport    TruthValue,
        dot11OBSSScanActivityThreshold              INTEGER
        }
```

Change attribute dot11RTSThreshold { dot11OperationEntry 2 } in the "dot11Operation TABLE" in Annex D as follows:

dot11RTSThreshold OBJECT-TYPE
SYNTAX INTEGER (0..65536)
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This attribute shall indicate the number of octets in a~~n~~ ~~MPDU~~PSDU, below which an RTS/CTS handshake shall not be performed, except as RTS/CTS is used as a cross modulation protection mechanism as defined in 9.10. An RTS/CTS handshake shall be performed at the beginning of any frame exchange sequence where the ~~MPDU~~PSDU is of type Data or Management, the ~~MPDU~~PSDU has an individual address in the Address 1 field, and the length of the ~~MPDU~~PSDU is greater than this threshold. Setting this attribute to be larger than the maximum ~~MSDU~~PSDU size shall have the effect of turning off the RTS/CTS handshake for frames of Data or Management type transmitted by this STA. Setting this attribute to zero shall have the effect of turning on the RTS/CTS handshake for all frames of Data or Management type transmitted by this STA. ~~The default value of this attribute shall be 3000.~~"
DEFVAL { 65535 }
::= { dot11OperationEntry 2 }

Change attribute dot11FragmentationThreshold { dot11OperationEntry 5 } in the "dot11Operation TABLE" in Annex D as follows:

dot11FragmentationThreshold OBJECT-TYPE
SYNTAX INTEGER (256..~~2340~~8000)

MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This attribute shall specify the current maximum size, in octets, of the ~~MPDU~~ PSDU that may be delivered to the PHY. This maximum size does not apply when an MSDU or A-MSDU is transmitted using an HT-immediate or HT-delayed Block Ack agreement, or when an MSDU, A-MSDU or MMPDU is carried in an A-MPDU. ~~An MSDU, A-MSDU or MMPDU shall be broken into fragments if its size exceeds the value of this attribute after adding MAC headers and trailers.~~ Except as described above, a~~A~~n MSDU, A-MSDU or MMPDU shall be fragmented when the resulting frame has an individual address in the Address 1 field, and the length of the frame is larger than this threshold. The default value for this attribute shall be the lesser of ~~3000~~ 8000 or the aMPDUMaxLength or the aPSDUMaxLength of the attached PHY and shall never exceed the lesser of ~~3000~~ 8000 or the aMPDUMaxLength or the aPSDUMaxLength of the attached PHY. The value of this attribute shall never be less than 256."
::= { dot11OperationEntry 5 }

Insert the following attribute definitions (21 through 41) into the "dot11Operation TABLE" in Annex D after attribute dot11EDCAAveragingPeriod { dot11OperationEntry 20 }:

```
dot11HTProtection OBJECT-TYPE
          SYNTAX INTEGER { HTNoProtection (0), HTNonmemberProtection(1),
HT20MHzProtection(2), HTNonHTmixed(3) }
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute indicates the level of protection that needs
to be provided to the transmissions in an IEEE 802.11 network with HT STAs."
          DEFVAL { HTNoProtection}
          ::= { dot11OperationEntry 21 }

dot11RIFSMode OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that use of RIFS is
allowed in the BSS."
          DEFVAL { false }
          ::= { dot11OperationEntry 22 }

dot11PSMPControlledAccess OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE indicates that the AP accepts
associations only from STAs for which dot11PSMPOptionImplemented is TRUE."
          DEFVAL { false }
          ::= { dot11OperationEntry 23 }
```



```
dot11ServiceIntervalGranularity OBJECT-TYPE
          SYNTAX INTEGER (0..7)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute indicates the SI granularity to be used for
scheduled PSMP. The value of the granularity is given by
(dot11ServiceIntervalGranularity+1)*5 ms."
          DEFVAL { 0 }
          ::= { dot11OperationEntry 24 }

dot11DualCTSProtection OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE indicates that the AP uses dual CTS
protection to protect the non-STBC frame and STBC frame transmissions."
          DEFVAL { false }
          ::= { dot11OperationEntry 25 }

dot11LSIGTXOPFullProtectionEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the LSIG TXOP
protection may be used by STAs that have the attribute
dot11LSigTxopProtectionOptionImplemented set to TRUE."
          DEFVAL { false }
          ::= { dot11OperationEntry 26 }

dot11NonGFEntitiesPresent OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that STA that are not
HT-greenfield Capable are present in the BSS."
          DEFVAL { false }
          ::= { dot11OperationEntry 27 }

dot11PCOActivated OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the PCO is
activated."
          DEFVAL { false }
```

```
          ::= { dot11OperationEntry 28 }

dot11PCOFortyMaxDuration OBJECT-TYPE
          SYNTAX INTEGER (1..200)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"The attribute indicates the maximum duration of 40 MHz phase in TU under PCO
operation. The value of this attribute shall be equal to or larger than
dot11PCOFortyMinDuration."
          DEFVAL { 30 }
          ::= { dot11OperationEntry 29 }

dot11PCOTwentyMaxDuration OBJECT-TYPE
          SYNTAX INTEGER (1..200)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"The attribute indicates the maximum duration of 20 MHz phase in TU under PCO
operation. The value of this attribute shall be equal to or larger than
dot11PCOTwentyMinDuration."
          DEFVAL { 30 }
          ::= { dot11OperationEntry 30 }

dot11PCOFortyMinDuration OBJECT-TYPE
          SYNTAX INTEGER (1..200)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"The attribute indicates the minimum duration of 40 MHz phase in TU under PCO
operation."
          DEFVAL { 20 }
          ::= { dot11OperationEntry 31 }

dot11PCOTwentyMinDuration OBJECT-TYPE
          SYNTAX INTEGER (1..200)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"The attribute indicates the minimum duration of 20 MHz phase in TU under PCO
operation."
          DEFVAL { 20 }
          ::= { dot11OperationEntry 32 }

dot11FortyMHzIntolerant OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
“This attribute, when TRUE, indicates that the STA requests that 40 MHz mask
PPDUs are not transmitted within range of the STA.”
```



```
          DEFVAL { false }
::= { dot11OperationEntry 33 }

dot11BSSWidthTriggerScanInterval OBJECT-TYPE
          SYNTAX INTEGER (10..900)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"This attribute indicates the maximum interval in seconds between scan
operations to be performed to detect BSS channel width trigger events."
          DEFVAL { 300 }
:::= { dot11OperationEntry 34 }

dot11BSSWidthChannelTransitionDelayFactor OBJECT-TYPE
          SYNTAX INTEGER (5..100)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"This attribute indicates the minimum ratio between the delay time in
performing a switch from 20 MHz BSS operation to 20/40 MHz BSS operation and
the maximum interval between OBSS scan operations."
          DEFVAL { 5 }
:::= { dot11OperationEntry 35 }

dot11OBSSScanPassiveDwell OBJECT-TYPE
          SYNTAX INTEGER (5..1000)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"This attribute indicates the minimum amount of time in TU that the STA
continuously scans each channel when performing a passive OBSS scan
operation."
          DEFVAL { 20 }
:::= { dot11OperationEntry 36 }

dot11OBSSScanActiveDwell OBJECT-TYPE
          SYNTAX INTEGER (10..1000)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"This attribute indicates the minimum amount of time in TU that the STA
continuously scans each channel when performing an active OBSS scan
operation."
          DEFVAL { 10 }
::= { dot11OperationEntry 37 }

dot11OBSSScanPassiveTotalPerChannel OBJECT-TYPE
          SYNTAX INTEGER (200..10000)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
```

```
"This attribute indicates the minimum total amount of time in TU that the STA
scans each channel when performing a passive OBSS scan operation."
          DEFVAL { 200 }
::= { dot11OperationEntry 38 }

dot11OBSSScanActiveTotalPerChannel OBJECT-TYPE
          SYNTAX INTEGER (20..10000)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"This attribute indicates the minimum total amount of time in TU that the STA
scans each channel when performing an active OBSS scan operation."
          DEFVAL { 20 }
::= { dot11OperationEntry 39 }

dot112040BSSCoexistenceManagementSupport OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"This attribute, when TRUE, indicates that the STA supports the transmission
and reception of the 20/40 BSS Coexistence Management frame."
          DEFVAL { false }
::= { dot11OperationEntry 40 }

dot11OBSSScanActivityThreshold OBJECT-TYPE
          SYNTAX INTEGER (0..100)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
"This attribute indicates in hundredths of percent, the maximum total time
that a STA may be active on the medium during a period of
dot11BSSWidthChannelTransitionDelayFactor * dot11BSSWidthTriggerScanInterval
seconds without being obligated to perform OBSS Scan operations. The default
value of this attribute is 25, which equates to 0.25%."
          DEFVAL { 25 }
::= { dot11OperationEntry 41}
```

Change the "Dot11CountersEntry" sequence list in the "dot11Counters TABLE" in Annex D as follows:

```
Dot11CountersEntry ::=
       SEQUENCE {
          dot11TransmittedFragmentCount              Counter32,
          dot11MulticastTransmittedFrameCount        Counter32,
          dot11FailedCount                           Counter32,
          dot11RetryCount                            Counter32,
          dot11MultipleRetryCount                    Counter32,
          dot11FrameDuplicateCount                   Counter32,
          dot11RTSSuccessCount                       Counter32,
          dot11RTSFailureCount                       Counter32,
```



```
dot11ACKFailureCount                        Counter32,
dot11ReceivedFragmentCount                  Counter32,
dot11MulticastReceivedFrameCount            Counter32,
dot11FCSErrorCount                          Counter32,
dot11TransmittedFrameCount                  Counter32,
dot11WEPUndecryptableCount                  Counter32,
dot11QoSDiscardedFragmentCount              Counter32,
dot11AssociatedStationCount                 Counter32,
dot11QoSCFPollsReceivedCount                Counter32,
dot11QoSCFPollsUnusedCount                  Counter32,
dot11QoSCFPollsUnusableCount                Counter32,
dot11QoSCFPollsLostCount                    Counter32,
dot11TransmittedAMSDUCount                  Counter32,
dot11FailedAMSDUCount                       Counter32,
dot11RetryAMSDUCount                        Counter32,
dot11MultipleRetryAMSDUCount                Counter32,
dot11TransmittedOctetsInAMSDUCount          Counter64,
dot11AMSDUAckFailureCount                   Counter32,
dot11ReceivedAMSDUCount                     Counter32,
dot11ReceivedOctetsInAMSDUCount             Counter64,
dot11TransmittedAMPDUCount                  Counter32,
dot11TransmittedMPDUsInAMPDUCount           Counter32,
dot11TransmittedOctetsInAMPDUCount          Counter64,
dot11AMPDUReceivedCount                     Counter32,
dot11MPDUInReceivedAMPDUCount               Counter32,
dot11ReceivedOctetsInAMPDUCount             Counter64,
dot11AMPDUDelimiterCRCErrorCount            Counter32,
dot11ImplicitBARFailureCount                Counter32,
dot11ExplicitBARFailureCount                Counter32,
dot11ChannelWidthSwitchCount                Counter32,
dot11TwentyMHzFrameTransmittedCount         Counter32,
dot11FortyMHzFrameTransmittedCount          Counter32,
dot11TwentyMHzFrameReceivedCount            Counter32,
dot11FortyMHzFrameReceivedCount             Counter32,
dot11PSMPUTTGrantDuration                   Counter32,
dot11PSMPUTTUsedDuration                    Counter32,
dot11GrantedRDGUsedCount                    Counter32,
dot11GrantedRDGUnusedCount                  Counter32,
dot11TransmittedFramesInGrantedRDGCount     Counter32,
dot11TransmittedOctetsInGrantedRDGCount     Counter64,
dot11BeamformingFrameCount                  Counter32,
dot11DualCTSSuccessCount                    Counter32,
dot11DualCTSFailureCount                    Counter32,
dot11STBCCTSSuccessCount                    Counter32,
dot11STBCCTSFailureCount                    Counter32,
dot11nonSTBCCTSSuccessCount                 Counter32,
dot11nonSTBCCTSFailureCount                 Counter32,
dot11RTSLSIGSuccessCount                    Counter32,
dot11RTSLSIGFailureCount                    Counter32,
dot11PBACErrors                             Counter32
```

```
        }
```

Insert the following attribute descriptions (21 through 58) into the "dot11Counters TABLE" in Annex D after attribute dot11QoSCFPollsLostCount { dot11CountersEntry 20 }:

```
dot11TransmittedAMSDUCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented for an acknowledged A-MSDU
frame with an individual address in the address 1 field or an A-MSDU frame
with a group  address in the address 1 field."
          ::= { dot11CountersEntry 21 }

dot11FailedAMSDUCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when an A-MSDU is not
transmitted successfully due to the number of transmit attempts exceeding
either the dot11ShortRetryLimit or dot11LongRetryLimit."
          ::= { dot11CountersEntry 22 }

dot11RetryAMSDUCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when an A-MSDU is
successfully transmitted after one or more retransmissions."
          ::= { dot11CountersEntry 23 }

dot11MultipleRetryAMSDUCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when an A-MSDU is
successfully transmitted after more than one retransmission."
          ::= { dot11CountersEntry 24 }

dot11TransmittedOctetsInAMSDUCount OBJECT-TYPE
          SYNTAX Counter64
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
```

```
                "This counter shall be incremented by the number of octets in
the framebody of an A-MSDU frame when an A-MSDU frame is successfully
transmitted."
          ::= { dot11CountersEntry 25 }

dot11AMSDUAckFailureCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented when an acknowledgment to
an A-MSDU is not received when expected. This acknowledgment can be in an ACK
or the BlockAck frame."
          ::= { dot11CountersEntry 26 }

dot11ReceivedAMSDUCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented for a received A-MSDU frame
with the station's MAC address in the address 1 field or an A-MSDU frame with
a group address in the address 1 field."
          ::= { dot11CountersEntry 27 }

dot11ReceivedOctetsInAMSDUCount OBJECT-TYPE
          SYNTAX Counter64
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented by the number of octets in
the framebody of an A-MSDU frame when an A-MSDU frame is received."
          ::= { dot11CountersEntry 28 }

dot11TransmittedAMPDUCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented when an A-MPDU is
transmitted."
          ::= { dot11CountersEntry 29 }

dot11TransmittedMPDUsInAMPDUCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall increment by the number of MPDUs in the A-
MPDU when an A-MPDU is transmitted."
          ::= { dot11CountersEntry 30 }
```

```
dot11TransmittedOctetsInAMPDUCount OBJECT-TYPE
         SYNTAX Counter64
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This counter shall be incremented by the number of octets in
the A-MPDU frame when an A-MPDU frame is transmitted."
         ::= { dot11CountersEntry 31 }

dot11AMPDUReceivedCount OBJECT-TYPE
         SYNTAX Counter32
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This counter shall be incremented when the MAC receives an A-
MPDU from the PHY."
         ::= { dot11CountersEntry 32 }

dot11MPDUInReceivedAMPDUCount OBJECT-TYPE
         SYNTAX Counter32
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This counter shall be incremented by the number of MPDUs
received in the A-MPDU when an A-MPDU is received."
         ::= { dot11CountersEntry 33 }

dot11ReceivedOctetsInAMPDUCount OBJECT-TYPE
         SYNTAX Counter64
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This counter shall be incremented by the number of octets in
the A-MPDU frame when an A-MPDU frame is received."
         ::= { dot11CountersEntry 34 }

dot11AMPDUDelimiterCRCErrorCount OBJECT-TYPE
         SYNTAX Counter32
         MAX-ACCESS read-only
         STATUS current
         DESCRIPTION
              "This counter shall be incremented when an MPDU delimiter has
a CRC error when this is the first CRC error in the received A-MPDU or when
the previous delimiter has been decoded correctly.”
         ::= { dot11CountersEntry 35 }

dot11ImplicitBARFailureCount OBJECT-TYPE
         SYNTAX Counter32
         MAX-ACCESS read-only
         STATUS current
```



```
          DESCRIPTION
               "This counter shall be incremented when the expected BlockAck
is not received in response to an Implicit BlockAckReq frame."
          ::= { dot11CountersEntry 36 }

dot11ExplicitBARFailureCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when the expected BlockAck
is not received in response to an Explicit BlockAckReq."
          ::= { dot11CountersEntry 37 }

dot11ChannelWidthSwitchCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be increment when the bandwidth used is
switched from 20 to 40 or vice-versa."
          ::= { dot11CountersEntry 38 }

dot11TwentyMHzFrameTransmittedCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when a Frame is transmitted
only on the primary channel."
          ::= { dot11CountersEntry 39 }

dot11FortyMHzFrameTransmittedCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when a Frame is transmitted
on both control and secondary channels."
          ::= { dot11CountersEntry 40 }

dot11TwentyMHzFrameReceivedCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when a Frame is received
only on the primary channel."
          ::= { dot11CountersEntry 41 }

dot11FortyMHzFrameReceivedCount OBJECT-TYPE
```

```
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when a Frame is received on
both the control and secondary channels.”
          ::= { dot11CountersEntry 42 }

dot11PSMPUTTGrantDuration OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter contains the cumulative duration of PSMP-UTT
granted to the STA, in units of 4µs."
          ::= { dot11CountersEntry 43 }

dot11PSMPUTTUsedDuration OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter contains the cumulative duration of transmission
by the STA during its allocated PSMP-UTT, in units of 4µs"
          ::= { dot11CountersEntry 44 }

dot11GrantedRDGUsedCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter at the RD initiator shall be incremented when an
allocated RDG is used by the station, apart from transmitting a response
frame such as ACK or BlockAck frames."
          ::= { dot11CountersEntry 45 }

dot11GrantedRDGUnusedCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter at the initiator shall be incremented when an
allocated RDG is not used by the station, apart from transmitting a response
frame such as ACK or BlockAck frames."
          ::= { dot11CountersEntry 46 }

dot11TransmittedFramesInGrantedRDGCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
```



```
                "This counter at the initiator shall be incremented for every
frame, other than response frames such as ACK or BlockAck frames,
transmitted by the station during a granted RDG."
          ::= { dot11CountersEntry 47 }

dot11TransmittedOctetsInGrantedRDGCount OBJECT-TYPE
          SYNTAX Counter64
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter at the initiator shall be incremented by the
number of octets in the framebody of a frame, other than response frames such
as ACK or BlockAck frames, transmitted by the station during a granted RDG."
          ::= { dot11CountersEntry 48 }

dot11BeamformingFrameCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented when the transmitter sends
a frame with new/updated beamforming parameters."
          ::= { dot11CountersEntry 49 }

dot11DualCTSSuccessCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented when AP sends a dual CTS in
response to a STA initiating TXOP in extended range."
          ::= { dot11CountersEntry 50 }

dot11DualCTSFailureCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented when AP fails to send a
dual CTS in response to a STA initiating TXOP in extended range."
          ::= { dot11CountersEntry 51 }

dot11STBCCTSSuccessCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This counter shall be incremented when AP does not detect a
collision PIFS after sending a CTS to self STBC frame in extended range."
          ::= { dot11CountersEntry 52 }
```

```
dot11STBCCTSFailureCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when AP detects a collision
PIFS after sending a CTS to self STBC frame in extended range."
          ::= { dot11CountersEntry 53 }

dot11nonSTBCCTSSuccessCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when AP does not detect a
collision PIFS after sending a CTS to self that is an non-STBC frame in
extended range."
          ::= { dot11CountersEntry 54 }

dot11nonSTBCCTSFailureCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when AP detects a collision
PIFS after sending a CTS to self that is an non-STBC frame in extended
range."
          ::= { dot11CountersEntry 55 }

dot11RTSLSIGSuccessCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when the duration/ID field
is set according to the rules of EPP in the received CTS following a
transmission of RTS in EPP mode."
          ::= { dot11CountersEntry 56 }

dot11RTSLSIGFailureCount OBJECT-TYPE
          SYNTAX Counter32
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This counter shall be incremented when the duration/ID field
is not set according to the rules of EPP in the received CTS following a
transmission of RTS in EPP mode."
          ::= { dot11CountersEntry 57 }

dot11PBACErrors OBJECT-TYPE
          SYNTAX Counter32
```

```
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
          "This variable indicates the number of errors encountered in the
PBAC procedures."
               DEFAULT { 0 }
          ::= { dot11CountersEntry 58}
```

Change attribute dot11PhyType { dot11PhyOperationEntry 1 } in the "dot11PhyOperation TABLE" in Annex D as follows:

```
dot11PHYType OBJECT-TYPE
          SYNTAX INTEGER { fhss(1), dsss(2), irbaseband(3), ofdm(4),
hrdsss(5), erp(6), ht (7) }
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This is an 8-bit integer value that identifies the PHY type
supported by the attached PLCP and PMD. Currently defined values and their
corresponding PHY types are:

               FHSS 2.4 GHz = 01, DSSS 2.4 GHz = 02, IR Baseband = 03, OFDM 5
GHz = 04, HRDSSS = 05, ERP = 06, HT = 07"
::= { dot11PhyOperationEntry 1 }
```

Change the "Dot11PhyAntennaEntry" sequence list in the "dot11PhyAntenna TABLE" in Annex D as follows:

```
Dot11PhyAntennaEntry ::=
     SEQUENCE {
          dot11CurrentTxAntenna                                 Integer32,
          dot11DiversitySupport                                 INTEGER,
          dot11CurrentRxAntenna                                 Integer32,
          dot11AntennaSelectionOptionImplemented                TruthValue,
          dot11TransmitExplicitCSIFeedbackASOptionImplemented   TruthValue,
          dot11TransmitIndicesFeedbackASOptionImplemented       TruthValue,
          dot11ExplicitCSIFeedbackASOptionImplemented           TruthValue,
          dot11TransmitIndicesComputationASOptionImplemented    TruthValue,
          dot11ReceiveAntennaSelectionOptionImplemented         TruthValue,
          dot11TransmitSoundingPPDUOptionImplemented            TruthValue,
          dot11NumberOfActiveRxAntennas                         INTEGER
     }
```

Insert the following attribute descriptions (4 through 11) into the "dot11PhyAntenna TABLE" in Annex D after attribute dot11CurrentRxAntenna { dot11PhyAntennaEntry 3 }:

```
dot11AntennaSelectionOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
```

```
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that ASEL is supported
by the station implementation. "
          DEFVAL { false }
          ::= { dot11PhyAntennaEntry 4 }

dot11TransmitExplicitCSIFeedbackASOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the transmit ASEL
based on explicit CSI feedback is supported by the station implementation. "
          DEFVAL { false }
          ::= { dot11PhyAntennaEntry 5 }

dot11TransmitIndicesFeedbackASOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the transmit ASEL
based on antenna indices feedback is supported by the station
implementation."
          DEFVAL { false }
          ::= { dot11PhyAntennaEntry 6 }

dot11ExplicitCSIFeedbackASOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the computation of
CSI and feedback the results to support the peer to do ASEL is supported by
the station implementation."
          DEFVAL { false }
          ::= { dot11PhyAntennaEntry 7 }

dot11TransmitIndicesComputationASOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the transmit ASEL
based on antenna indices selection computation and feedback the results to
support the peer to do ASEL is supported by the station implementation."
          DEFVAL { false }
          ::= { dot11PhyAntennaEntry 8 }
```

```
dot11ReceiveAntennaSelectionOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the receive ASEL is
supported by the station implementation. "
          DEFVAL { false }
          ::= { dot11PhyAntennaEntry 9 }

dot11TransmitSoundingPPDUOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the transmission of
sounding PPDUs is supported by the station implementation. "
          DEFVAL { false }
          ::= { dot11PhyAntennasEntry 10 }

dot11NumberOfActiveRxAntennas OBJECT-TYPE
          SYNTAX INTEGER (1..4)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
          "This attribute indicates the number of current active antennas
being used to receive."
          ::= { dot11PhyAntennaEntry 11 }
```

Insert the following tables ("dot11 Phy HT TABLE," "dot11 Supported MCS Tx TABLE," "dot11 Supported MCS Rx TABLE," and "dot11 Transmit Beamforming Config TABLE") after the "dot11PhyERP TABLE" in Annex D:

```
-- **********************************************************************
-- * dot11 Phy HT TABLE
-- **********************************************************************

dot11PhyHTTable OBJECT-TYPE
          SYNTAX SEQUENCE OF Dot11PhyHTEntry
          MAX-ACCESS not-accessible
          STATUS current
          DESCRIPTION
               "Entry of attributes for dot11PhyHTTable. Implemented as a
table indexed on ifIndex to allow for multiple instances on an Agent."
::= { dot11phy 15 }

dot11PhyHTEntry OBJECT-TYPE
          SYNTAX Dot11PhyHTEntry
          MAX-ACCESS not-accessible
          STATUS current
```

```
        DESCRIPTION
            "An entry in the dot11PhyHTEntry Table. ifIndex - Each IEEE
802.11 interface is represented by an ifEntry. Interface tables in this MIB
module are indexed by ifIndex."
        INDEX {ifIndex}
        ::= { dot11PhyHTTable 1 }

Dot11PhyHTEntry ::= SEQUENCE {
        dot11FortyMHzOperationImplemented           TruthValue,
        dot11FortyMHzOperationEnabled               TruthValue,
        dot11CurrentPrimaryChannel                  INTEGER,
        dot11CurrentSecondaryChannel                INTEGER,
        dot11NumberOfSpatialStreamsImplemented      INTEGER,
        dot11NumberOfSpatialStreamsEnabled          INTEGER,
        dot11HTGreenfieldOptionImplemented          TruthValue,
        dot11HTGreenfieldOptionEnabled              TruthValue,
        dot11ShortGIOptionInTwentyImplemented       TruthValue,
        dot11ShortGIOptionInTwentyEnabled           TruthValue,
        dot11ShortGIOptionInFortyImplemented        TruthValue,
        dot11ShortGIOptionInFortyEnabled            TruthValue,
        dot11LDPCCodingOptionImplemented            TruthValue,
        dot11LDPCCodingOptionEnabled                TruthValue,
        dot11TxSTBCOptionImplemented                TruthValue,
        dot11TxSTBCOptionEnabled                    TruthValue,
        dot11RxSTBCOptionImplemented                TruthValue,
        dot11RxSTBCOptionEnabled                    TruthValue,
        dot11BeamFormingOptionImplemented           TruthValue,
        dot11BeamFormingOptionEnabled               TruthValue,
        dot11HighestSupportedDataRate               Integer,
        dot11TxMCSSetDefined                        TruthValue,
        dot11TxRxMCSSetNotEqual                     TruthValue,
        dot11TxMaximumNumberSpatialStreamsSupported Integer,
        dot11TxUnequalModulationSupported           TruthValue }

dot11FortyMHzOperationImplemented OBJECT-TYPE
        SYNTAX TruthValue
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
            "This attribute, when TRUE, indicates that the 40 MHz
Operation is implemented."
        DEFVAL { false }
        ::= { dot11PhyHTEntry 1 }

dot11FortyMHzOperationEnabled OBJECT-TYPE
        SYNTAX TruthValue
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
```



```
               "This attribute, when TRUE, indicates that the 40 MHz
Operation is enabled."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 2 }

dot11CurrentPrimaryChannel OBJECT-TYPE
          SYNTAX INTEGER
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the operating channel. If 20/40 MHz
BSS is currently in use then this attribute indicates the primary channel."
          ::= { dot11PhyHTEntry 3 }

dot11CurrentSecondaryChannel OBJECT-TYPE
          SYNTAX INTEGER
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the channel number of the secondary
channel. If 20/40 MHz BSS is not currently in use, this attribute value shall
be 0."
          ::= { dot11PhyHTEntry 4 }


dot11NumberOfSpatialStreamsImplemented OBJECT-TYPE
          SYNTAX INTEGER (1..4)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the maximum number of spatial
streams implemented."
          DEFVAL { 2 }
          ::= { dot11PhyHTEntry 5 }

dot11NumberOfSpatialStreamsEnabled OBJECT-TYPE
          SYNTAX INTEGER (1..4)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the maximum number of spatial
streams enabled."
          DEFVAL { 2 }
          ::= { dot11PhyHTEntry 6 }

dot11HTGreenfieldOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
```

```
               "This attribute, when TRUE, indicates that the HT-greenfield
option is implemented."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 7 }

dot11HTGreenfieldOptionEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the HT-greenfield
option is enabled."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 8 }

dot11ShortGIOptionInTwentyImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the Short Guard
option is implemented for 20 MHz operation."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 9 }

dot11ShortGIOptionInTwentyEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the Short Guard
option is enabled for 20 MHz operation."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 10 }

dot11ShortGIOptionInFortyImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the Short Guard
option is implemented for 40 MHz operation."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 11 }

dot11ShortGIOptionInFortyEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
```

```
                "This attribute, when TRUE, indicates that the Short Guard
option is enabled for 40 MHz operation."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 12 }

dot11LDPCCodingOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This attribute, when TRUE, indicates that the LDPC coding
option is implemented."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 13 }

dot11LDPCCodingOptionEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This attribute, when TRUE, indicates that the LDPC coding
option is enabled."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 14 }

dot11TxSTBCOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This attribute, when TRUE, indicates that the entity is
capable of transmitting frames using STBC option."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 15 }

dot11TxSTBCOptionEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
                "This attribute, when TRUE, indicates that the entity's
capability of transmitting frames using STBC option is enabled."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 16 }

dot11RxSTBCOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
```

```
               "This attribute, when TRUE, indicates that the entity is
capable of receiving frames that are sent using the STBC."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 17 }

dot11RxSTBCOptionEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the entity’s
capability of receiving frames that are sent using the STBC is enabled."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 18 }

dot11BeamFormingOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the beamforming
option is implemented."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 19 }

dot11BeamFormingOptionEnabled OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the beamforming
option is enabled."
          DEFVAL { false }
          ::= { dot11PhyHTEntry 20 }

dot11HighestSupportedDataRate OBJECT-TYPE
          SYNTAX INTEGER (0..600)
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
               "This attribute shall specify the Highest Data Rate in Mb/s at
which the station may receive data."
          DEFVAL { 0 }
          ::= { dot11PhyHTEntry 21 }

dot11TxMCSSetDefined OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-write
          STATUS current
          DESCRIPTION
```



```
          "This attribute, when TRUE, indicates that the Tx MCS set is
defined."
     DEFVAL { false }
     ::= { dot11PhyHTEntry 22 }

dot11TxRxMCSSetNotEqual OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-only
     STATUS current
     DESCRIPTION
          "This attribute, when TRUE, indicates that the supported Tx
and Rx MCS sets are not equal."
     DEFVAL { false }
     ::= { dot11PhyHTEntry 23 }

dot11TxMaximumNumberSpatialStreamsSupported OBJECT-TYPE
     SYNTAX INTEGER (0..3)
     MAX-ACCESS read-only
     STATUS current
     DESCRIPTION
          "This attribute indicates the Tx maximum number of spatial
streams supported."
     DEFVAL { 0 }
     ::= { dot11PhyHTEntry 24 }

dot11TxUnequalModulationSupported OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-only
     STATUS current
     DESCRIPTION
          "This attribute, when TRUE, indicates that Tx UEQM is
supported."
     DEFVAL { false }
     ::= { dot11PhyHTEntry 25 }

-- **********************************************************************
-- * End of dot11 PHY HT TABLE
-- **********************************************************************

-- **********************************************************************
-- * dot11 Supported MCS Tx TABLE
-- **********************************************************************
dot11SupportedMCSTxTable OBJECT-TYPE
     SYNTAX SEQUENCE OF Dot11SupportedMCSTxEntry
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
     "The Transmit MCS supported by the PLCP and PMD, represented by a
count from 1 to 127, subject to limitations of each individual PHY."
     ::= { dot11phy 16 }
```

```
dot11SupportedMCSTxEntry OBJECT-TYPE
          SYNTAX Dot11SupportedMCSTxEntry
          MAX-ACCESS not-accessible
          STATUS current
          DESCRIPTION
          "An Entry (conceptual row) in the dot11SupportedMCSTx Table.
          ifIndex - Each IEEE 802.11 interface is represented by an
          ifEntry. Interface tables in this MIB module are indexed by
ifIndex."
          INDEX { ifIndex,
dot11SupportedMCSTxIndex }
          ::= { dot11SupportedMCSTxTable 1 }

Dot11SupportedMCSTxEntry ::=
          SEQUENCE {
               dot11SupportedMCSTxIndex          Integer32,
               dot11SupportedMCSTxValue          Integer32 }

dot11SupportedMCSTxIndex OBJECT-TYPE
          SYNTAX Integer32 (1..255)
          MAX-ACCESS not-accessible
          STATUS current
          DESCRIPTION
               "Index object that identifies which MCS to access. Range is
1..255."
          ::= { dot11SupportedMCSTxEntry 1 }

dot11SupportedMCSTxValue OBJECT-TYPE
          SYNTAX Integer32 (1..127)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "The Transmit MCS supported by the PLCP and PMD, represented
by a count from 1 to 127, subject to limitations of each individual PHY."
          ::= { dot11SupportedMCSTxEntry 2 }

-- **********************************************************************
-- * End of dot11 Supported MCS Tx TABLE
-- **********************************************************************

-- **********************************************************************
-- * dot11 Supported MCS Rx TABLE
-- **********************************************************************

dot11SupportedMCSRxTable OBJECT-TYPE
          SYNTAX SEQUENCE OF Dot11SupportedMCSRxEntry
          MAX-ACCESS not-accessible
          STATUS current
          DESCRIPTION
```



```
          "The receive MCS supported by the PLCP and PMD, represented by
a count from 1 to 127, subject to limitations of each individual PHY."
     ::= { dot11phy 17 }

dot11SupportedMCSRxEntry OBJECT-TYPE
     SYNTAX Dot11SupportedMCSRxEntry
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
          "An Entry (conceptual row) in the dot11SupportedMCSRx Table.
ifIndex - Each IEEE 802.11 interface is represented by an ifEntry. Interface
tables in this MIB module are indexed by ifIndex."
     INDEX {
          ifIndex,
          dot11SupportedMCSRxIndex }
     ::= { dot11SupportedMCSRxTable 1 }

Dot11SupportedMCSRxEntry ::=
     SEQUENCE {
          dot11SupportedMCSRxIndex          Integer32,
          dot11SupportedMCSRxValue          Integer32 }

dot11SupportedMCSRxIndex OBJECT-TYPE
     SYNTAX Integer32 (1..255)
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
          "Index object that identifies which MCS to access. Range is
1..255."
     ::= { dot11SupportedMCSRxEntry 1 }

dot11SupportedMCSRxValue OBJECT-TYPE
     SYNTAX Integer32 (1..127)
     MAX-ACCESS read-only
     STATUS current
     DESCRIPTION
          "The receive MCS supported by the PLCP and PMD, represented by
a count from 1 to 127, subject to limitations of each individual PHY."
     ::= { dot11SupportedMCSRxEntry 2 }

-- **********************************************************************
-- * End of dot11 Supported MCS Rx TABLE
-- **********************************************************************

-- **********************************************************************
-- * dot11 Transmit Beamforming Config TABLE
-- **********************************************************************

dot11TransmitBeamformingConfigTable OBJECT-TYPE
     SYNTAX SEQUENCE OF Dot11TransmitBeamformingConfigEntry
```

```
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
             "Entry of attributes for dot11TransmitBeamformingConfigTable.
Implemented as a table indexed on ifIndex to allow for multiple instances on
an Agent."
        ::= { dot11phy 18 }

dot11TransmitBeamformingConfigEntry OBJECT-TYPE
        SYNTAX Dot11TransmitBeamformingConfigEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
             "An entry in the dot11TransmitBeamformingConfig Table.

             ifIndex - Each IEEE 802.11 interface is represented by an
ifEntry. Interface tables in this MIB module are indexed by ifIndex."
        INDEX {ifIndex}
        ::= { dot11TransmitBeamformingConfigTable 1 }

Dot11TransmitBeamformingConfigEntry ::=
     SEQUENCE {
        dot11ReceiveStaggerSoundingOptionImplemented          TruthValue,
        dot11TransmitStaggerSoundingOptionImplemented         TruthValue,
        dot11ReceiveNDPOptionImplemented                      TruthValue,
        dot11TransmitNDPOptionImplemented                     TruthValue,
        dot11ImplicitTransmitBeamformingOptionImplemented     TruthValue,
        dot11CalibrationOptionImplemented                     INTEGER,
        dot11ExplicitCSITransmitBeamformingOptionImplemented TruthValue,
        dot11ExplicitNonCompressedBeamformingMatrixOptionImplemented
                                                              TruthValue,
        dot11ExplicitTransmitBeamformingCSIFeedbackOptionImplemented
                                                              INTEGER,
        dot11ExplicitNonCompressedBeamformingFeedbackOptionImplemented
                                                              INTEGER,
        dot11ExplicitCompressedBeamformingFeedbackOptionImplemented
                                                              INTEGER,
        dot11NumberBeamFormingCSISupportAntenna               INTEGER,
        dot11NumberNonCompressedBeamformingMatrixSupportAntenna
                                                              INTEGER,
        dot11NumberCompressedBeamformingMatrixSupportAntenna INTEGER
     }

dot11ReceiveStaggerSoundingOptionImplemented OBJECT-TYPE
        SYNTAX TruthValue
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
             "This attribute, when TRUE, indicates that the STA
implementation supports the receiving of staggered sounding frames."
```



```
          DEFVAL { false }
          ::= { dot11TransmitBeamformingConfigEntry 1 }

dot11TransmitStaggerSoundingOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the STA
implementation supports the transmission of staggered sounding frames."
          DEFVAL { false }
          ::= { dot11TransmitBeamformingConfigEntry 2 }

dot11ReceiveNDPOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the STA
implementation is capable of receiving NDP as sounding frames."
          DEFVAL { false }
          ::= { dot11TransmitBeamformingConfigEntry 3 }

dot11TransmitNDPOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that the STA
implementation is capable of transmitting NDP as sounding frames."
          DEFVAL { false }
          ::= { dot11TransmitBeamformingConfigEntry 4 }

dot11ImplicitTransmitBeamformingOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that STA implementation
is capable of applying implicit transmit beamforming."
          DEFVAL { false }
          ::= { dot11TransmitBeamformingConfigEntry 5 }

dot11CalibrationOptionImplemented OBJECT-TYPE
          SYNTAX INTEGER { inCapable (0), unableToInitiate (1),
ableToInitiate (2), fullyCapable (3) }
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the level of calibration supported
by the STA implementation."
```

```
          DEFVAL { inCapable }
          ::= { dot11TransmitBeamformingConfigEntry 6 }

dot11ExplicitCSITransmitBeamformingOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that STA implementation
is capable of applying transmit beamforming using CSI explicit feedback in
its transmission."
          DEFVAL { false }
          ::= { dot11TransmitBeamformingConfigEntry 7 }

dot11ExplicitNonCompressedBeamformingMatrixOptionImplemented OBJECT-TYPE
          SYNTAX TruthValue
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute, when TRUE, indicates that STA implementation
is capable of applying transmit beamforming using noncompressed beamforming
feedback matrix explicit feedback in its transmission."
          DEFVAL { false }
          ::= { dot11TransmitBeamformingConfigEntry 8 }

dot11ExplicitTransmitBeamformingCSIFeedbackOptionImplemented OBJECT-TYPE
          SYNTAX INTEGER { inCapable (0), delayed (1), immediate (2),
unsolicitedImmediate (3), aggregated (4), delayedAggregated (5),
immediateAggregated(6), unsolicitedImmediateAggregated (7) }
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the level of CSI explicit feedback
returned by the STA implementation."
          DEFVAL { inCapable }
          ::= { dot11TransmitBeamformingConfigEntry 9 }

dot11ExplicitNonCompressedBeamformingFeedbackOptionImplemented OBJECT-TYPE
          SYNTAX INTEGER { inCapable (0), delayed (1), immediate (2),
unsolicitedImmediate (3), aggregated (4), delayedAggregated (5),
immediateAggregated(6), unsolicitedImmediateAggregated (7) }
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the level of noncompressed
beamforming feedback matrix explicit feedback returned by the STA
implementation."
          DEFVAL { inCapable }
          ::= { dot11TransmitBeamformingConfigEntry 10 }

dot11ExplicitCompressedBeamformingFeedbackOptionImplemented OBJECT-TYPE
```

```
          SYNTAX INTEGER { inCapable (0), delayed (1), immediate (2),
unsolicitedImmediate (3), aggregated (4), delayedAggregated (5),
immediateAggregated(6), unsolicitedImmediateAggregated (7) }
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the level of noncompressed
beamforming feedback matrix explicit feedback returned by the STA
implementation."
          DEFVAL { inCapable }
          ::= { dot11TransmitBeamformingConfigEntry 11 }

dot11NumberBeamFormingCSISupportAntenna OBJECT-TYPE
          SYNTAX INTEGER (1..4)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the maximum number of beamform
antennas the beamformee can support when CSI feedback is required."
          ::= { dot11TransmitBeamformingConfigEntry 12 }

dot11NumberNonCompressedBeamformingMatrixSupportAntenna OBJECT-TYPE
          SYNTAX INTEGER (1..4)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the maximum number of beamform
antennas the beamformee can support when noncompressed beamforming feedback
matrix feedback is required."
          ::= { dot11TransmitBeamformingConfigEntry 13 }

dot11NumberCompressedBeamformingMatrixSupportAntenna OBJECT-TYPE
          SYNTAX INTEGER (1..4)
          MAX-ACCESS read-only
          STATUS current
          DESCRIPTION
               "This attribute indicates the maximum number of beamform
antennas the beamformee can support when compressed beamforming feedback
matrix feedback is required."
          ::= { dot11TransmitBeamformingConfigEntry 14 }

-- ********************************************************************
-- * End of dot11 Transmit Beamforming Config TABLE
-- ********************************************************************
```

Change "dot11Compliance" in the "Compliance Statements" section in Annex D as follows:

```
dot11Compliance MODULE-COMPLIANCE
          STATUS current
          DESCRIPTION
```

"The compliance statement for SNMPv2 entities that implement the IEEE 802.11 MIB."
MODULE -- this module
MANDATORY-GROUPS {
dot11SMTbase~~9~~10,
dot11MACbase~~2~~3, dot11CountersGroup~~2~~3,
dot11SmtAuthenticationAlgorithms,
dot11ResourceTypeID, dot11PhyOperationComplianceGroup }

Insert the following component description after "GROUP dot11PhyERPComplianceGroup" in the "Compliance Statements" section in Annex D:

```
GROUP dot11PhyHTComplianceGroup
         DESCRIPTION
              "Implementation of this group is required when object
dot11PHYType has the value of ht. This group is mutually exclusive with the
groups dot11PhyIRComplianceGroup and dot11PhyFHSSComplianceGroup"
```

Change the OPTIONAL-GROUPS of the "Compliance Statements" section of Annex D as follows:

```
-- OPTIONAL-GROUPS { dot11SMTprivacy, dot11MACStatistics,
--         dot11PhyAntennaComplianceGroup, dot11PhyTxPowerComplianceGroup,
--         dot11PhyRegDomainsSupportGroup,
--         dot11PhyAntennasListGroup, dot11PhyRateGroup,
--         dot11SMTbase3, dot11MultiDomainCapabilityGroup,
--         dot11PhyFHSSComplianceGroup, dot11RSNAadditions,
--         dot11RegulatoryClassesGroup, dot11Qosadditions,
--         dot11RRMCompliance,
--         dot11FTComplianceGroup,
--         dot11PhyAntennaComplianceGroup2,
--         dot11HTMACadditions,
--         dot11PhyMCSGroup,
--         dot11TransmitBeamformingGroup }
```

Change the status of "dot11PHYAntennaComplianceGroup" in the "Groups - units of conformance" section in Annex D as follows:

dot11PhyAntennaComplianceGroup OBJECT-GROUP
STATUS ~~current~~deprecated
::= { dot11Groups 8 }

Change the status of "dot11MACbase2" in the "Groups - units of conformance" section in Annex D as follows:

dot11MACbase2 OBJECT-GROUP
STATUS ~~current~~deprecated
::= { dot11Groups 31 }

Change the status of "dot11CountersGroup2" in the "Groups - units of conformanace" section in Annex D as follows:

```
dot11CountersGroup2 OBJECT-GROUP
          STATUS ~~current~~deprecated
::= { dot11Groups 32 }
```

Change the status of "dot11SMTbase9" in the "Groups - units of conformance" section in Annex D as follows:

```
dot11SMTbase9 OBJECT-GROUP
          STATUS ~~current~~deprecated
::= { dot11Groups 43 }
```

Insert the following groups (44 through 51) into the "Groups - units of conformance" section in Annex D:

```
dot11PhyAntennaComplianceGroup2 OBJECT-GROUP
          OBJECTS {
               dot11CurrentTxAntenna,
               dot11DiversitySupport,
               dot11CurrentRxAntenna,
               dot11AntennaSelectionOptionImplemented,
               dot11TransmitExplicitCSIFeedbackASOptionImplemented,
               dot11TransmitIndicesFeedbackASOptionImplemented,
               dot11ExplicitCSIFeedbackASOptionImplemented,
               dot11TransmitIndicesComputationASOptionImplemented,
               dot11ReceiveAntennaSelectionOptionImplemented }
          STATUS current
          DESCRIPTION
               "Attributes for Data Rates for IEEE 802.11."
          ::= { dot11Groups 44 }

dot11MACbase3 OBJECT-GROUP
          OBJECTS {
               dot11MACAddress,
               dot11Address,
               dot11GroupAddressesStatus,
               dot11RTSThreshold,
               dot11ShortRetryLimit,
               dot11LongRetryLimit,
               dot11FragmentationThreshold,
               dot11MaxTransmitMSDULifetime,
               dot11MaxReceiveLifetime,
               dot11ManufacturerID,
               dot11ProductID,
```

```
            dot11CAPLimit,
            dot11HCCWmin,
            dot11HCCWmax,
            dot11HCCAIFSN,
            dot11ADDBAResponseTimeout,
            dot11ADDTSResponseTimeout,
            dot11ChannelUtilizationBeaconInterval,
            dot11ScheduleTimeout,
            dot11DLSResponseTimeout,
            dot11QAPMissingAckRetryLimit,
            dot11EDCAAveragingPeriod,
            dot11HTProtection,
            dot11RIFSMode,
            dot11PSMPControlledAccess,
            dot11ServiceIntervalGranularity,
            dot11DualCTSProtection,
            dot11LSIGTXOPFullProtectionEnabled,
            dot11NonGFEntitiesPresent, dot11PCOActivated,
            dot11PCOFortyMaxDuration,
            dot11PCOTwentyMaxDuration,
            dot11PCOFortyMinDuration,
            dot11PCOTwentyMinDuration }
        STATUS current
        DESCRIPTION
            "The MAC object class provides the necessary support for the
access control, generation, and verification of frame check sequences
(FCSs), and proper delivery of valid data to upper layers."
        ::= { dot11Groups 45 }

dot11CountersGroup3 OBJECT-GROUP
        OBJECTS {
            dot11TransmittedFragmentCount,
            dot11MulticastTransmittedFrameCount,
            dot11FailedCount,
            dot11ReceivedFragmentCount,
            dot11MulticastReceivedFrameCount,
            dot11FCSErrorCount,
            dot11WEPUndecryptableCount,
            dot11TransmittedFrameCount,
            dot11QosDiscardedFragmentCount,
            dot11AssociatedStationCount,
            dot11QosCFPollsReceivedCount,
            dot11QosCFPollsUnusedCount,
            dot11QosCFPollsUnusableCount,
            dot11QoSCFPollsLostCount,
            dot11TransmittedAMSDUCount,
            dot11FailedAMSDUCount,
            dot11RetryAMSDUCount,
            dot11MultipleRetryAMSDUCount,
            dot11TransmittedOctetsInAMSDUCount,
```

```
            dot11AMSDUAckFailureCount,
            dot11ReceivedAMSDUCount,
            dot11ReceivedOctetsInAMSDUCount,
            dot11TransmittedAMPDUCount,
            dot11TransmittedMPDUsInAMPDUCount,
            dot11TransmittedOctetsInAMPDUCount,
            dot11AMPDUReceivedCount,
            dot11MPDUInReceivedAMPDUCount,
            dot11ReceivedOctetsInAMPDUCount,
            dot11AMPDUDelimiterCRCErrorCount,
            dot11ImplicitBARFailureCount,
            dot11ExplicitBARFailureCount,
            dot11ChannelWidthSwitchCount,
            dot11TwentyMHzFrameTransmittedCount,
            dot11FortyMHzFrameTransmittedCount,
            dot11TwentyMHzFrameReceivedCount,
            dot11FortyMHzFrameReceivedCount,
            dot11PSMPUTTGrantDuration,
            dot11PSMPUTTUsedDuration,
            dot11GrantedRDGUsedCount,
            dot11GrantedRDGUnusedCount,
            dot11TransmittedFramesInGrantedRDGCount,
            dot11TransmittedOctetsInGrantedRDGCount,
            dot11BeamformingCount,
            dot11DualCTSSuccessCount,
            dot11DualCTSFailureCount,
            dot11STBCCTSSuccessCount,
            dot11STBCCTSFailureCount,
            dot11nonSTBCCTSSuccessCount,
            dot11nonSTBCCTSFailureCount,
            dot11RTSLSIGSuccessCount,
            dot11RTSLSIGFailureCount }
        STATUS current
        DESCRIPTION
            "Attributes from the dot11CountersGroup that are not described
in the dot11MACStatistics group. These objects are mandatory."
::= { dot11Groups 46 }

dot11SMTbase10 OBJECT-GROUP
        OBJECTS {
            dot11MediumOccupancyLimit,
            dot11CFPollable,
            dot11CFPPeriod,
            dot11CFPMaxDuration,
            dot11AuthenticationResponseTimeOut,
            dot11PrivacyOptionImplemented,
            dot11PowerManagementMode,
            dot11DesiredSSID,
            dot11DesiredBSSType,
            dot11OperationalRateSet,
```

```
dot11BeaconPeriod,
dot11DTIMPeriod,
dot11AssociationResponseTimeOut,
dot11DisassociateReason,
dot11DisassociateStation,
dot11DeauthenticateReason,
dot11DeauthenticateStation,
dot11AuthenticateFailStatus,
dot11AuthenticateFailStation,
dot11MultiDomainCapabilityImplemented,
dot11MultiDomainCapabilityEnabled,
dot11CountryString,
dot11RSNAOptionImplemented,
dot11RegulatoryClassesImplemented,
dot11RegulatoryClassesRequired,
dot11QosOptionImplemented,
dot11ImmediateBlockAckOptionImplemented,
dot11DelayedBlockAckOptionImplemented,
dot11DirectOptionImplemented,
dot11APSDOptionImplemented,
dot11QAckOptionImplemented,
dot11QBSSLoadOptionImplemented,
dot11QueueRequestOptionImplemented,
dot11TXOPRequestOptionImplemented,
dot11MoreDataAckOptionImplemented,
dot11AssociateinNQBSS,
dot11DLSAllowedInQBSS,
dot11DLSAllowed,
dot11AssociateStation,
dot11AssociateID,
dot11AssociateFailStation,
dot11AssociateFailStatus,
dot11ReassociateStation,
dot11ReassociateID,
dot11ReassociateFailStation,
dot11ReassociateFailStatus,
dot11RadioMeasurementCapable,
dot11RadioMeasurementEnabled,
dot11RadioMeasurementProbeDelay,
dot11MeasurementPilotReceptionEnabled,
dot11MeasurementPilotTransmissionEnabled,
dot11MeasurementPilotTransmissionInVirtualApSetEnabled,
dot11MeasurementPilotPeriod,
dot11LinkMeasurementEnabled,
dot11NeighborReportEnabled,
dot11ParallelMeasurementsEnabled,
dot11TriggeredMeasurementsEnabled,
dot11RepeatedMeasurementsEnabled,
dot11MeasurementPauseEnabled,
dot11QuietIntervalEnabled,
```

```
               dot11FastBSSTransitionImplemented,
               dot11LCIDSEImplemented,
               dot11LCIDSERequired,
               dot11DSERequired,
               dot11ExtendedChannelSwitchEnabled,
               dot11HighThroughputOptionImplemented,
               dot11RSNAPBACRequired,
               dot11PSMPOptionImplemented }
          STATUS current
          DESCRIPTION
               "The SMTbase10 object class provides the necessary support at
the STA to manage the processes in the STA such that the STA may work
cooperatively as a part of an IEEE 802.11 network."
::= { dot11Groups 47 }

dot11PhyMCSGroup OBJECT-GROUP
          OBJECTS {
               dot11SupportedMCSTxValue,
               dot11SupportedMCSRxValue }
          STATUS current
          DESCRIPTION
               "Attributes for MCS for IEEE 802.11 HT."
          ::= { dot11Groups 48 }

dot11PhyHTComplianceGroup OBJECT-GROUP
          OBJECTS {
               dot11HighThroughputOptionImplemented,
               dot11FortyMHzOperationImplemented,
               dot11FortyMHzOperationEnabled,
               dot11CurrentPrimaryChannel,
               dot11CurrentSecondaryChannel,
               dot11HTGreenfieldOptionImplemented,
               dot11HTGreenfieldOptionEnabled,
               dot11ShortGIOptionInTwentyImplemented,
               dot11ShortGIOptionInTwentyEnabled,
               dot11ShortGIOptionInFortyImplemented,
               dot11ShortGIOptionInFortyEnabled,
               dot11LDPCCodingOptionImplemented,
               dot11LDPCCodingOptionEnabled,
               dot11TxSTBCOptionImplemented,
               dot11TxSTBCOptionEnabled,
               dot11RxSTBCOptionImplemented,
               dot11RxSTBCOptionEnabled,
               dot11BeamFormingOptionImplemented,
               dot11BeamFormingOptionEnabled }
          STATUS current
          DESCRIPTION
               "Attributes that configure the HT for IEEE 802.11."
          ::= { dot11Groups 49 }
```

```
dot11HTMACAdditions OBJECT-GROUP
         OBJECTS {
              dot11HTOperationalMCSSet,
              dot11MIMOPowerSave,
              dot11NDelayedBlockAckOptionImplemented,
              dot11MaxAMSDULength,
              dot11STBCControlFrameOptionImplemented,
              dot11LsigTxopProtectionOptionImplemented,
              dot11MaxRxAMPDUFactor,
              dot11MinimumMPDUStartSpacing,
              dot11PCOOptionImplemented,
              dot11TransitionTime,
              dot11MCSFeedbackOptionImplemented,
              dot11HTControlFieldSupported,
              dot11RDResponderOptionImplemented }
         STATUS current
         DESCRIPTION
              "Attributes that configure the HT for IEEE 802.11."
         ::= { dot11Groups 50 }

dot11TransmitBeamformingGroup OBJECT-GROUP
         OBJECTS {
         dot11ReceiveStaggerSoundingOptionImplemented,
         dot11TransmitStaggerSoundingOptionImplemented,
         dot11ReceiveNDPOptionImplemented,
         dot11TransmitNDPOptionImplemented,
         dot11ImplicitTransmitBeamformingOptionImplemented,
         dot11CalibrationOptionImplemented,
         dot11ExplicitCSITransmitBeamformingOptionImplemented,
         dot11ExplicitNonCompressedBeamformingMatrixOptionImplemented,
         dot11ExplicitTransmitBeamformingCSIFeedbackOptionImplemented,
         dot11ExplicitNonCompressedBeamformingFeedbackOptionImplemented,
         dot11ExplicitCompressedBeamformingFeedbackOptionImplemented,
         dot11NumberBeamFormingCSISupportAntenna,
         dot11NumberNonCompressedBeamformingMatrixSupportAntenna,
         dot11NumberCompressedBeamformingMatrixSupportAntenna
          }
      STATUS current
      DESCRIPTION
              "Attributes that configure the Beamforming for IEEE 802.11
HT."
         ::= { dot11Groups 51 }
```


Annex G

(informative)

Change the title of Clause G as follows:

~~An example~~ Examples of encoding a frame for OFDM PHYs

Change the subclause headings throughout Clause G as shown:

G.1 Example 1 - BCC encoding

G.1.1 ~~G.1~~ Introduction

Add the following paragraph at the end of the new G.1.1:

In each Annex G table that has "Binary value" columns, the bit positions of the binary values are specified in the header of the table.

G.1.2 ~~G.2~~ The message for the BCC example

Change the first paragraph of the new G.1.2 as follows:

The message being encoded consists of the first 72 characters (shown in **bold** and including line breaks) of the well-known "Ode to Joy" by F. Schiller:

Change the first 72 characters of the text quoted in the new G.1.2 to a bold font as follows:

Joy, bright spark of divinity,
Daughter of Elysium,
Fire-insired we tread
Thy sanctuary.
Thy magic power re-unites
All that custom has divided,
All men become brothers
Under the sway of thy gentle wings.

Replace Table G.1 with the following table:

Table G.1—Message for BCC example

Octet ##	Value	Value	Value	Value	Value
1...5	0x04	0x02	0x00	0x2E	0x00
6...10	0x60	0x08	0xCD	0x37	0xA6
11...15	0x00	0x20	0xD6	0x01	0x3C
16...20	0xF1	0x00	0x60	0x08	0xAD

Table G.1—Message for BCC example *(continued)*

Octet ##	Value	Value	Value	Value	Value
21...25	0x3B	0xAF	0x00	0x00	0x4A
26...30	0x6F	0x79	0x2C	0x20	0x62
31...35	0x72	0x69	0x67	0x68	0x74
36...40	0x20	0x73	0x70	0x61	0x72
41...45	0x6B	0x20	0x6F	0x66	0x20
46...50	0x64	0x69	0x76	0x69	0x6E
51...55	0x69	0x74	0x79	0x2C	0x0A
56...60	0x44	0x61	0x75	0x67	0x68
61...65	0x74	0x65	0x72	0x20	0x6F
66...70	0x66	0x20	0x45	0x6C	0x79
71...75	0x73	0x69	0x75	0x6D	0x2C
76...80	0x0A	0x46	0x69	0x72	0x65
81...85	0x2D	0x69	0x6E	0x73	0x69
86...90	0x72	0x65	0x64	0x20	0x77
91...95	0x65	0x20	0x74	0x72	0x65
96...100	0x61	0x67	0x33	0x21	0xB6

G.1.3 ~~G.3~~ Generation of the preamble

G.1.3.1 ~~G.3.1~~ Generation of the short sequences

G.1.3.2 ~~G.3.2~~ Generation of the long sequence

G.1.4 ~~G.4~~ Generation of the SIGNAL fields

G.1.4.1 ~~G.4.1~~ SIGNAL field bit assignment

G.1.4.2 ~~G.4.2~~ Coding the SIGNAL field bits

G.1.4.3 ~~G.4.3~~ Interleaving the SIGNAL field bits

G.1.4.4 ~~G.4.4~~ SIGNAL field frequency domain

G.1.4.5 ~~G.4.5~~ SIGNAL field time domain

G.1.5 ~~G.5~~ Generating the DATA bits for the BCC example

G.1.5.1 ~~G.5.1~~ Delineating, SERVICE field prepending, and zero padding

Change the text of the new G.1.5.1 as follows:

The transmitted message shown in Table G.1 contains 100 octets or, equivalently, 800 bits. The bits are prepended by the 16 SERVICE field bits and are appended by 6 tail bits. The resulting 822 bits are appended by ~~zero~~some number of bits with value zero to yield an intege~~er~~ral number of OFDM symbols. For the 36 Mb/s mode, there are 144 data bits per OFDM symbol; the overall number of bits is ceiling (822/144) × 144 = 864. Hence, 864 – 822 = 42 zero bits are appended.

~~The data bits are shown in Table G.13 and Table G.14. For clarity, only the first and last 144 bits are shown.~~ The DATA bits are shown in Table G.13.

Replace Table G.13 with the following table, and delete Table G.14 (titled "Last 144 DATA bits"):

Table G.13—DATA bits before scrambling

Bit ##	Binary value b7 b0	Binary value b15 b8	Binary value b23 b16	Hex value	Hex value	Hex value
000–023	00000000	00000000	00000100	0x00	0x00	0x04
024–047	00000010	00000000	00101110	0x02	0x00	0x2E
048–071	00000000	01100000	00001000	0x00	0x60	0x08
072–095	11001101	00110111	10100110	0xCD	0x37	0xA6
096–119	00000000	00100000	11010110	0x00	0x20	0xD6
120–143	00000001	00111100	11110001	0x01	0x3C	0xF1
144–167	00000000	01100000	00001000	0x00	0x60	0x08
168–191	10101101	00111011	10101111	0xAD	0x3B	0xAF
192–215	00000000	00000000	01001010	0x00	0x00	0x4A
216–239	01101111	01111001	00101100	0x6F	0x79	0x2C
240–263	00100000	01100010	01110010	0x20	0x62	0x72
264–287	01101001	01100111	01101000	0x69	0x67	0x68
288–311	01110100	00100000	01110011	0x74	0x20	0x73
312–335	01110000	01100001	01110010	0x70	0x61	0x72
336–359	01101011	00100000	01101111	0x6B	0x20	0x6F
360–383	01100110	00100000	01100100	0x66	0x20	0x64
384–407	01101001	01110110	01101001	0x69	0x76	0x69
408–431	01101110	01101001	01110100	0x6E	0x69	0x74
432–455	01111001	00101100	00001010	0x79	0x2C	0x0A
456–479	01000100	01100001	01110101	0x44	0x61	0x75
480–503	01100111	01101000	01110100	0x67	0x68	0x74

Table G.13—DATA bits before scrambling *(continued)*

Bit ##	Binary value b7 b0	Binary value b15 b8	Binary value b23 b16	Hex value	Hex value	Hex value
504–527	01100101	01110010	00100000	0x65	0x72	0x20
528–551	01101111	01100110	00100000	0x6F	0x66	0x20
552–575	01000101	01101100	01111001	0x45	0x6C	0x79
576–599	01110011	01101001	01110101	0x73	0x69	0x75
600–623	01101101	00101100	00001010	0x6D	0x2C	0x0A
624–647	01000110	01101001	01110010	0x46	0x69	0x72
648–671	01100101	00101101	01101001	0x65	0x2D	0x69
672–695	01101110	01110011	01101001	0x6E	0x73	0x69
696–719	01110010	01100101	01100100	0x72	0x65	0x64
720–743	00100000	01110111	01100101	0x20	0x77	0x65
744–767	00100000	01110100	01110010	0x20	0x74	0x72
768–791	01100101	01100001	01100111	0x65	0x61	0x67
792–815	00110011	00100001	10110110	0x33	0x21	0xB6
816–839	00000000	00000000	00000000	0x00	0x00	0x00
840–863	00000000	00000000	00000000	0x00	0x00	0x00

G.1.5.2 ~~G.5.2~~ Scrambling the BCC example

Change the text of the new G.1.5.2 as follows:

The 864 bits are scrambled by the scrambler defined ~~of Figure 17-7 (~~in 17.3.5.4~~)~~. The initial state of the scrambler is the state 1011101. The generated scrambling sequence is given in Table G.15.

After scrambling, the 6 bits in location 816 (i.e., bit 817~~the 817th bit~~) to 821 (i.e., bit 822~~the 822nd bit~~) are zeroed. ~~The first and last 144 scrambled bits are show in Table G.16 and G.17, respectively.~~ The scrambled DATA bits are shown in Table G.16.

Replace Table G.16 with the following table, and delete Table G.17 (titled "Last 144 bits after scrambling"):

Table G.16—DATA bits after scrambling

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
000–023	01101100	00011001	10001001	0x6C	0x19	0x89
024–047	10001111	01101000	00100001	0x8F	0x68	0x21
048–071	11110100	10100101	01100001	0xF4	0xA5	0x61
072–095	01001111	11010111	10101110	0x4F	0xD7	0xAE

Table G.16—DATA bits after scrambling *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
096–119	00100100	00001100	11110011	0x24	0x0C	0xF3
120–143	00111010	11100100	10111100	0x3A	0xE4	0xBC
144–167	01010011	10011000	11000000	0x53	0x98	0xC0
168–191	00011110	00110101	10110011	0x1E	0x35	0xB3
192–215	11100011	11111000	00100101	0xE3	0xF8	0x25
216–239	01100000	11010110	00100101	0x60	0xD6	0x25
240–263	00110101	00110011	11111110	0x35	0x33	0xFE
264–287	11110000	01000001	00101011	0xF0	0x41	0x2B
288–311	10001111	01010011	00011100	0x8F	0x53	0x1C
312–335	10000011	01000001	10111110	0x83	0x41	0xBE
336–359	00111001	00101000	01100110	0x39	0x28	0x66
360–383	01000100	01100110	11001101	0x44	0x66	0xCD
384–407	11110110	10100011	11011000	0xF6	0xA3	0xD8
408–431	00001101	11010100	10000001	0x0D	0xD4	0x81
432–455	00111011	00101111	11011111	0x3B	0x2F	0xDF
456–479	11000011	01011000	11110111	0xC3	0x58	0xF7
480–503	11000110	01010010	11101011	0xC6	0x52	0xEB
504–527	01110000	10001111	10011110	0x70	0x8F	0x9E
528–551	01101010	10010000	10000001	0x6A	0x90	0x81
552–575	11111101	01111100	10101001	0xFD	0x7C	0xA9
576–599	11010001	01010101	00010010	0xD1	0x55	0x12
600–623	00000100	01110100	11011001	0x04	0x74	0xD9
624–647	11101001	00111011	11001101	0xE9	0x3B	0xCD
648–671	10010011	10001101	01111011	0x93	0x8D	0x7B
672–695	01111100	01110000	00000010	0x7C	0x70	0x02
696–719	00100000	10011001	10100001	0x20	0x99	0xA1
720–743	01111101	10001010	00100111	0x7D	0x8A	0x27
744–767	00010111	00111001	00010101	0x17	0x39	0x15
768–791	10100000	11101100	10010101	0xA0	0xEC	0x95
792–815	00010110	10010001	00010000	0x16	0x91	0x10
816–839	00000000	11011100	01111111	0x00	0xDC	0x7F
840–863	00001110	11110010	11001001	0x0E	0xF2	0xC9

G.1.6 ~~G.6~~ Generating the first DATA symbol for the BCC example

G.1.6.1 ~~G.6.1~~ Coding the DATA bits

Change the text of the new G.1.6.1 as follows:

The scrambled bits are coded with a rate 3/4 ~~Ω~~ convolutional code. ~~The first 144 scrambled bits of Table G.16 are mapped into the 192 bits of G.18.~~ The DATA encoded bits are shown in Table G.18.

Replace Table G.18 with the following table:

Table G.18—BCC-encoded DATA bits

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Binary value b24 b31	Hex value	Hex value	Hex value	Hex value
0000–0031	00101011	00001000	10100001	11110000	0x2B	0x08	0xA1	0xF0
0032–0063	10011101	10110101	10011010	00011101	0x9D	0xB5	0x9A	0x1D
0064–0095	01001010	11111011	11101000	11000010	0x4A	0xFB	0xE8	0xC2
0096–0127	10001111	11000000	11001000	01110011	0x8F	0xC0	0xC8	0x73
0128–0159	11000000	01000011	11100000	00011001	0xC0	0x43	0xE0	0x19
0160–0191	11100000	11010011	11101011	10110010	0xE0	0xD3	0xEB	0xB2
0192–0223	10101111	10011000	11111101	01011001	0xAF	0x98	0xFD	0x59
0224–0255	00001111	10001011	01101001	01100110	0x0F	0x8B	0x69	0x66
0256–0287	00001100	10101010	11011001	00010000	0x0C	0xAA	0xD9	0x10
0288–0319	01010110	10001011	10100110	01000000	0x56	0x8B	0xA6	0x40
0320–0351	01100100	10110011	00100001	10011110	0x64	0xB3	0x21	0x9E
0352–0383	10001110	10010001	11000001	00000101	0x8E	0x91	0xC1	0x05
0384–0415	10110111	10110111	11000101	11011000	0xB7	0xB7	0xC5	0xD8
0416–0447	10000000	00101111	10100010	11011101	0x80	0x2F	0xA2	0xDD
0448–0479	01101111	00101011	10010111	01100001	0x6F	0x2B	0x97	0x61
0480–0511	11011001	11011101	00001101	00010010	0xD9	0xDD	0x0D	0x12
0512–0543	01110110	00100111	00000010	01001100	0x76	0x27	0x02	0x4C
0544–0575	10010010	10111100	00010010	01001011	0x92	0xBC	0x12	0x4B
0576–0607	01101010	11110111	01110000	00100011	0x6A	0xF7	0x70	0x23
0608–0639	00100111	10001110	00000001	10110100	0x27	0x8E	0x01	0xB4
0640–0671	11010110	11000011	01101010	01100000	0xD6	0xC3	0x6A	0x60
0672–0703	01001101	01001011	11001011	01010001	0x4D	0x4B	0xCB	0x51
0704–0735	10011100	10110000	10000000	11101011	0x9C	0xB0	0x80	0xEB
0736–0767	10001001	00110100	00010100	01000000	0x89	0x34	0x14	0x40

Table G.18—BCC-encoded DATA bits *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Binary value b24 b31	Hex value	Hex value	Hex value	Hex value
0768–0799	01101100	10011110	00101100	01010001	0x6C	0x9E	0x2C	0x51
0800–0831	01001011	01111100	01101001	00010001	0x4B	0x7C	0x69	0x11
0832–0863	00010101	10000110	11111101	10111110	0x15	0x86	0xFD	0xBE
0864–0895	01011110	11111001	10111110	00101000	0x5E	0xF9	0xBE	0x28
0896–0927	11101111	11001010	01010101	00000011	0xEF	0xCA	0x55	0x03
0928–0959	11111101	00100110	10010001	00111011	0xFD	0x26	0x91	0x3B
0960–0991	10010101	11101100	01011011	00100011	0x95	0xEC	0x5B	0x23
0992–1023	10011001	01011111	00101000	00111110	0x99	0x5F	0x28	0x3E
1024–1055	11010100	11101001	11110111	10111000	0xD4	0xE9	0xF7	0xB8
1056–1087	00010011	01110101	10001110	11110010	0x13	0x75	0x8E	0xF2
1088–1119	10100000	00011011	01101100	11101001	0xA0	0x1B	0x6C	0xE9
1120–1151	00000111	01011101	10110000	10111111	0x07	0x5D	0xB0	0xBF

G.1.6.2 ~~G.6.2~~ Interleaving the DATA bits

G.1.6.3 ~~G.6.3~~ Mapping into symbols

G.1.7 ~~G.7~~ Generating the additional DATA symbols

G.1.8 ~~G.8~~ The entire packet for the BCC example

Change the text of the new G.1.8 as follows:

The packet in its entirety is shown in ~~Table G.24~~in tables in this subclause. ~~The short sequences section, the long sequences section, the SIGNAL field, and the DATA symbols are separated by double lines.~~ The short training sequence section is illustrated in Table G.24, the long training sequence section in Table G.25, the SIGNAL field in Table G.26, and the six DATA symbols in Table G.27 through Table G.32.

Replace Table G.24 with the following table:

Table G.24—Time domain representation of the short training sequence

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
0	0.023	0.023	1	–0.132	0.002	2	–0.013	–0.079	3	0.143	–0.013
4	0.092	0.000	5	0.143	–0.013	6	–0.013	–0.079	7	–0.132	0.002

Table G.24—Time domain representation of the short training sequence *(continued)*

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
8	0.046	0.046	9	0.002	–0.132	10	–0.079	–0.013	11	–0.013	0.143
12	0.000	0.092	13	–0.013	0.143	14	–0.079	–0.013	15	0.002	–0.132
16	0.046	0.046	17	–0.132	0.002	18	–0.013	–0.079	19	0.143	–0.013
20	0.092	0.000	21	0.143	–0.013	22	–0.013	–0.079	23	–0.132	0.002
24	0.046	0.046	25	0.002	–0.132	26	–0.079	–0.013	27	–0.013	0.143
28	0.000	0.092	29	–0.013	0.143	30	–0.079	–0.013	31	0.002	–0.132
32	0.046	0.046	33	–0.132	0.002	34	–0.013	–0.079	35	0.143	–0.013
36	0.092	0.000	37	0.143	–0.013	38	–0.013	–0.079	39	–0.132	0.002
40	0.046	0.046	41	0.002	–0.132	42	–0.079	–0.013	43	–0.013	0.143
44	0.000	0.092	45	–0.013	0.143	46	–0.079	–0.013	47	0.002	–0.132
48	0.046	0.046	49	–0.132	0.002	50	–0.013	–0.079	51	0.143	–0.013
52	0.092	0.000	53	0.143	–0.013	54	–0.013	–0.079	55	–0.132	0.002
56	0.046	0.046	57	0.002	–0.132	58	–0.079	–0.013	59	–0.013	0.143
60	0.000	0.092	61	–0.013	0.143	62	–0.079	–0.013	63	0.002	–0.132
64	0.046	0.046	65	–0.132	0.002	66	–0.013	–0.079	67	0.143	–0.013
68	0.092	0.000	69	0.143	–0.013	70	–0.013	–0.079	71	–0.132	0.002
72	0.046	0.046	73	0.002	–0.132	74	–0.079	–0.013	75	–0.013	0.143
76	0.000	0.092	77	–0.013	0.143	78	–0.079	–0.013	79	0.002	–0.132
80	0.046	0.046	81	–0.132	0.002	82	–0.013	–0.079	83	0.143	–0.013
84	0.092	0.000	85	0.143	–0.013	86	–0.013	–0.079	87	–0.132	0.002
88	0.046	0.046	89	0.002	–0.132	90	–0.079	–0.013	91	–0.013	0.143
92	0.000	0.092	93	–0.013	0.143	94	–0.079	–0.013	95	0.002	–0.132
96	0.046	0.046	97	–0.132	0.002	98	–0.013	–0.079	99	0.143	–0.013
100	0.092	0.000	101	0.143	–0.013	102	–0.013	–0.079	103	–0.132	0.002
104	0.046	0.046	105	0.002	–0.132	106	–0.079	–0.013	107	–0.013	0.143
108	0.000	0.092	109	–0.013	0.143	110	–0.079	–0.013	111	0.002	–0.132
112	0.046	0.046	113	–0.132	0.002	114	–0.013	–0.079	115	0.143	–0.013
116	0.092	0.000	117	0.143	–0.013	118	–0.013	–0.079	119	–0.132	0.002
120	0.046	0.046	121	0.002	–0.132	122	–0.079	–0.013	123	–0.013	0.143
124	0.000	0.092	125	–0.013	0.143	126	–0.079	–0.013	127	0.002	–0.132
128	0.046	0.046	129	–0.132	0.002	130	–0.013	–0.079	131	0.143	–0.013
132	0.092	0.000	133	0.143	–0.013	134	–0.013	–0.079	135	–0.132	0.002
136	0.046	0.046	137	0.002	–0.132	138	–0.079	–0.013	139	–0.013	0.143

Table G.24—Time domain representation of the short training sequence *(continued)*

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
140	0.000	0.092	141	–0.013	0.143	142	–0.079	–0.013	143	0.002	–0.132
144	0.046	0.046	145	–0.132	0.002	146	–0.013	–0.079	147	0.143	–0.013
148	0.092	0.000	149	0.143	–0.013	150	–0.013	–0.079	151	–0.132	0.002
152	0.046	0.046	153	0.002	–0.132	154	–0.079	–0.013	155	–0.013	0.143
156	0.000	0.092	157	–0.013	0.143	158	–0.079	–0.013	159	0.002	–0.132

Insert the following tables (Table G.25 through Table G.32) after Table G.24:

Table G.25—Time domain representation of the long training sequence

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
160	–0.055	0.023	161	0.012	–0.098	162	0.092	–0.106	163	–0.092	–0.115
164	–0.003	–0.054	165	0.075	0.074	166	–0.127	0.021	167	–0.122	0.017
168	–0.035	0.151	169	–0.056	0.022	170	–0.060	–0.081	171	0.070	–0.014
172	0.082	–0.092	173	–0.131	–0.065	174	–0.057	–0.039	175	0.037	–0.098
176	0.062	0.062	177	0.119	0.004	178	–0.022	–0.161	179	0.059	0.015
180	0.024	0.059	181	–0.137	0.047	182	0.001	0.115	183	0.053	–0.004
184	0.098	0.026	185	–0.038	0.106	186	–0.115	0.055	187	0.060	0.088
188	0.021	–0.028	189	0.097	–0.083	190	0.040	0.111	191	–0.005	0.120
192	0.156	0.000	193	–0.005	–0.120	194	0.040	–0.111	195	0.097	0.083
196	0.021	0.028	197	0.060	–0.088	198	–0.115	–0.055	199	–0.038	–0.106
200	0.098	–0.026	201	0.053	0.004	202	0.001	–0.115	203	–0.137	–0.047
204	0.024	–0.059	205	0.059	–0.015	206	–0.022	0.161	207	0.119	–0.004
208	0.062	–0.062	209	0.037	0.098	210	–0.057	0.039	211	–0.131	0.065
212	0.082	0.092	213	0.070	0.014	214	–0.060	0.081	215	–0.056	–0.022
216	–0.035	–0.151	217	–0.122	–0.017	218	–0.127	–0.021	219	0.075	–0.074
220	–0.003	0.054	221	–0.092	0.115	222	0.092	0.106	223	0.012	0.098
224	–0.156	0.000	225	0.012	–0.098	226	0.092	–0.106	227	–0.092	–0.115
228	–0.003	–0.054	229	0.075	0.074	230	–0.127	0.021	231	–0.122	0.017
232	–0.035	0.151	233	–0.056	0.022	234	–0.060	–0.081	235	0.070	–0.014
236	0.082	–0.092	237	–0.131	–0.065	238	–0.057	–0.039	239	0.037	–0.098
240	0.062	0.062	241	0.119	0.004	242	–0.022	–0.161	243	0.059	0.015
244	0.024	0.059	245	–0.137	0.047	246	0.001	0.115	247	0.053	–0.004

Table G.25—Time domain representation of the long training sequence *(continued)*

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
248	0.098	0.026	249	–0.038	0.106	250	–0.115	0.055	251	0.060	0.088
252	0.021	–0.028	253	0.097	–0.083	254	0.040	0.111	255	–0.005	0.120
256	0.156	0.000	257	–0.005	–0.120	258	0.040	–0.111	259	0.097	0.083
260	0.021	0.028	261	0.060	–0.088	262	–0.115	–0.055	263	–0.038	–0.106
264	0.098	–0.026	265	0.053	0.004	266	0.001	–0.115	267	–0.137	–0.047
268	0.024	–0.059	269	0.059	–0.015	270	–0.022	0.161	271	0.119	–0.004
272	0.062	–0.062	273	0.037	0.098	274	–0.057	0.039	275	–0.131	0.065
276	0.082	0.092	277	0.070	0.014	278	–0.060	0.081	279	–0.056	–0.022
280	–0.035	–0.151	281	–0.122	–0.017	282	–0.127	–0.021	283	0.075	–0.074
284	–0.003	0.054	285	–0.092	0.115	286	0.092	0.106	287	0.012	0.098
288	–0.156	0.000	289	0.012	–0.098	290	0.092	–0.106	291	–0.092	–0.115
292	–0.003	–0.054	293	0.075	0.074	294	–0.127	0.021	295	–0.122	0.017
296	–0.035	0.151	297	–0.056	0.022	298	–0.060	–0.081	299	0.070	–0.014
300	0.082	–0.092	301	–0.131	–0.065	302	–0.057	–0.039	303	0.037	–0.098
304	0.062	0.062	305	0.119	0.004	306	–0.022	–0.161	307	0.059	0.015
308	0.024	0.059	309	–0.137	0.047	310	0.001	0.115	311	0.053	–0.004
312	0.098	0.026	313	–0.038	0.106	314	–0.115	0.055	315	0.060	0.088
316	0.021	–0.028	317	0.097	–0.083	318	0.040	0.111	319	–0.005	0.120

Table G.26—Time domain representation of the SIGNAL field (1 symbol)

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
320	0.109	0.000	321	0.033	–0.044	322	–0.002	–0.038	323	–0.081	0.084
324	0.007	–0.100	325	–0.001	–0.113	326	–0.021	–0.005	327	0.136	–0.105
328	0.098	–0.044	329	0.011	–0.002	330	–0.033	0.044	331	–0.060	0.124
332	0.010	0.097	333	0.000	–0.008	334	0.018	–0.083	335	–0.069	0.027
336	–0.219	0.000	337	–0.069	–0.027	338	0.018	0.083	339	0.000	0.008
340	0.010	–0.097	341	–0.060	–0.124	342	–0.033	–0.044	343	0.011	0.002
344	0.098	0.044	345	0.136	0.105	346	–0.021	0.005	347	–0.001	0.113
348	0.007	0.100	349	–0.081	–0.084	350	–0.002	0.038	351	0.033	0.044
352	0.062	0.000	353	0.057	0.052	354	0.016	0.174	355	0.035	0.116
356	–0.051	–0.202	357	0.011	0.036	358	0.089	0.209	359	–0.049	–0.008
360	–0.035	0.044	361	0.017	–0.059	362	0.053	–0.017	363	0.099	0.100

Table G.26—Time domain representation of the SIGNAL field (1 symbol) *(continued)*

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
364	0.034	–0.148	365	–0.003	–0.094	366	–0.120	0.042	367	–0.136	–0.070
368	–0.031	0.000	369	–0.136	0.070	370	–0.120	–0.042	371	–0.003	0.094
372	0.034	0.148	373	0.099	–0.100	374	0.053	0.017	375	0.017	0.059
376	–0.035	–0.044	377	–0.049	0.008	378	0.089	–0.209	379	0.011	–0.036
380	–0.051	0.202	381	0.035	–0.116	382	0.016	–0.174	383	0.057	–0.052
384	0.062	0.000	385	0.033	–0.044	386	–0.002	–0.038	387	–0.081	0.084
388	0.007	–0.100	389	–0.001	–0.113	390	–0.021	–0.005	391	0.136	–0.105
392	0.098	–0.044	393	0.011	–0.002	394	–0.033	0.044	395	–0.060	0.124
396	0.010	0.097	397	0.000	–0.008	398	0.018	–0.083	399	–0.069	0.027

Table G.27—Time domain representation of the DATA field: symbol 1of 6

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
400	–0.139	0.050	401	0.004	0.014	402	0.011	–0.100	403	–0.097	–0.020
404	0.062	0.081	405	0.124	0.139	406	0.104	–0.015	407	0.173	–0.140
408	–0.040	0.006	409	–0.133	0.009	410	–0.002	–0.043	411	–0.047	0.092
412	–0.109	0.082	413	–0.024	0.010	414	0.096	0.019	415	0.019	–0.023
416	–0.087	–0.049	417	0.002	0.058	418	–0.021	0.228	419	–0.103	0.023
420	–0.019	–0.175	421	0.018	0.132	422	–0.071	0.160	423	–0.153	–0.062
424	–0.107	0.028	425	0.055	0.140	426	0.070	0.103	427	–0.056	0.025
428	–0.043	0.002	429	0.016	–0.118	430	0.026	–0.071	431	0.033	0.177
432	0.020	–0.021	433	0.035	–0.088	434	–0.008	0.101	435	–0.035	–0.010
436	0.065	0.030	437	0.092	–0.034	438	0.032	–0.123	439	–0.018	0.092
440	0.000	–0.006	441	–0.006	–0.056	442	–0.019	0.040	443	0.053	–0.131
444	0.022	–0.133	445	0.104	–0.032	446	0.163	–0.045	447	–0.105	–0.030
448	–0.110	–0.069	449	–0.008	–0.092	450	–0.049	–0.043	451	0.085	–0.017
452	0.090	0.063	453	0.015	0.153	454	0.049	0.094	455	0.011	0.034
456	–0.012	0.012	457	–0.015	–0.017	458	–0.061	0.031	459	–0.070	–0.040
460	0.011	–0.109	461	0.037	–0.060	462	–0.003	–0.178	463	–0.007	–0.128
464	–0.059	0.100	465	0.004	0.014	466	0.011	–0.100	467	–0.097	–0.020
468	0.062	0.081	469	0.124	0.139	470	0.104	–0.015	471	0.173	–0.140
472	–0.040	0.006	473	–0.133	0.009	474	–0.002	–0.043	475	–0.047	0.092
476	–0.109	0.082	477	–0.024	0.010	478	0.096	0.019	479	0.019	–0.023

Table G.28—Time domain representation of the DATA field: symbol 2 of 6

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
480	–0.058	0.016	481	–0.096	–0.045	482	–0.110	0.003	483	–0.070	0.216
484	–0.040	0.059	485	0.010	–0.056	486	0.034	0.065	487	0.117	0.033
488	0.078	–0.133	489	–0.043	–0.146	490	0.158	–0.071	491	0.254	–0.021
492	0.068	0.117	493	–0.044	0.114	494	–0.035	0.041	495	0.085	0.070
496	0.120	0.010	497	0.057	0.055	498	0.063	0.188	499	0.091	0.149
500	–0.017	–0.039	501	–0.078	–0.075	502	0.049	0.079	503	–0.014	–0.007
504	0.030	–0.027	505	0.080	0.054	506	–0.186	–0.067	507	–0.039	–0.027
508	0.043	–0.072	509	–0.092	–0.089	510	0.029	0.105	511	–0.144	0.003
512	–0.069	–0.041	513	0.132	0.057	514	–0.126	0.070	515	–0.031	0.109
516	0.161	–0.009	517	0.056	–0.046	518	–0.004	0.028	519	–0.049	0.000
520	–0.078	–0.005	521	0.015	–0.087	522	0.149	–0.104	523	–0.021	–0.051
524	–0.154	–0.106	525	0.024	0.030	526	0.046	0.123	527	–0.004	–0.098
528	–0.061	–0.128	529	–0.024	–0.038	530	0.066	–0.048	531	–0.067	0.027
532	0.054	–0.050	533	0.171	–0.049	534	–0.108	0.132	535	–0.161	–0.019
536	–0.070	–0.072	537	–0.177	0.049	538	–0.172	–0.050	539	0.051	–0.075
540	0.122	–0.057	541	0.009	–0.044	542	–0.012	–0.021	543	0.004	0.009
544	–0.030	0.081	545	–0.096	–0.045	546	–0.110	0.003	547	–0.070	0.216
548	–0.040	0.059	549	0.010	–0.056	550	0.034	0.065	551	0.117	0.033
552	0.078	–0.133	553	–0.043	–0.146	554	0.158	–0.071	555	0.254	–0.021
556	0.068	0.117	557	–0.044	0.114	558	–0.035	0.041	559	0.085	0.070

Table G.29—Time domain representation of the DATA field: symbol 3 of 6

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
560	0.001	0.011	561	–0.099	–0.048	562	0.054	–0.196	563	0.124	0.035
564	0.092	0.045	565	–0.037	–0.066	566	–0.021	–0.004	567	0.042	–0.065
568	0.061	0.048	569	0.046	0.004	570	–0.063	–0.045	571	–0.102	0.152
572	–0.039	–0.019	573	–0.005	–0.106	574	0.083	0.031	575	0.226	0.028
576	0.140	–0.010	577	–0.132	–0.033	578	–0.116	0.088	579	0.023	0.052
580	–0.171	–0.080	581	–0.246	–0.025	582	–0.062	–0.038	583	–0.055	–0.062
584	–0.004	–0.060	585	0.034	0.000	586	–0.030	0.021	587	0.075	–0.122
588	0.043	–0.080	589	–0.022	0.041	590	0.026	0.013	591	–0.031	–0.018
592	0.059	0.008	593	0.109	0.078	594	0.002	0.101	595	–0.016	0.054

Table G.29—Time domain representation of the DATA field: symbol 3 of 6 *(continued)*

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
596	–0.059	0.070	597	0.017	0.114	598	0.104	–0.034	599	–0.024	–0.059
600	–0.081	0.051	601	–0.040	–0.069	602	–0.069	0.058	603	–0.067	0.117
604	0.007	–0.131	605	0.009	0.028	606	0.075	0.117	607	0.118	0.030
608	–0.041	0.148	609	0.005	0.098	610	0.026	0.002	611	–0.116	0.045
612	–0.020	0.084	613	0.101	0.006	614	0.205	–0.064	615	0.073	–0.063
616	–0.174	–0.118	617	–0.024	0.026	618	–0.041	0.129	619	–0.042	–0.053
620	0.148	–0.126	621	–0.030	–0.049	622	–0.015	–0.021	623	0.089	–0.069
624	–0.119	0.011	625	–0.099	–0.048	626	0.054	–0.196	627	0.124	0.035
628	0.092	0.045	629	–0.037	–0.066	630	–0.021	–0.004	631	0.042	–0.065
632	0.061	0.048	633	0.046	0.004	634	–0.063	–0.045	635	–0.102	0.152
636	–0.039	–0.019	637	–0.005	–0.106	638	0.083	0.031	639	0.226	0.028

Table G.30—Time domain representation of the DATA field: symbol 4 of 6

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
640	0.085	–0.065	641	0.034	–0.142	642	0.004	–0.012	643	0.126	–0.043
644	0.055	0.068	645	–0.020	0.077	646	0.008	–0.056	647	–0.034	0.046
648	–0.040	–0.134	649	–0.056	–0.131	650	0.014	0.097	651	0.045	–0.009
652	–0.113	–0.170	653	–0.065	–0.230	654	0.065	–0.011	655	0.011	0.048
656	–0.091	–0.059	657	–0.110	0.024	658	0.074	–0.034	659	0.124	0.022
660	–0.037	0.071	661	0.015	0.002	662	0.028	0.099	663	–0.062	0.068
664	0.064	0.016	665	0.078	0.156	666	0.009	0.219	667	0.147	0.024
668	0.106	0.030	669	–0.080	0.143	670	–0.049	–0.100	671	–0.036	–0.082
672	–0.089	0.021	673	–0.070	–0.029	674	–0.086	0.048	675	–0.066	–0.015
676	–0.024	0.002	677	–0.030	–0.023	678	–0.032	0.020	679	–0.002	0.212
680	0.158	–0.024	681	0.141	–0.119	682	–0.146	0.058	683	–0.155	0.083
684	–0.002	–0.030	685	0.018	–0.129	686	0.012	–0.018	687	–0.008	–0.037
688	0.031	0.040	689	0.023	0.097	690	0.014	–0.039	691	0.050	0.019
692	–0.072	–0.141	693	–0.023	–0.051	694	0.024	0.099	695	–0.127	–0.116
696	0.094	0.102	697	0.183	0.098	698	–0.040	–0.020	699	0.065	0.077
700	0.088	–0.147	701	–0.039	–0.059	702	–0.057	0.124	703	–0.077	0.020

Table G.30—Time domain representation of the DATA field: symbol 4 of 6 *(continued)*

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
704	0.030	–0.120	705	0.034	–0.142	706	0.004	–0.012	707	0.126	–0.043
708	0.055	0.068	709	–0.020	0.077	710	0.008	–0.056	711	–0.034	0.046
712	–0.040	–0.134	713	–0.056	–0.131	714	0.014	0.097	715	0.045	–0.009
716	–0.113	–0.170	717	–0.065	–0.230	718	0.065	–0.011	719	0.011	0.048
720	–0.026	–0.021	721	–0.002	0.041	722	0.001	0.071	723	–0.037	–0.117

Table G.31—Time domain representation of the DATA field: symbol 5 of 6

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
724	–0.106	–0.062	725	0.002	0.057	726	–0.008	–0.011	727	0.019	0.072
728	0.016	0.059	729	–0.065	–0.077	730	0.142	–0.062	731	0.087	0.025
732	–0.003	–0.103	733	0.107	–0.152	734	–0.054	0.036	735	–0.030	–0.003
736	0.058	–0.020	737	–0.028	0.007	738	–0.027	–0.099	739	0.049	–0.075
740	0.174	0.031	741	0.134	0.156	742	0.060	0.077	743	–0.010	–0.022
744	–0.084	0.040	745	–0.074	0.011	746	–0.163	0.054	747	–0.052	–0.008
748	0.076	–0.042	749	0.043	0.101	750	0.058	–0.018	751	0.003	–0.090
752	0.059	–0.018	753	0.023	–0.031	754	0.007	–0.017	755	0.066	–0.017
756	–0.135	–0.098	757	–0.056	–0.081	758	0.089	0.154	759	0.120	0.122
760	0.102	0.001	761	–0.141	0.102	762	0.006	–0.011	763	0.057	–0.039
764	–0.059	0.066	765	0.132	0.111	766	0.012	0.114	767	0.047	–0.106
768	0.160	–0.099	769	–0.076	0.084	770	–0.049	0.073	771	0.005	–0.086
772	–0.052	–0.108	773	–0.073	0.129	774	–0.129	–0.034	775	–0.153	–0.111
776	–0.193	0.098	777	–0.107	–0.068	778	0.004	–0.009	779	–0.039	0.024
780	–0.054	–0.079	781	0.024	0.084	782	0.052	–0.002	783	0.028	–0.044
784	0.040	0.018	785	–0.002	0.041	786	0.001	0.071	787	–0.037	–0.117
788	–0.106	–0.062	789	0.002	0.057	790	–0.008	–0.011	791	0.019	0.072
792	0.016	0.059	793	–0.065	–0.077	794	0.142	–0.062	795	0.087	0.025
796	–0.003	–0.103	797	0.107	–0.152	798	–0.054	0.036	799	–0.030	–0.003

Table G.32—Time domain representation of the DATA field: symbol 6 of 6

##	Real	Imag	##	Real	Imag	##	Real	Imag	##	Real	Imag
800	0.029	–0.026	801	–0.047	0.077	802	–0.007	–0.002	803	0.050	–0.021
804	0.046	–0.040	805	–0.061	–0.099	806	–0.121	0.008	807	0.014	0.050
808	0.145	0.034	809	0.001	–0.046	810	–0.058	–0.121	811	0.040	0.001
812	–0.029	0.041	813	0.002	–0.066	814	0.015	–0.054	815	0.010	–0.029
816	0.008	–0.119	817	–0.134	0.002	818	0.064	0.079	819	0.095	–0.102
820	–0.069	–0.014	821	0.156	0.037	822	0.047	–0.008	823	–0.076	0.025
824	0.117	–0.143	825	0.056	–0.042	826	0.002	0.075	827	–0.039	–0.058
828	–0.092	0.014	829	–0.041	0.047	830	–0.058	0.092	831	0.012	0.154
832	0.079	0.091	833	–0.067	0.017	834	–0.102	–0.032	835	0.039	0.084
836	–0.036	0.014	837	–0.001	–0.046	838	0.195	0.131	839	0.039	0.067
840	–0.007	0.045	841	0.051	0.008	842	–0.074	–0.109	843	–0.033	0.070
844	–0.028	0.176	845	–0.041	0.045	846	0.014	–0.084	847	0.054	–0.040
848	0.110	–0.020	849	0.014	–0.021	850	0.006	0.139	851	0.008	0.011
852	–0.060	–0.040	853	0.008	0.179	854	0.008	0.020	855	0.044	–0.114
856	0.021	–0.015	857	–0.008	–0.052	858	0.091	–0.109	859	–0.025	–0.040
860	–0.049	0.006	861	–0.043	–0.041	862	–0.178	–0.026	863	–0.073	–0.057
864	0.000	–0.031	865	–0.047	0.077	866	–0.007	–0.002	867	0.050	–0.021
868	0.046	–0.040	869	–0.061	–0.099	870	–0.121	0.008	871	0.014	0.050
872	0.145	0.034	873	0.001	–0.046	874	–0.058	–0.121	875	0.040	0.001
876	–0.029	0.041	877	0.002	–0.066	878	0.015	–0.054	879	0.010	–0.029
880	0.004	–0.059									

Insert the following subclauses (G.2 through G.3.6) after G.1.8:

G.2 Generating encoded DATA bits—LDPC example 1

LDPC example 1 is similar to the BCC example. This example illustrates LDPC shortening, encoding, and puncturing of a single codeword.

Input TXVECTOR parameters for LDPC example 1:

— FEC_CODING = LDPC_CODING = 1	(LDPC encoder; not BCC)
— CH_BANDWIDTH = HT_CBW20 = 0	(CH_BANDWIDTH = 0 => 20 MHz)
— MCS = 4	(MCS = 4; QAM 16; Coding rate = 3/4)
— Coding rate R = 3/4	
— LENGTH = 100 octets	(with 16-bit SERVICE field becomes 102 Octets = 816 bits to scramble and encode)
— STBC = 0	(STBC = 0 => OFF; m_STBC=1)

G.2.1 The message for LDPC example 1

The message being encoded consists of the first 72 characters (shown in **bold** and including line breaks) of the well-known “Ode to Joy” by F. Schiller:

Joy, bright spark of divinity,
Daughter of Elysium,
Fire-insired we tread
Thy sanctuary.
Thy magic power re-unites
All that custom has divided,
All men become brothers
Under the sway of thy gentle wings.

The message is converted to ASCII; then it is prepended with an appropriate MAC header, and a CRC32 is added. The resulting 100 octets PSDU is shown in Table G.33.

NOTE 1—The message for LDPC example 1 is identical to the message for the BCC example; in other words, the FCS field (octets 97–100) has the same CRC 32 value.

NOTE 2—The DurationID field (i.e., octets 3 and 4) remains 0x02E = 46 µs.

Table G.33—Message for LDPC example 1

Octet ##	Value	Value	Value	Value	Value
1...5	0x04	0x02	0x00	0x2E	0x00
6...10	0x60	0x08	0xCD	0x37	0xA6
11...15	0x00	0x20	0xD6	0x01	0x3C
16...20	0xF1	0x00	0x60	0x08	0xAD
21...25	0x3B	0xAF	0x00	0x00	0x4A
26...30	0x6F	0x79	0x2C	0x20	0x62
31...35	0x72	0x69	0x67	0x68	0x74
36...40	0x20	0x73	0x70	0x61	0x72
41...45	0x6B	0x20	0x6F	0x66	0x20
46...50	0x64	0x69	0x76	0x69	0x6E
51...55	0x69	0x74	0x79	0x2C	0x0A
56...60	0x44	0x61	0x75	0x67	0x68
61...65	0x74	0x65	0x72	0x20	0x6F
66...70	0x66	0x20	0x45	0x6C	0x79
71...75	0x73	0x69	0x75	0x6D	0x2C
76...80	0x0A	0x46	0x69	0x72	0x65
81...85	0x2D	0x69	0x6E	0x73	0x69
86...90	0x72	0x65	0x64	0x20	0x77
91...95	0x65	0x20	0x74	0x72	0x65
96...100	0x61	0x67	0x33	0x21	0xB6

G.2.2 Prepending the SERVICE field for LDPC example 1

The transmitted message shown in Table G.33 contains 100 octets, or equivalently, 800 bits. The bits are prepended by the 16 SERVICE field bits (bits 0–15 in Table G.34), as defined in 20.3.11.1, but tail bits and padding bits are not appended as in the BCC example. The resulting 816 bits are shown in Table G.34.

Table G.34—DATA bits for LDPC example 1 before scrambling

Bit ##	Binary value b7 b0	Binary value b15 b8	Binary value b23 b16	Hex value	Hex value	Hex value
000–023	00000000	00000000	00000100	0x00	0x00	0x04
024–047	00000010	00000000	00101110	0x02	0x00	0x2E
048–071	00000000	01100000	00001000	0x00	0x60	0x08
072–095	11001101	00110111	10100110	0xCD	0x37	0xA6
096–119	00000000	00100000	11010110	0x00	0x20	0xD6
120–143	00000001	00111100	11110001	0x01	0x3C	0xF1
144–167	00000000	01100000	00001000	0x00	0x60	0x08
168–191	10101101	00111011	10101111	0xAD	0x3B	0xAF
192–215	00000000	00000000	01001010	0x00	0x00	0x4A
216–239	01101111	01111001	00101100	0x6F	0x79	0x2C
240–263	00100000	01100010	01110010	0x20	0x62	0x72
264–287	01101001	01100111	01101000	0x69	0x67	0x68
288–311	01110100	00100000	01110011	0x74	0x20	0x73
312–335	01110000	01100001	01110010	0x70	0x61	0x72
336–359	01101011	00100000	01101111	0x6B	0x20	0x6F
360–383	01100110	00100000	01100100	0x66	0x20	0x64
384–407	01101001	01110110	01101001	0x69	0x76	0x69
408–431	01101110	01101001	01110100	0x6E	0x69	0x74
432–455	01111001	00101100	00001010	0x79	0x2C	0x0A
456–479	01000100	01100001	01110101	0x44	0x61	0x75
480–503	01100111	01101000	01110100	0x67	0x68	0x74
504–527	01100101	01110010	00100000	0x65	0x72	0x20
528–551	01101111	01100110	00100000	0x6F	0x66	0x20
552–575	01000101	01101100	01111001	0x45	0x6C	0x79
576–599	01110011	01101001	01110101	0x73	0x69	0x75
600–623	01101101	00101100	00001010	0x6D	0x2C	0x0A
624–647	01000110	01101001	01110010	0x46	0x69	0x72
648–671	01100101	00101101	01101001	0x65	0x2D	0x69

Table G.34—DATA bits for LDPC example 1 before scrambling *(continued)*

Bit ##	Binary value b7 b0	Binary value b15 b8	Binary value b23 b16	Hex value	Hex value	Hex value
672–695	01101110	01110011	01101001	0x6E	0x73	0x69
696–719	01110010	01100101	01100100	0x72	0x65	0x64
720–743	00100000	01110111	01100101	0x20	0x77	0x65
744–767	00100000	01110100	01110010	0x20	0x74	0x72
768–791	01100101	01100001	01100111	0x65	0x61	0x67
792–815	00110011	00100001	10110110	0x33	0x21	0xB6

G.2.3 Scrambling LDPC example 1

The 816 bits are scrambled by the scrambler defined in 17.3.5.4. The initial state of the scrambler is the state 1011101 binary (0x5D hexadecimal). The scrambled sequence is given in Table G.35.

NOTE—The scrambled entries for the correct CRC32 value are given in bits 784–815.

Table G.35—DATA bits for LDPC example 1 after scrambling

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
000–023	01101100	00011001	10001001	0x6C	0x19	0x89
024–047	10001111	01101000	00100001	0x8F	0x68	0x21
048–071	11110100	10100101	01100001	0xF4	0xA5	0x61
072–095	01001111	11010111	10101110	0x4F	0xD7	0xAE
096–119	00100100	00001100	11110011	0x24	0x0C	0xF3
120–143	00111010	11100100	10111100	0x3A	0xE4	0xBC
144–167	01010011	10011000	11000000	0x53	0x98	0xC0
168–191	00011110	00110101	10110011	0x1E	0x35	0xB3
192–215	11100011	11111000	00100101	0xE3	0xF8	0x25
216–239	01100000	11010110	00100101	0x60	0xD6	0x25
240–263	00110101	00110011	11111110	0x35	0x33	0xFE
264–287	11110000	01000001	00101011	0xF0	0x41	0x2B
288–311	10001111	01010011	00011100	0x8F	0x53	0x1C
312–335	10000011	01000001	10111110	0x83	0x41	0xBE
336–359	00111001	00101000	01100110	0x39	0x28	0x66
360–383	01000100	01100110	11001101	0x44	0x66	0xCD
384–407	11110110	10100011	11011000	0xF6	0xA3	0xD8

Table G.35—DATA bits for LDPC example 1 after scrambling *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
408–431	00001101	11010100	10000001	0x0D	0xD4	0x81
432–455	00111011	00101111	11011111	0x3B	0x2F	0xDF
456–479	11000011	01011000	11110111	0xC3	0x58	0xF7
480–503	11000110	01010010	11101011	0xC6	0x52	0xEB
504–527	01110000	10001111	10011110	0x70	0x8F	0x9E
528–551	01101010	10010000	10000001	0x6A	0x90	0x81
552–575	11111101	01111100	10101001	0xFD	0x7C	0xA9
576–599	11010001	01010101	00010010	0xD1	0x55	0x12
600–623	00000100	01110100	11011001	0x04	0x74	0xD9
624–647	11101001	00111011	11001101	0xE9	0x3B	0xCD
648–671	10010011	10001101	01111011	0x93	0x8D	0x7B
672–695	01111100	01110000	00000010	0x7C	0x70	0x02
696–719	00100000	10011001	10100001	0x20	0x99	0xA1
720–743	01111101	10001010	00100111	0x7D	0x8A	0x27
744–767	00010111	00111001	00010101	0x17	0x39	0x15
768–791	10100000	11101100	10010101	0xA0	0xEC	0x95
792–815	00010110	10010001	00010000	0x16	0x91	0x10

G.2.4 Inserting shortening bits for LDPC example 1

The equations of 20.3.11.6.5 are solved to calculate the following derived parameters for LDPC example 1 from the input TXVECTOR parameters:

— $N_{CW} = 1$ (number of codewords)
— $L_{LDPC} = 1944$ (size of codeword)
— $N_{CBPS} = 208$ (number of coded bits per symbol)
— $N_{avbits} = 1248$ (number of available bits)
— $N_{shrt} = 642$ (number of bits to be shortened)
— $N_{punc} = 54$ (number of bits to be punctured)
— $N_{SYM} = 6$ (number of OFDM symbols)
— $N_{rep} = 0$ (number of bits to be repeated)

The results of applying shortening bits, as prescribed in paragraph (c) of 20.3.11.6.5, is given in Table G.36.

NOTE—N_{shrt} = 642 shortening bits have been inserted as zeros in bits 816–1457.

Table G.36—DATA bits for LDPC example 1 after insertion of shortening bits

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0000–0023	01101100	00011001	10001001	0x6C	0x19	0x89
0024–0047	10001111	01101000	00100001	0x8F	0x68	0x21
0048–0071	11110100	10100101	01100001	0xF4	0xA5	0x61
0072–0095	01001111	11010111	10101110	0x4F	0xD7	0xAE
0096–0119	00100100	00001100	11110011	0x24	0x0C	0xF3
0120–0143	00111010	11100100	10111100	0x3A	0xE4	0xBC
0144–0167	01010011	10011000	11000000	0x53	0x98	0xC0
0168–0191	00011110	00110101	10110011	0x1E	0x35	0xB3
0192–0215	11100011	11111000	00100101	0xE3	0xF8	0x25
0216–0239	01100000	11010110	00100101	0x60	0xD6	0x25
0240–0263	00110101	00110011	11111110	0x35	0x33	0xFE
0264–0287	11110000	01000001	00101011	0xF0	0x41	0x2B
0288–0311	10001111	01010011	00011100	0x8F	0x53	0x1C
0312–0335	10000011	01000001	10111110	0x83	0x41	0xBE
0336–0359	00111001	00101000	01100110	0x39	0x28	0x66
0360–0383	01000100	01100110	11001101	0x44	0x66	0xCD
0384–0407	11110110	10100011	11011000	0xF6	0xA3	0xD8
0408–0431	00001101	11010100	10000001	0x0D	0xD4	0x81
0432–0455	00111011	00101111	11011111	0x3B	0x2F	0xDF
0456–0479	11000011	01011000	11110111	0xC3	0x58	0xF7
0480–0503	11000110	01010010	11101011	0xC6	0x52	0xEB
0504–0527	01110000	10001111	10011110	0x70	0x8F	0x9E
0528–0551	01101010	10010000	10000001	0x6A	0x90	0x81
0552–0575	11111101	01111100	10101001	0xFD	0x7C	0xA9
0576–0599	11010001	01010101	00010010	0xD1	0x55	0x12
0600–0623	00000100	01110100	11011001	0x04	0x74	0xD9
0624–0647	11101001	00111011	11001101	0xE9	0x3B	0xCD
0648–0671	10010011	10001101	01111011	0x93	0x8D	0x7B
0672–0695	01111100	01110000	00000010	0x7C	0x70	0x02
0696–0719	00100000	10011001	10100001	0x20	0x99	0xA1
0720–0743	01111101	10001010	00100111	0x7D	0x8A	0x27
0744–0767	00010111	00111001	00010101	0x17	0x39	0x15

Table G.36—DATA bits for LDPC example 1 after insertion of shortening bits *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0768–0791	10100000	11101100	10010101	0xA0	0xEC	0x95
0792–0815	00010110	10010001	00010000	0x16	0x91	0x10
0816–0839	00000000	00000000	00000000	0x00	0x00	0x00
0840–0863	00000000	00000000	00000000	0x00	0x00	0x00
0864–0887	00000000	00000000	00000000	0x00	0x00	0x00
0888–0911	00000000	00000000	00000000	0x00	0x00	0x00
0912–0935	00000000	00000000	00000000	0x00	0x00	0x00
0936–0959	00000000	00000000	00000000	0x00	0x00	0x00
0960–0983	00000000	00000000	00000000	0x00	0x00	0x00
0984–1007	00000000	00000000	00000000	0x00	0x00	0x00
1008–1031	00000000	00000000	00000000	0x00	0x00	0x00
1032–1055	00000000	00000000	00000000	0x00	0x00	0x00
1056–1079	00000000	00000000	00000000	0x00	0x00	0x00
1080–1103	00000000	00000000	00000000	0x00	0x00	0x00
1104–1127	00000000	00000000	00000000	0x00	0x00	0x00
1128–1151	00000000	00000000	00000000	0x00	0x00	0x00
1152–1175	00000000	00000000	00000000	0x00	0x00	0x00
1176–1199	00000000	00000000	00000000	0x00	0x00	0x00
1200–1223	00000000	00000000	00000000	0x00	0x00	0x00
1224–1247	00000000	00000000	00000000	0x00	0x00	0x00
1248–1271	00000000	00000000	00000000	0x00	0x00	0x00
1272–1295	00000000	00000000	00000000	0x00	0x00	0x00
1296–1319	00000000	00000000	00000000	0x00	0x00	0x00
1320–1343	00000000	00000000	00000000	0x00	0x00	0x00
1344–1367	00000000	00000000	00000000	0x00	0x00	0x00
1368–1391	00000000	00000000	00000000	0x00	0x00	0x00
1392–1415	00000000	00000000	00000000	0x00	0x00	0x00
1416–1439	00000000	00000000	00000000	0x00	0x00	0x00
1440–1457	00000000	00000000	00 - - - - - -	0x00	0x00	0x0-

G.2.5 Encoding data for LDPC example 1

The DATA with shortening bits are LDPC encoded as a single (N_{CW}=1) codeword (L_{LDPC}=944; R=3/4) as prescribed by paragraph (c) of 20.3.11.6.5. The results are given in Table G.37.

NOTE—The LDPC encoder appends 486 bits (i.e., bits 1458–1943) after the shortening bits.

Table G.37—DATA bits for LDPC example 1 after LDPC encoding

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0000–0023	01101100	00011001	10001001	0x6C	0x19	0x89
0024–0047	10001111	01101000	00100001	0x8F	0x68	0x21
0048–0071	11110100	10100101	01100001	0xF4	0xA5	0x61
0072–0095	01001111	11010111	10101110	0x4F	0xD7	0xAE
0096–0119	00100100	00001100	11110011	0x24	0x0C	0xF3
0120–0143	00111010	11100100	10111100	0x3A	0xE4	0xBC
0144–0167	01010011	10011000	11000000	0x53	0x98	0xC0
0168–0191	00011110	00110101	10110011	0x1E	0x35	0xB3
0192–0215	11100011	11111000	00100101	0xE3	0xF8	0x25
0216–0239	01100000	11010110	00100101	0x60	0xD6	0x25
0240–0263	00110101	00110011	11111110	0x35	0x33	0xFE
0264–0287	11110000	01000001	00101011	0xF0	0x41	0x2B
0288–0311	10001111	01010011	00011100	0x8F	0x53	0x1C
0312–0335	10000011	01000001	10111110	0x83	0x41	0xBE
0336–0359	00111001	00101000	01100110	0x39	0x28	0x66
0360–0383	01000100	01100110	11001101	0x44	0x66	0xCD
0384–0407	11110110	10100011	11011000	0xF6	0xA3	0xD8
0408–0431	00001101	11010100	10000001	0x0D	0xD4	0x81
0432–0455	00111011	00101111	11011111	0x3B	0x2F	0xDF
0456–0479	11000011	01011000	11110111	0xC3	0x58	0xF7
0480–0503	11000110	01010010	11101011	0xC6	0x52	0xEB
0504–0527	01110000	10001111	10011110	0x70	0x8F	0x9E
0528–0551	01101010	10010000	10000001	0x6A	0x90	0x81
0552–0575	11111101	01111100	10101001	0xFD	0x7C	0xA9
0576–0599	11010001	01010101	00010010	0xD1	0x55	0x12
0600–0623	00000100	01110100	11011001	0x04	0x74	0xD9
0624–0647	11101001	00111011	11001101	0xE9	0x3B	0xCD
0648–0671	10010011	10001101	01111011	0x93	0x8D	0x7B

Table G.37—DATA bits for LDPC example 1 after LDPC encoding *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0672–0695	01111100	01110000	00000010	0x7C	0x70	0x02
0696–0719	00100000	10011001	10100001	0x20	0x99	0xA1
0720–0743	01111101	10001010	00100111	0x7D	0x8A	0x27
0744–0767	00010111	00111001	00010101	0x17	0x39	0x15
0768–0791	10100000	11101100	10010101	0xA0	0xEC	0x95
0792–0815	00010110	10010001	00010000	0x16	0x91	0x10
0816–0839	00000000	00000000	00000000	0x00	0x00	0x00
0840–0863	00000000	00000000	00000000	0x00	0x00	0x00
0864–0887	00000000	00000000	00000000	0x00	0x00	0x00
0888–0911	00000000	00000000	00000000	0x00	0x00	0x00
0912–0935	00000000	00000000	00000000	0x00	0x00	0x00
0936–0959	00000000	00000000	00000000	0x00	0x00	0x00
0960–0983	00000000	00000000	00000000	0x00	0x00	0x00
0984–1007	00000000	00000000	00000000	0x00	0x00	0x00
1008–1031	00000000	00000000	00000000	0x00	0x00	0x00
1032–1055	00000000	00000000	00000000	0x00	0x00	0x00
1056–1079	00000000	00000000	00000000	0x00	0x00	0x00
1080–1103	00000000	00000000	00000000	0x00	0x00	0x00
1104–1127	00000000	00000000	00000000	0x00	0x00	0x00
1128–1151	00000000	00000000	00000000	0x00	0x00	0x00
1152–1175	00000000	00000000	00000000	0x00	0x00	0x00
1176–1199	00000000	00000000	00000000	0x00	0x00	0x00
1200–1223	00000000	00000000	00000000	0x00	0x00	0x00
1224–1247	00000000	00000000	00000000	0x00	0x00	0x00
1248–1271	00000000	00000000	00000000	0x00	0x00	0x00
1272–1295	00000000	00000000	00000000	0x00	0x00	0x00
1296–1319	00000000	00000000	00000000	0x00	0x00	0x00
1320–1343	00000000	00000000	00000000	0x00	0x00	0x00
1344–1367	00000000	00000000	00000000	0x00	0x00	0x00
1368–1391	00000000	00000000	00000000	0x00	0x00	0x00
1392–1415	00000000	00000000	00000000	0x00	0x00	0x00
1416–1439	00000000	00000000	00000000	0x00	0x00	0x00
1440–1463	00000000	00000000	00100110	0x00	0x00	0x26

Table G.37—DATA bits for LDPC example 1 after LDPC encoding *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
1464–1487	00111101	10101001	10011100	0x3D	0xA9	0x9C
1488–1511	01000000	11010111	10110010	0x40	0xD7	0xB2
1512–1535	10000110	11100011	10111111	0x86	0xE3	0xBF
1536–1559	01000011	10100101	11011001	0x43	0xA5	0xD9
1560–1583	00001101	00000110	11010110	0x0D	0x06	0xD6
1584–1607	01100000	11110100	00011111	0x60	0xF4	0x1F
1608–1631	00110001	00001100	00010011	0x31	0x0C	0x13
1632–1655	01110110	00001111	10011111	0x76	0x0F	0x9F
1656–1679	11011010	10011111	10101001	0xDA	0x9F	0xA9
1680–1703	01110100	01011001	11011100	0x74	0x59	0xDC
1704–1727	10001001	11110010	11100010	0x89	0xF2	0xE2
1728–1751	11011000	01101000	10100001	0xD8	0x68	0xA1
1752–1775	01100011	00011101	10100101	0x63	0x1D	0xA5
1776–1799	10100110	10000000	11010001	0xA6	0x80	0xD1
1800–1823	10001001	01010111	11011100	0x89	0x57	0xDC
1824–1847	10110011	01011101	00110011	0xB3	0x5D	0x33
1848–1871	01110000	11011100	10110010	0x70	0xDC	0xB2
1872–1895	11110110	00111001	00111101	0xF6	0x39	0x3D
1896–1919	00100011	10011011	00110110	0x23	0x9B	0x36
1920–1943	00111110	00010101	00010001	0x3E	0x15	0x11

G.2.6 Removing shortening bits and puncturing for LDPC example 1

The shortening bits, applied before LDPC encoding, are now removed as prescribed in paragraph (c) of 20.3.11.6.5. Finally, either puncturing is applied as described in paragraph (d) of the same subclause, or the copying of repeated bits is applied as described in paragraph (e) of the same subclause. In LDPC example 1, because N_{punc} = 54 is nonzero and N_{rep} = 0, puncturing is prescribed and completes the LDPC encoding process.

The results are given in Table G.38.

NOTE—The N_{shrt} = 642 shortening bits have been removed, and the N_{punc} = 54 bits have been punctured from Table G.37 to produce bits 816–1247 of Table G.38.

Table G.38—DATA bits after puncturing and removal of shortening bits

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0000–0023	01101100	00011001	10001001	0x6C	0x19	0x89
0024–0047	10001111	01101000	00100001	0x8F	0x68	0x21
0048–0071	11110100	10100101	01100001	0xF4	0xA5	0x61
0072–0095	01001111	11010111	10101110	0x4F	0xD7	0xAE
0096–0119	00100100	00001100	11110011	0x24	0x0C	0xF3
0120–0143	00111010	11100100	10111100	0x3A	0xE4	0xBC
0144–0167	01010011	10011000	11000000	0x53	0x98	0xC0
0168–0191	00011110	00110101	10110011	0x1E	0x35	0xB3
0192–0215	11100011	11111000	00100101	0xE3	0xF8	0x25
0216–0239	01100000	11010110	00100101	0x60	0xD6	0x25
0240–0263	00110101	00110011	11111110	0x35	0x33	0xFE
0264–0287	11110000	01000001	00101011	0xF0	0x41	0x2B
0288–0311	10001111	01010011	00011100	0x8F	0x53	0x1C
0312–0335	10000011	01000001	10111110	0x83	0x41	0xBE
0336–0359	00111001	00101000	01100110	0x39	0x28	0x66
0360–0383	01000100	01100110	11001101	0x44	0x66	0xCD
0384–0407	11110110	10100011	11011000	0xF6	0xA3	0xD8
0408–0431	00001101	11010100	10000001	0x0D	0xD4	0x81
0432–0455	00111011	00101111	11011111	0x3B	0x2F	0xDF
0456–0479	11000011	01011000	11110111	0xC3	0x58	0xF7
0480–0503	11000110	01010010	11101011	0xC6	0x52	0xEB
0504–0527	01110000	10001111	10011110	0x70	0x8F	0x9E
0528–0551	01101010	10010000	10000001	0x6A	0x90	0x81
0552–0575	11111101	01111100	10101001	0xFD	0x7C	0xA9
0576–0599	11010001	01010101	00010010	0xD1	0x55	0x12
0600–0623	00000100	01110100	11011001	0x04	0x74	0xD9
0624–0647	11101001	00111011	11001101	0xE9	0x3B	0xCD
0648–0671	10010011	10001101	01111011	0x93	0x8D	0x7B
0672–0695	01111100	01110000	00000010	0x7C	0x70	0x02
0696–0719	00100000	10011001	10100001	0x20	0x99	0xA1
0720–0743	01111101	10001010	00100111	0x7D	0x8A	0x27
0744–0767	00010111	00111001	00010101	0x17	0x39	0x15
0768–0791	10100000	11101100	10010101	0xA0	0xEC	0x95

Table G.38—DATA bits after puncturing and removal of shortening bits ***(continued)***

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0792–0815	00010110	10010001	00010000	0x16	0x91	0x10
0816–0839	10011000	11110110	10100110	0x98	0xF6	0xA6
0840–0863	01110001	00000011	01011110	0x71	0x03	0x5E
0864–0887	11001010	00011011	10001110	0xCA	0x1B	0x8E
0888–0911	11111101	00001110	10010111	0xFD	0x0E	0x97
0912–0935	01100100	00110100	00011011	0x64	0x34	0x1B
0936–0959	01011001	10000011	11010000	0x59	0x83	0xD0
0960–0983	01111100	11000100	00110000	0x7C	0xC4	0x30
0984–1007	01001101	11011000	00111110	0x4D	0xD8	0x3E
1008–1031	01111111	01101010	01111110	0x7F	0x6A	0x7E
1032–1055	10100101	11010001	01100111	0xA5	0xD1	0x67
1056–1079	01110010	00100111	11001011	0x72	0x27	0xCB
1080–1103	10001011	01100001	10100010	0x8B	0x61	0xA2
1104–1127	10000101	10001100	01110110	0x85	0x8C	0x76
1128–1151	10010110	10011010	00000011	0x96	0x9A	0x03
1152–1175	01000110	00100101	01011111	0x46	0x25	0x5F
1176–1199	01110010	11001101	01110100	0x72	0xCD	0x74
1200–1223	11001101	11000011	01110010	0xCD	0xC3	0x72
1224–1247	11001011	11011000	11100100	0xCB	0xD8	0xE4

G.3 Generating encoded DATA bits—LDPC example 2

LDPC example 2 exercises the alternative branches of the LDPC encoding procedure not exercised in LDPC example 1. Example 2 also exhibits LDPC shortening, encoding, and padding by repetition and employs multiple codewords and diversifies the TXVECTOR parameters—all without making the length of this example cumbersome.

The length of the text of the message is increased by 40 octets, from 72 characters to 112 characters, in order to illustrate padding (rather than puncturing) and encoding of multiple codewords.

Input TXVECTOR parameters for LDPC example 2:

— FEC_CODING = LDPC_CODING = 1 (LDPC encoder; not BCC)

— CH_BANDWIDTH = HT_CBW40 = 1 (CH_BANDWIDTH = 1 => 40 MHz)

— MCS = 1 (MCS = 1; QPSK; coding rate = 1/2)

— Coding rate R = 1/2

— LENGTH = 140 octets (with 16-bit SERVICE field becomes 142 octets = 1136 bits to scramble and encode)

— STBC = 1 (STBC = 1 => ON; m_STBC = 2)

G.3.1 The message for LDPC example 2

The message being encoded consists of the first 112 characters (shown in **bold** and including line breaks) of the well-known “Ode to Joy” by F. Schiller:

Joy, bright spark of divinity,
Daughter of Elysium,
Fire-insired we tread
Thy sanctuary.
Thy magic power re-unites
All that custom has divided,
All men become brothers
Under the sway of thy gentle wings.

The message is converted to ASCII; then it is prepended with an appropriate MAC header and a CRC32 is added. The resulting 140 octets PSDU is shown in Table G.39.

Because of the additional 40 characters, note that the message for LDPC example 2 has a different FCS field (octets 137–140) than the previous examples and that the DurationID field (i.e., octets 3 and 4) changes to 0x036 = 54 µs.

Table G.39—Message for LDPC example 2

Octet ##	Value	Value	Value	Value	Value
1...5	0x04	0x02	0x00	0x36	0x00
6...10	0x60	0x08	0xCD	0x37	0xA6
11...15	0x00	0x20	0xD6	0x01	0x3C
16...20	0xF1	0x00	0x60	0x08	0xAD
21...25	0x3B	0xAF	0x00	0x00	0x4A
26...30	0x6F	0x79	0x2C	0x20	0x62
31...35	0x72	0x69	0x67	0x68	0x74
36...40	0x20	0x73	0x70	0x61	0x72
41...45	0x6B	0x20	0x6F	0x66	0x20
46...50	0x64	0x69	0x76	0x69	0x6E
51...55	0x69	0x74	0x79	0x2C	0x0A
56...60	0x44	0x61	0x75	0x67	0x68
61...65	0x74	0x65	0x72	0x20	0x6F
66...70	0x66	0x20	0x45	0x6C	0x79
71...75	0x73	0x69	0x75	0x6D	0x2C
76...80	0x0A	0x46	0x69	0x72	0x65
81...85	0x2D	0x69	0x6E	0x73	0x69
86...90	0x72	0x65	0x64	0x20	0x77

Table G.39—Message for LDPC example 2 *(continued)*

Octet ##	Value	Value	Value	Value	Value
91...95	0x65	0x20	0x74	0x72	0x65
96...100	0x61	0x64	0x0A	0x54	0x68
101...105	0x79	0x20	0x73	0x61	0x6E
106...110	0x63	0x74	0x75	0x61	0x72
111...115	0x79	0x2E	0x0A	0x54	0x68
116...120	0x79	0x20	0x6D	0x61	0x67
121...125	0x69	0x63	0x20	0x70	0x6F
126...130	0x77	0x65	0x72	0x20	0x72
131...135	0x65	0x2D	0x75	0x6E	0x69
136...140	0x74	0x3B	0xDB	0xB5	0x22

G.3.2 Prepending the SERVICE field for LDPC example 2

The transmitted message shown in Table G.39 contains 140 octets, or equivalently, 1120 bits. The bits are prepended by the 16 SERVICE field bits (bits 0–15 in Table G.40), as defined by 20.3.11.1, but tail bits and padding bits are not appended as in the BCC example. The resulting 1136 bits are shown in Table G.40.

Table G.40—DATA bits for LDPC example 2 before scrambling

Bit ##	Binary value b7 b0	Binary value b15 b8	Binary value b23 b16	Hex value	Hex value	Hex value
0000–0023	00000000	00000000	00000100	0x00	0x00	0x04
0024–0047	00000010	00000000	00110110	0x02	0x00	0x36
0048–0071	00000000	01100000	00001000	0x00	0x60	0x08
0072–0095	11001101	00110111	10100110	0xCD	0x37	0xA6
0096–0119	00000000	00100000	11010110	0x00	0x20	0xD6
0120–0143	00000001	00111100	11110001	0x01	0x3C	0xF1
0144–0167	00000000	01100000	00001000	0x00	0x60	0x08
0168–0191	10101101	00111011	10101111	0xAD	0x3B	0xAF
0192–0215	00000000	00000000	01001010	0x00	0x00	0x4A
0216–0239	01101111	01111001	00101100	0x6F	0x79	0x2C
0240–0263	00100000	01100010	01110010	0x20	0x62	0x72
0264–0287	01101001	01100111	01101000	0x69	0x67	0x68
0288–0311	01110100	00100000	01110011	0x74	0x20	0x73
0312–0335	01110000	01100001	01110010	0x70	0x61	0x72

Table G.40—DATA bits for LDPC example 2 before scrambling *(continued)*

Bit ##	Binary value b7 b0	Binary value b15 b8	Binary value b23 b16	Hex value	Hex value	Hex value
0336–0359	01101011	00100000	01101111	0x6B	0x20	0x6F
0360–0383	01100110	00100000	01100100	0x66	0x20	0x64
0384–0407	01101001	01110110	01101001	0x69	0x76	0x69
0408–0431	01101110	01101001	01110100	0x6E	0x69	0x74
0432–0455	01111001	00101100	00001010	0x79	0x2C	0x0A
0456–0479	01000100	01100001	01110101	0x44	0x61	0x75
0480–0503	01100111	01101000	01110100	0x67	0x68	0x74
0504–0527	01100101	01110010	00100000	0x65	0x72	0x20
0528–0551	01101111	01100110	00100000	0x6F	0x66	0x20
0552–0575	01000101	01101100	01111001	0x45	0x6C	0x79
0576–0599	01110011	01101001	01110101	0x73	0x69	0x75
0600–0623	01101101	00101100	00001010	0x6D	0x2C	0x0A
0624–0647	01000110	01101001	01110010	0x46	0x69	0x72
0648–0671	01100101	00101101	01101001	0x65	0x2D	0x69
0672–0695	01101110	01110011	01101001	0x6E	0x73	0x69
0696–0719	01110010	01100101	01100100	0x72	0x65	0x64
0720–0743	00100000	01110111	01100101	0x20	0x77	0x65
0744–0767	00100000	01110100	01110010	0x20	0x74	0x72
0768–0791	01100101	01100001	01100100	0x65	0x61	0x64
0792–0815	00001010	01010100	01101000	0x0A	0x54	0x68
0816–0839	01111001	00100000	01110011	0x79	0x20	0x73
0840–0863	01100001	01101110	01100011	0x61	0x6E	0x63
0864–0887	01110100	01110101	01100001	0x74	0x75	0x61
0888–0911	01110010	01111001	00101110	0x72	0x79	0x2E
0912–0935	00001010	01010100	01101000	0x0A	0x54	0x68
0936–0959	01111001	00100000	01101101	0x79	0x20	0x6D
0960–0983	01100001	01100111	01101001	0x61	0x67	0x69
0984–1007	01100011	00100000	01110000	0x63	0x20	0x70
1008–1031	01101111	01110111	01100101	0x6F	0x77	0x65
1032–1055	01110010	00100000	01110010	0x72	0x20	0x72
1056–1079	01100101	00101101	01110101	0x65	0x2D	0x75
1080–1103	01101110	01101001	01110100	0x6E	0x69	0x74

Table G.40—DATA bits for LDPC example 2 before scrambling *(continued)*

Bit ##	Binary value b7 b0	Binary value b15 b8	Binary value b23 b16	Hex value	Hex value	Hex value
1104–1127	00111011	11011011	10110101	0x3B	0xDB	0xB5
1128–1135	00100010	--------	--------	0x22	----	----

G.3.3 Scrambling LDPC example 2

The 1136 bits are scrambled by the scrambler defined in 17.3.5.4. The initial state of the scrambler is the state 1011101 binary (0x5D hexadecimal). The scrambled sequence is given in Table G.41.

Table G.41—DATA bits for LDPC example 2 after scrambling

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0000–0023	01101100	00011001	10001001	0x6C	0x19	0x89
0024–0047	10001111	01101000	00111001	0x8F	0x68	0x39
0048–0071	11110100	10100101	01100001	0xF4	0xA5	0x61
0072–0095	01001111	11010111	10101110	0x4F	0xD7	0xAE
0096–0119	00100100	00001100	11110011	0x24	0x0C	0xF3
0120–0143	00111010	11100100	10111100	0x3A	0xE4	0xBC
0144–0167	01010011	10011000	11000000	0x53	0x98	0xC0
0168–0191	00011110	00110101	10110011	0x1E	0x35	0xB3
0192–0215	11100011	11111000	00100101	0xE3	0xF8	0x25
0216–0239	01100000	11010110	00100101	0x60	0xD6	0x25
0240–0263	00110101	00110011	11111110	0x35	0x33	0xFE
0264–0287	11110000	01000001	00101011	0xF0	0x41	0x2B
0288–0311	10001111	01010011	00011100	0x8F	0x53	0x1C
0312–0335	10000011	01000001	10111110	0x83	0x41	0xBE
0336–0359	00111001	00101000	01100110	0x39	0x28	0x66
0360–0383	01000100	01100110	11001101	0x44	0x66	0xCD
0384–0407	11110110	10100011	11011000	0xF6	0xA3	0xD8
0408–0431	00001101	11010100	10000001	0x0D	0xD4	0x81
0432–0455	00111011	00101111	11011111	0x3B	0x2F	0xDF
0456–0479	11000011	01011000	11110111	0xC3	0x58	0xF7
0480–0503	11000110	01010010	11101011	0xC6	0x52	0xEB
0504–0527	01110000	10001111	10011110	0x70	0x8F	0x9E

Table G.41—DATA bits for LDPC example 2 after scrambling *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0528–0551	01101010	10010000	10000001	0x6A	0x90	0x81
0552–0575	11111101	01111100	10101001	0xFD	0x7C	0xA9
0576–0599	11010001	01010101	00010010	0xD1	0x55	0x12
0600–0623	00000100	01110100	11011001	0x04	0x74	0xD9
0624–0647	11101001	00111011	11001101	0xE9	0x3B	0xCD
0648–0671	10010011	10001101	01111011	0x93	0x8D	0x7B
0672–0695	01111100	01110000	00000010	0x7C	0x70	0x02
0696–0719	00100000	10011001	10100001	0x20	0x99	0xA1
0720–0743	01111101	10001010	00100111	0x7D	0x8A	0x27
0744–0767	00010111	00111001	00010101	0x17	0x39	0x15
0768–0791	10100000	11101100	01010101	0xA0	0xEC	0x55
0792–0815	10001010	00111111	01101011	0x8A	0x3F	0x6B
0816–0839	10110110	11011000	10110001	0xB6	0xD8	0xB1
0840–0863	10001000	10000100	00001111	0x88	0x84	0x0F
0864–0887	00101100	10001000	10101000	0x2C	0x88	0xA8
0888–0911	11111000	10010010	10100000	0xF8	0x92	0xA0
0912–0935	10110111	10011110	00111100	0xB7	0x9E	0x3C
0936–0959	01100100	01010101	00001110	0x64	0x55	0x0E
0960–0983	01111000	11111011	01110011	0x78	0xFB	0x73
0984–1007	01010100	00000000	01000010	0x54	0x00	0x42
1008–1031	10101011	10000010	10111111	0xAB	0x82	0xBF
1032–1055	11100111	11001011	00100110	0xE7	0xCB	0x26
1056–1079	11110011	01000000	00001101	0xF3	0x40	0x0D
1080–1103	00000111	01101010	00010101	0x07	0x6A	0x15
1104–1127	00010111	11111111	10100101	0x17	0xFF	0xA5
1128–1135	11011100	--------	--------	0xDC	----	----

G.3.4 Inserting the shortening bits for LDPC example 2

The equations of 20.3.11.6.5 are solved to calculate the following derived parameters for LDPC example 2 from the input TXVECTOR parameters:

- $N_{CW} = 2$ (number of codewords)
- $L_{LDPC} = 1296$ (size of codeword)
- $N_{CBPS} = 216$ (number of coded bits per symbol)

— N_{avbits} = 2592 (number of available bits)
— N_{shrt} = 160 (number of bits to be shortened)
— N_{punc} = 0 (number of bits to be punctured)
— N_{SYM} = 12 (number of OFDM symbols)
— N_{rep} = 160 (number of bits to be repeated)

The results of applying shortening bits, as prescribed in paragraph (c) of 20.3.11.6.5, is given in Table G.42.

NOTE—N_{shrt} = 160 shortening bits have been inserted as zeros: 80 zeros at bits 568–647 and 80 zeros at bits 1216–1295; this order equally distributes the shortening bits across the N_{CW} = 2 codewords.

Table G.42—DATA bits for LDPC example 2 after insertion of shortening bits

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0000–0023	01101100	00011001	10001001	0x6C	0x19	0x89
0024–0047	10001111	01101000	00111001	0x8F	0x68	0x39
0048–0071	11110100	10100101	01100001	0xF4	0xA5	0x61
0072–0095	01001111	11010111	10101110	0x4F	0xD7	0xAE
0096–0119	00100100	00001100	11110011	0x24	0x0C	0xF3
0120–0143	00111010	11100100	10111100	0x3A	0xE4	0xBC
0144–0167	01010011	10011000	11000000	0x53	0x98	0xC0
0168–0191	00011110	00110101	10110011	0x1E	0x35	0xB3
0192–0215	11100011	11111000	00100101	0xE3	0xF8	0x25
0216–0239	01100000	11010110	00100101	0x60	0xD6	0x25
0240–0263	00110101	00110011	11111110	0x35	0x33	0xFE
0264–0287	11110000	01000001	00101011	0xF0	0x41	0x2B
0288–0311	10001111	01010011	00011100	0x8F	0x53	0x1C
0312–0335	10000011	01000001	10111110	0x83	0x41	0xBE
0336–0359	00111001	00101000	01100110	0x39	0x28	0x66
0360–0383	01000100	01100110	11001101	0x44	0x66	0xCD
0384–0407	11110110	10100011	11011000	0xF6	0xA3	0xD8
0408–0431	00001101	11010100	10000001	0x0D	0xD4	0x81
0432–0455	00111011	00101111	11011111	0x3B	0x2F	0xDF
0456–0479	11000011	01011000	11110111	0xC3	0x58	0xF7
0480–0503	11000110	01010010	11101011	0xC6	0x52	0xEB
0504–0527	01110000	10001111	10011110	0x70	0x8F	0x9E
0528–0551	01101010	10010000	10000001	0x6A	0x90	0x81
0552–0575	11111101	01111100	00000000	0xFD	0x7C	0x00

Table G.42—DATA bits for LDPC example 2 after insertion of shortening bits *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0576–0599	00000000	00000000	00000000	0x00	0x00	0x00
0600–0623	00000000	00000000	00000000	0x00	0x00	0x00
0624–0647	00000000	00000000	00000000	0x00	0x00	0x00
0648–0671	10101001	11010001	01010101	0xA9	0xD1	0x55
0672–0695	00010010	00000100	01110100	0x12	0x04	0x74
0696–0719	11011001	11101001	00111011	0xD9	0xE9	0x3B
0720–0743	11001101	10010011	10001101	0xCD	0x93	0x8D
0744–0767	01111011	01111100	01110000	0x7B	0x7C	0x70
0768–0791	00000010	00100000	10011001	0x02	0x20	0x99
0792–0815	10100001	01111101	10001010	0xA1	0x7D	0x8A
0816–0839	00100111	00010111	00111001	0x27	0x17	0x39
0840–0863	00010101	10100000	11101100	0x15	0xA0	0xEC
0864–0887	01010101	10001010	00111111	0x55	0x8A	0x3F
0888–0911	01101011	10110110	11011000	0x6B	0xB6	0xD8
0912–0935	10110001	10001000	10000100	0xB1	0x88	0x84
0936–0959	00001111	00101100	10001000	0x0F	0x2C	0x88
0960–0983	10101000	11111000	10010010	0xA8	0xF8	0x92
0984–1007	10100000	10110111	10011110	0xA0	0xB7	0x9E
1008–1031	00111100	01100100	01010101	0x3C	0x64	0x55
1032–1055	00001110	01111000	11111011	0x0E	0x78	0xFB
1056–1079	01110011	01010100	00000000	0x73	0x54	0x00
1080–1103	01000010	10101011	10000010	0x42	0xAB	0x82
1104–1127	10111111	11100111	11001011	0xBF	0xE7	0xCB
1128–1151	00100110	11110011	01000000	0x26	0xF3	0x40
1152–1175	00001101	00000111	01101010	0x0D	0x07	0x6A
1176–1199	00010101	00010111	11111111	0x15	0x17	0xFF
1200–1223	10100101	11011100	00000000	0xA5	0xDC	0x00
1224–1247	00000000	00000000	00000000	0x00	0x00	0x00
1248–1271	00000000	00000000	00000000	0x00	0x00	0x00
1272–1295	00000000	00000000	00000000	0x00	0x00	0x00

G.3.5 Encoding the data for LDPC example 2

The DATA with shortening bits are LDPC encoded as two (N_{CW} = 2) codewords (L_{LDPC} = 1296; R = 1/2) as prescribed by paragraph (c) of 20.3.11.6.5. The results are given in Table G.43.

NOTE—The LDPC encoder appends 648 bits as follows: bits 648–1295 after the first shortened codeword and another 648 bits (bits 1944–2591) after the second shortened codeword.

Table G.43—DATA bits for LDPC example 2 after LDPC encoding

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0000–0023	01101100	00011001	10001001	0x6C	0x19	0x89
0024–0047	10001111	01101000	00111001	0x8F	0x68	0x39
0048–0071	11110100	10100101	01100001	0xF4	0xA5	0x61
0072–0095	01001111	11010111	10101110	0x4F	0xD7	0xAE
0096–0119	00100100	00001100	11110011	0x24	0x0C	0xF3
0120–0143	00111010	11100100	10111100	0x3A	0xE4	0xBC
0144–0167	01010011	10011000	11000000	0x53	0x98	0xC0
0168–0191	00011110	00110101	10110011	0x1E	0x35	0xB3
0192–0215	11100011	11111000	00100101	0xE3	0xF8	0x25
0216–0239	01100000	11010110	00100101	0x60	0xD6	0x25
0240–0263	00110101	00110011	11111110	0x35	0x33	0xFE
0264–0287	11110000	01000001	00101011	0xF0	0x41	0x2B
0288–0311	10001111	01010011	00011100	0x8F	0x53	0x1C
0312–0335	10000011	01000001	10111110	0x83	0x41	0xBE
0336–0359	00111001	00101000	01100110	0x39	0x28	0x66
0360–0383	01000100	01100110	11001101	0x44	0x66	0xCD
0384–0407	11110110	10100011	11011000	0xF6	0xA3	0xD8
0408–0431	00001101	11010100	10000001	0x0D	0xD4	0x81
0432–0455	00111011	00101111	11011111	0x3B	0x2F	0xDF
0456–0479	11000011	01011000	11110111	0xC3	0x58	0xF7
0480–0503	11000110	01010010	11101011	0xC6	0x52	0xEB
0504–0527	01110000	10001111	10011110	0x70	0x8F	0x9E
0528–0551	01101010	10010000	10000001	0x6A	0x90	0x81
0552–0575	11111101	01111100	00000000	0xFD	0x7C	0x00
0576–0599	00000000	00000000	00000000	0x00	0x00	0x00
0600–0623	00000000	00000000	00000000	0x00	0x00	0x00
0624–0647	00000000	00000000	00000000	0x00	0x00	0x00

Table G.43—DATA bits for LDPC example 2 after LDPC encoding *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0648–0671	00001001	11000001	11111011	0x09	0xC1	0xFB
0672–0695	01101000	11001101	00000101	0x68	0xCD	0x05
0696–0719	10110110	11000111	01100101	0xB6	0xC7	0x65
0720–0743	10100101	10011001	11100000	0xA5	0x99	0xE0
0744–0767	01110011	01110000	01101101	0x73	0x70	0x6D
0768–0791	01011110	01111001	11100011	0x5E	0x79	0xE3
0792–0815	01100111	00100111	01011110	0x67	0x27	0x5E
0816–0839	10010101	10101000	11110110	0x95	0xA8	0xF6
0840–0863	00110101	01001000	10100111	0x35	0x48	0xA7
0864–0887	00100110	00101001	00110001	0x26	0x29	0x31
0888–0911	00101110	00011001	11110100	0x2E	0x19	0xF4
0912–0935	00110100	01101111	01010000	0x34	0x6F	0x50
0936–0959	01010000	11101001	11000100	0x50	0xE9	0xC4
0960–0983	00000110	11011001	11101110	0x06	0xD9	0xEE
0984–1007	11111000	00011011	11011001	0xF8	0x1B	0xD9
1008–1031	01101100	10000110	11010011	0x6C	0x86	0xD3
1032–1055	11101001	01100100	11001000	0xE9	0x64	0xC8
1056–1079	11110001	10100001	00001011	0xF1	0xA1	0x0B
1080–1103	11000010	01000100	01010100	0xC2	0x44	0x54
1104–1127	10100000	10001100	10111011	0xA0	0x8C	0xBB
1128–1151	10100011	11100100	10101001	0xA3	0xE4	0xA9
1152–1175	10101011	01010000	11100010	0xAB	0x50	0xE2
1176–1199	01110000	00101000	00110110	0x70	0x28	0x36
1200–1223	11111100	00110000	00110100	0xFC	0x30	0x34
1224–1247	01101010	01001001	00100010	0x6A	0x49	0x22
1248–1271	11010101	00000111	11001111	0xD5	0x07	0xCF
1272–1295	00110101	00111010	10001110	0x35	0x3A	0x8E
1296–1319	10101001	11010001	01010101	0xA9	0xD1	0x55
1320–1343	00010010	00000100	01110100	0x12	0x04	0x74
1344–1367	11011001	11101001	00111011	0xD9	0xE9	0x3B
1368–1391	11001101	10010011	10001101	0xCD	0x93	0x8D
1392–1415	01111011	01111100	01110000	0x7B	0x7C	0x70
1416–1439	00000010	00100000	10011001	0x02	0x20	0x99

Table G.43—DATA bits for LDPC example 2 after LDPC encoding *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
1440–1463	10100001	01111101	10001010	0xA1	0x7D	0x8A
1464–1487	00100111	00010111	00111001	0x27	0x17	0x39
1488–1511	00010101	10100000	11101100	0x15	0xA0	0xEC
1512–1535	01010101	10001010	00111111	0x55	0x8A	0x3F
1536–1559	01101011	10110110	11011000	0x6B	0xB6	0xD8
1560–1583	10110001	10001000	10000100	0xB1	0x88	0x84
1584–1607	00001111	00101100	10001000	0x0F	0x2C	0x88
1608–1631	10101000	11111000	10010010	0xA8	0xF8	0x92
1632–1655	10100000	10110111	10011110	0xA0	0xB7	0x9E
1656–1679	00111100	01100100	01010101	0x3C	0x64	0x55
1680–1703	00001110	01111000	11111011	0x0E	0x78	0xFB
1704–1727	01110011	01010100	00000000	0x73	0x54	0x00
1728–1751	01000010	10101011	10000010	0x42	0xAB	0x82
1752–1775	10111111	11100111	11001011	0xBF	0xE7	0xCB
1776–1799	00100110	11110011	01000000	0x26	0xF3	0x40
1800–1823	00001101	00000111	01101010	0x0D	0x07	0x6A
1824–1847	00010101	00010111	11111111	0x15	0x17	0xFF
1848–1871	10100101	11011100	00000000	0xA5	0xDC	0x00
1872–1895	00000000	00000000	00000000	0x00	0x00	0x00
1896–1919	00000000	00000000	00000000	0x00	0x00	0x00
1920–1943	00000000	00000000	00000000	0x00	0x00	0x00
1944–1967	01100100	10110110	01010100	0x64	0xB6	0x54
1968–1991	00110001	00000001	01100001	0x31	0x01	0x61
1992–2015	00101001	00010011	01110000	0x29	0x13	0x70
2016–2039	01010000	10000000	11001110	0x50	0x80	0xCE
2040–2063	01000101	11000000	10101000	0x45	0xC0	0xA8
2064–2087	11001101	11111000	01111100	0xCD	0xF8	0x7C
2088–2111	01010011	01010001	01001110	0x53	0x51	0x4E
2112–2135	11010011	10101110	00010011	0xD3	0xAE	0x13
2136–2159	11110000	11101101	10111111	0xF0	0xED	0xBF
2160–2183	10001110	10010100	00110100	0x8E	0x94	0x34
2184–2207	11111011	00010000	11011001	0xFB	0x10	0xD9
2208–2231	10111110	00110001	10011111	0xBE	0x31	0x9F

Table G.43—DATA bits for LDPC example 2 after LDPC encoding *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
2232–2255	01100000	00011100	10100110	0x60	0x1C	0xA6
2256–2279	01010101	11111001	10100110	0x55	0xF9	0xA6
2280–2303	10101010	00111000	01110001	0xAA	0x38	0x71
2304–2327	01111010	10101100	10110010	0x7A	0xAC	0xB2
2328–2351	11110101	11010001	10000001	0xF5	0xD1	0x81
2352–2375	01010000	11110001	00001011	0x50	0xF1	0x0B
2376–2399	10111101	10010011	10001011	0xBD	0x93	0x8B
2400–2423	10100010	10010110	00100101	0xA2	0x96	0x25
2424–2447	11100011	01101100	11000111	0xE3	0x6C	0xC7
2448–2471	00000101	00011000	00101000	0x05	0x18	0x28
2472–2495	11110011	00111001	11011000	0xF3	0x39	0xD8
2496–2519	00010001	01110101	00010111	0x11	0x75	0x17
2520–2543	11011101	11111011	11010010	0xDD	0xFB	0xD2
2544–2567	10101010	11101011	10100110	0xAA	0xEB	0xA6
2568–2591	10000101	10110011	01011000	0x85	0xB3	0x58

G.3.6 Removing shortening bits and repetition for LDPC example 2

The shortening bits, applied before LDPC encoding, are now removed as prescribed in paragraph (c) of 20.3.11.6.5. Finally, either puncturing is applied as described in paragraph (d) of the same subclause, or the copying of repeated bits is applied as described in paragraph (e) of the same subclause. In LDPC example 1, because N_{punc} = 0 and N_{rep} = 160 are nonzero, repetition is prescribed and completes the LDPC encoding process.

The results are given in Table G.44.

NOTE 1—N_{shrt} = 642 shortening bits have been removed, and N_{punc} = 54 bits have been punctured from Table G.37 to produce bits 816–1247 of Table G.38.

NOTE 2—The first 80 shortening bits (bits 568–647 from Table G.43) have been removed from the first codeword between bits 567 and 568 of Table G.44, and the second 80 shortening bits (bits 1864–1943 of Table G.43) have been removed between bits 1215 and 1216 of Table G.44. Also, 80 bits have been repeated from the beginning of the first codeword (bits 0–79) to the end of the first codeword (bits 1216–1295), and 80 bits have been repeated from the beginning of the second codeword (bits 1296–1375) to end of the second codeword (bits 2512–2591) in Table G.44.

Table G.44—DATA bits after removal of shortening bits and copying of repetition bits

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0000–0023	01101100	00011001	10001001	0x6C	0x19	0x89
0024–0047	10001111	01101000	00111001	0x8F	0x68	0x39
0048–0071	11110100	10100101	01100001	0xF4	0xA5	0x61
0072–0095	01001111	11010111	10101110	0x4F	0xD7	0xAE
0096–0119	00100100	00001100	11110011	0x24	0x0C	0xF3
0120–0143	00111010	11100100	10111100	0x3A	0xE4	0xBC
0144–0167	01010011	10011000	11000000	0x53	0x98	0xC0
0168–0191	00011110	00110101	10110011	0x1E	0x35	0xB3
0192–0215	11100011	11111000	00100101	0xE3	0xF8	0x25
0216–0239	01100000	11010110	00100101	0x60	0xD6	0x25
0240–0263	00110101	00110011	11111110	0x35	0x33	0xFE
0264–0287	11110000	01000001	00101011	0xF0	0x41	0x2B
0288–0311	10001111	01010011	00011100	0x8F	0x53	0x1C
0312–0335	10000011	01000001	10111110	0x83	0x41	0xBE
0336–0359	00111001	00101000	01100110	0x39	0x28	0x66
0360–0383	01000100	01100110	11001101	0x44	0x66	0xCD
0384–0407	11110110	10100011	11011000	0xF6	0xA3	0xD8
0408–0431	00001101	11010100	10000001	0x0D	0xD4	0x81
0432–0455	00111011	00101111	11011111	0x3B	0x2F	0xDF
0456–0479	11000011	01011000	11110111	0xC3	0x58	0xF7
0480–0503	11000110	01010010	11101011	0xC6	0x52	0xEB
0504–0527	01110000	10001111	10011110	0x70	0x8F	0x9E
0528–0551	01101010	10010000	10000001	0x6A	0x90	0x81
0552–0575	11111101	01111100	00001001	0xFD	0x7C	0x09
0576–0599	11000001	11111011	01101000	0xC1	0xFB	0x68
0600–0623	11001101	00000101	10110110	0xCD	0x05	0xB6
0624–0647	11000111	01100101	10100101	0xC7	0x65	0xA5
0648–0671	10011001	11100000	01110011	0x99	0xE0	0x73
0672–0695	01110000	01101101	01011110	0x70	0x6D	0x5E
0696–0719	01111001	11100011	01100111	0x79	0xE3	0x67
0720–0743	00100111	01011110	10010101	0x27	0x5E	0x95
0744–0767	10101000	11110110	00110101	0xA8	0xF6	0x35

Table G.44—DATA bits after removal of shortening bits and copying of repetition bits *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
0768–0791	01001000	10100111	00100110	0x48	0xA7	0x26
0792–0815	00101001	00110001	00101110	0x29	0x31	0x2E
0816–0839	00011001	11110100	00110100	0x19	0xF4	0x34
0840–0863	01101111	01010000	01010000	0x6F	0x50	0x50
0864–0887	11101001	11000100	00000110	0xE9	0xC4	0x06
0888–0911	11011001	11101110	11111000	0xD9	0xEE	0xF8
0912–0935	00011011	11011001	01101100	0x1B	0xD9	0x6C
0936–0959	10000110	11010011	11101001	0x86	0xD3	0xE9
0960–0983	01100100	11001000	11110001	0x64	0xC8	0xF1
0984–1007	10100001	00001011	11000010	0xA1	0x0B	0xC2
1008–1031	01000100	01010100	10100000	0x44	0x54	0xA0
1032–1055	10001100	10111011	10100011	0x8C	0xBB	0xA3
1056–1079	11100100	10101001	10101011	0xE4	0xA9	0xAB
1080–1103	01010000	11100010	01110000	0x50	0xE2	0x70
1104–1127	00101000	00110110	11111100	0x28	0x36	0xFC
1128–1151	00110000	00110100	01101010	0x30	0x34	0x6A
1152–1175	01001001	00100010	11010101	0x49	0x22	0xD5
1176–1199	00000111	11001111	00110101	0x07	0xCF	0x35
1200–1223	00111010	10001110	01101100	0x3A	0x8E	0x6C
1224–1247	00011001	10001001	10001111	0x19	0x89	0x8F
1248–1271	01101000	00111001	11110100	0x68	0x39	0xF4
1272–1295	10100101	01100001	01001111	0xA5	0x61	0x4F
1296–1319	10101001	11010001	01010101	0xA9	0xD1	0x55
1320–1343	00010010	00000100	01110100	0x12	0x04	0x74
1344–1367	11011001	11101001	00111011	0xD9	0xE9	0x3B
1368–1391	11001101	10010011	10001101	0xCD	0x93	0x8D
1392–1415	01111011	01111100	01110000	0x7B	0x7C	0x70
1416–1439	00000010	00100000	10011001	0x02	0x20	0x99
1440–1463	10100001	01111101	10001010	0xA1	0x7D	0x8A
1464–1487	00100111	00010111	00111001	0x27	0x17	0x39
1488–1511	00010101	10100000	11101100	0x15	0xA0	0xEC
1512–1535	01010101	10001010	00111111	0x55	0x8A	0x3F

Table G.44—DATA bits after removal of shortening bits and copying of repetition bits *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
1536–1559	01101011	10110110	11011000	0x6B	0xB6	0xD8
1560–1583	10110001	10001000	10000100	0xB1	0x88	0x84
1584–1607	00001111	00101100	10001000	0x0F	0x2C	0x88
1608–1631	10101000	11111000	10010010	0xA8	0xF8	0x92
1632–1655	10100000	10110111	10011110	0xA0	0xB7	0x9E
1656–1679	00111100	01100100	01010101	0x3C	0x64	0x55
1680–1703	00001110	01111000	11111011	0x0E	0x78	0xFB
1704–1727	01110011	01010100	00000000	0x73	0x54	0x00
1728–1751	01000010	10101011	10000010	0x42	0xAB	0x82
1752–1775	10111111	11100111	11001011	0xBF	0xE7	0xCB
1776–1799	00100110	11110011	01000000	0x26	0xF3	0x40
1800–1823	00001101	00000111	01101010	0x0D	0x07	0x6A
1824–1847	00010101	00010111	11111111	0x15	0x17	0xFF
1848–1871	10100101	11011100	01100100	0xA5	0xDC	0x64
1872–1895	10110110	01010100	00110001	0xB6	0x54	0x31
1896–1919	00000001	01100001	00101001	0x01	0x61	0x29
1920–1943	00010011	01110000	01010000	0x13	0x70	0x50
1944–1967	10000000	11001110	01000101	0x80	0xCE	0x45
1968–1991	11000000	10101000	11001101	0xC0	0xA8	0xCD
1992–2015	11111000	01111100	01010011	0xF8	0x7C	0x53
2016–2039	01010001	01001110	11010011	0x51	0x4E	0xD3
2040–2063	10101110	00010011	11110000	0xAE	0x13	0xF0
2064–2087	11101101	10111111	10001110	0xED	0xBF	0x8E
2088–2111	10010100	00110100	11111011	0x94	0x34	0xFB
2112–2135	00010000	11011001	10111110	0x10	0xD9	0xBE
2136–2159	00110001	10011111	01100000	0x31	0x9F	0x60
2160–2183	00011100	10100110	01010101	0x1C	0xA6	0x55
2184–2207	11111001	10100110	10101010	0xF9	0xA6	0xAA
2208–2231	00111000	01110001	01111010	0x38	0x71	0x7A
2232–2255	10101100	10110010	11110101	0xAC	0xB2	0xF5
2256–2279	11010001	10000001	01010000	0xD1	0x81	0x50
2280–2303	11110001	00001011	10111101	0xF1	0x0B	0xBD

Table G.44—DATA bits after removal of shortening bits and copying of repetition bits *(continued)*

Bit ##	Binary value b0 b7	Binary value b8 b15	Binary value b16 b23	Hex value	Hex value	Hex value
2304–2327	10010011	10001011	10100010	0x93	0x8B	0xA2
2328–2351	10010110	00100101	11100011	0x96	0x25	0xE3
2352–2375	01101100	11000111	00000101	0x6C	0xC7	0x05
2376–2399	00011000	00101000	11110011	0x18	0x28	0xF3
2400–2423	00111001	11011000	00010001	0x39	0xD8	0x11
2424–2447	01110101	00010111	11011101	0x75	0x17	0xDD
2448–2471	11111011	11010010	10101010	0xFB	0xD2	0xAA
2472–2495	11101011	10100110	10000101	0xEB	0xA6	0x85
2496–2519	10110011	01011000	10101001	0xB3	0x58	0xA9
2520–2543	11010001	01010101	00010010	0xD1	0x55	0x12
2544–2567	00000100	01110100	11011001	0x04	0x74	0xD9
2568–2591	11101001	00111011	11001101	0xE9	0x3B	0xCD

Annex I

(normative)

Regulatory classes

I.1 External regulatory references

Change rows 13 and 14, insert a row for behavior limits set 16, change the last row, and insert a note and footnote in Table I.3 as shown (note that the entire table is not shown):

Table I.3—Behavior limits sets

Behavior limits set	United States	Europe	Japan
13 ~~Reserved~~ 20/40 MHz BSS primary channel with secondary channel above the primary channel or 20 MHz BSS primary channel operated by an FC HT AP and also 20 MHz operational channel for a non-AP STA when the non-AP STA is associated with an FC HT AP.[d] See NOTE.	Reserved	Reserved	Reserved
14 ~~Reserved~~ 20/40 MHz BSS primary channel with secondary channel below the primary channel or 20 MHz BSS primary channel operated by an FC HT AP and also 20 MHz operational channel for a non-AP STA when the non-AP STA is associated with an FC HT AP.[d] See NOTE.	Reserved	Reserved	Reserved
16 DFS with 50–100 µs pulses	FCC 47CFR [B8], Section 2.947, and FCC MO&O 06-96, Appendix Section 6.2, Table 6, Radar Type 5	Reserved	ARIB STD-T71 [Ba], Section 3.1.7(2)(i)(3)A)(b)2)
~~16~~17–255	Reserved	Reserved	Reserved
NOTE—The fields that specify the 40 MHz channels are described in 20.3.15.3.			

[d]For 20 MHz operation where the regulatory class signifies 40 MHz channel spacing, the 20 MHz channel corresponds to the channel number indicated.

Annex J

(normative)

Country information element and regulatory classes

J.1 Country information and regulatory classes

Change the rows for regulatory classes 2 and 4, insert rows for regulatory classes 22 through 33, change the reserved rows, and insert the note in Table J.1 as follows (note that the entire table is not shown):

Table J.1—Regulatory classes in the USA

Regulatory class	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Transmit power limit (mW)	Transmit power limit (EIRP)	Emissions limits set	Behavior limits set
2	5	20	52, 56, 60, 64	200	—	1	1, 4, 16
4	5	20	100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	200	—	1	1, 4, 16
16~~–255~~21	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
22	5	40	36, 44	40	—	1	1,2,13
23	5	40	52, 60	200	—	1	1,4,13
24	5	40	100, 108, 116, 124, 132	200	—	1	1,4,13,16
25	5	40	149, 157	800	—	1	1,13
26	5	40	149, 157	1000	—	4	10,13
27	5	40	40, 48	40	—	1	1,2,14
28	5	40	56, 64	200	—	1	1,4,14
29	5	40	104, 112, 120, 128, 136	200	—	1	1,4,14,16
30	5	40	153, 161	800	—	1	1,14
31	5	40	153, 161	1000	—	4	10,14
32	2.407	40	1–7	1000	—	4	10,13
33	2.407	40	5–11	1000	—	4	10,14
34–255	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
NOTE—The channel spacing for regulatory classes 22 through 33 is for the supported bandwidth rather than the operating bandwidth. In these regulatory classes, the AP operates either a 20/40 MHz BSS or a 20 MHz BSS, and the operating bandwidth for a non-AP STA is either 20 MHz or 40 MHz.							

Insert rows for regulatory classes 5 through 12, insert the note, and change the reserved row in Table J.2 as follows (note that the entire table is not shown):

Table J.2—Regulatory classes in Europe

Regulatory class	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Transmit power limit (mW)	Emissions limits set	Behavior limits set
5	5	40	36, 44	200	1	2,3,13
6	5	40	52, 60	200	1	1,3,4,13
7	5	40	100, 108, 116, 124, 132	1000	1	1,3,4,13
8	5	40	40, 48	200	1	2,3,14
9	5	40	56, 64	200	1	1,3,4,14
10	5	40	104, 112, 120, 128, 136	1000	1	1,3,4,14
11	2.407	40	1–9	100	4	10,13
12	2.407	40	5–13	100	4	10,14
~~5~~13–255	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
NOTE—The channel spacing for regulatory classes 5 through 12 is for the supported bandwidth rather than the operating bandwidth. In these regulatory classes, the AP operates in a 20/40 MHz BSS, and the operating bandwidth for a non-AP STA is either 20 MHz or 40 MHz.						

Change Table J.3 as follows:

Table J.3—Regulatory classes in Japan

Regulatory class	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Transmit power limit (dBm)	Transmit power limit (mW/MHz)	EIRP (mW/MHz)	Emissions limits set	Behavior limits set
1	5	20	~~34, 38, 42, 46~~ 36, 40, 44, 48	~~22~~ —	10	10	1	1, 2, 6
2–31	***These cells remain unchanged.***				—	—	***These cells remain unchanged.***	
32	5~~.0~~	20	52, 56, 60, 64	~~22~~ —	10	10	1	1, 2, 3, 4, 5, 6
33	5	20	52, 56, 60, 64	—	10	5	1	1, 2, 4, 5, 6
34	5	20	100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	—	10	50	1	1, 3, 4, 5, 6, 16

Table J.3—Regulatory classes in Japan *(continued)*

Regulatory class	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Transmit power limit (dBm)	Transmit power limit (mW/MHz)	EIRP (mW/MHz)	Emissions limits set	Behavior limits set
35	5	20	100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	—	10	25	1	1, 4, 5, 6, 16
36	5	40	36, 44	—	5	5	1	1, 2, 6, 13
37	5	40	52, 60	—	5	5	1	1, 2, 3, 4, 5, 6, 13
38	5	40	52, 60	—	5	2.5	1	1, 2, 4, 5, 6, 13
39	5	40	100, 108, 116, 124, 132	—	5	25	1	1, 3, 4, 5, 6, 13, 16
40	5	40	100, 108, 116, 124, 132	—	5	12.5	1	1, 4, 5, 6, 13, 16
41	5	40	40, 48	—	5	5	1	1, 2, 6, 14
42	5	40	56, 64	—	5	5	1	1, 2, 3, 4, 5, 6, 14
43	5	40	56, 64	—	5	2.5	1	1, 2, 4, 5, 6, 14
44	5	40	104, 112, 120, 128, 136	—	5	25	1	1, 3, 4, 5, 6, 14, 16
45	5	40	104, 112, 120, 128, 136	—	5	12.5	1	1, 4, 5, 6, 14, 16
46	4	40	184, 192	24	25	—	2	5, 6, 7, 13
47	4	40	184, 192	24	25	—	2	5, 6, 8, 13
48	4	40	184, 192	24	25	—	3	5, 6, 7, 13
49	4	40	184, 192	24	25	—	3	5, 6, 8, 13
50	4	40	184, 192	—	5	—	1	5, 6, 8, 13
51	4	40	188, 196	24	25	—	2	5, 6, 7, 14
52	4	40	188, 196	24	25	—	2	5, 6, 8, 14
53	4	40	188, 196	24	25	—	3	5, 6, 7, 14
54	4	40	188, 196	24	25	—	3	5, 6, 8, 14
55	4	40	188, 196	—	5	—	1	5, 6, 8, 14
56	2.407	40	1–9	—	5	—	4	10,13
57	2.407	40	5–13	—	5	—	4	10, 14
~~33~~58–255	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved

NOTE—The channel spacing for regulatory classes 34–55 is for the supported bandwidth rather than the operating bandwidth. In these regulatory domains, the AP operates in a 20/40 MHz BSS, and the operating bandwidth of a non-AP STA is either 20 MHz or 40 MHz.

Annex P

(informative)

Bibliography

P.1 General

Insert the following entry in P.1, renumbering as necessary:

[Ba] ARIB STD-T71 (5.0), Broadband Mobile Access Communication System (CSMA), ARIB, December 2007.[1]

[Bb] ISO/IEC 14977:1996, Information technology — Syntactic metalanguage — Extended BNF.[2]

[1]ARIB publications are available from the Association of Radio Industries and Businesses (www.arib.or.jp).

[2]ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO/IEC publications are also available in the United States from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (http://global.ihs.com/). Electronic copies are available in the United States from the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

Annex Q

(normative)

ASN.1 encoding of the RRM MIB

Change the "Dot11RRMNeighborReportEntry" sequence list of the "dot11RRMNeighborReport TABLE" in Annex Q as follows:

```
Dot11RRMNeighborReportEntry ::=
   SEQUENCE {
     dot11RRMNeighborReportIndex                          Unsigned32,
     dot11RRMNeighborReportIfIndex                        InterfaceIndex,
     dot11RRMNeighborReportBSSID                          MacAddress,
     dot11RRMNeighborReportAPReachability                 INTEGER,
     dot11RRMNeighborReportSecurity                       TruthValue,
     dot11RRMNeighborReportCapSpectrumMgmt                TruthValue,
     dot11RRMNeighborReportCapQoS                         TruthValue,
     dot11RRMNeighborReportCapAPSD                        TruthValue,
     dot11RRMNeighborReportCapRRM                         TruthValue,
     dot11RRMNeighborReportCapDelayBlockAck               TruthValue,
     dot11RRMNeighborReportCapImmediateBlockAck           TruthValue,
     dot11RRMNeighborReportKeyScope                       TruthValue,
     dot11RRMNeighborReportRegulatoryClass                INTEGER,
     dot11RRMNeighborReportChannelNumber                  INTEGER,
     dot11RRMNeighborReportPhyType                        INTEGER,
     dot11RRMNeighborReportNeighborTSFInfo                OCTETSTRING,
     dot11RRMNeighborReportPilotPeriod                    Unsigned32,
     dot11RRMNeighborReportPilotMultipleBSSID             OCTET,
     ot11RRMNeighborReportRRMEnabledCapabilities          OCTETSTRING,
     dot11RRMNeighborReportVendorSpecific                 OCTETSTRING,
     dot11RRMNeighborReportRowStatus                      RowStatus
     dot11RRMNeighborReportMobilityDomain                 TruthValue,
     dot11RRMNeighborReportCapHT                          TruthValue,
     dot11RRMNeighborReportHTLDPCCodingCap                TruthValue,
     dot11RRMNeighborReportHTSupportedChannelWidthSet     TruthValue,
     dot11RRMNeighborReportHTSMPowerSave                  Unsigned32,
     dot11RRMNeighborReportHTGreenfield                   TruthValue,
     dot11RRMNeighborReportHTShortGIfor20MHz              TruthValue,
     dot11RRMNeighborReportHTShortGIfor40MHz              TruthValue,
     dot11RRMNeighborReportHTTxSTBC                       TruthValue,
     dot11RRMNeighborReportHTRxSTBC                       Unsigned32,
     dot11RRMNeighborReportHTDelayedBlockAck              TruthValue,
     dot11RRMNeighborReportHTMaxAMSDULength               TruthValue,
     dot11RRMNeighborReportHTDSSCCKModein40MHz            TruthValue,
     dot11RRMNeighborReportHTFortyMHzIntolerant           TruthValue,
     dot11RRMNeighborReportHTLSIGTXOPProtectionSupport    TruthValue,
     dot11RRMNeighborReportHTMaxAMPDULengthExponent       Integer,
     dot11RRMNeighborReportHTMinMPDUStartSpacing          Integer,
     dot11RRMNeighborReportHTRxMCSBitMask                 Unsigned32,
     dot11RRMNeighborReportHTRxHighestSupportedDataRate   Unsigned32,
```

```
dot11RRMNeighborReportHTTxMCSSetDefined                    TruthValue,
dot11RRMNeighborReportHTTxRxMCSSetNotEqual                 TruthValue,
dot11RRMNeighborReportHTTxMaxNumberSpatialStreamsSupported
                                                           Unsigned32,
dot11RRMNeighborReportHTTxUnequalModulationSupported       TruthValue,
dot11RRMNeighborReportHTPCO                                TruthValue,
dot11RRMNeighborReportHTPCOTransitionTime                  Unsigned32,
dot11RRMNeighborReportHTMCSFeedback                        Unsigned32,
dot11RRMNeighborReportHTCSupport                           TruthValue,
dot11RRMNeighborReportHTRDResponder                        TruthValue,
dot11RRMNeighborReportHTImplictTransmitBeamformingReceivingCap
                                                           TruthValue,
dot11RRMNeighborReportHTReceiveStaggeredSoundingCap        TruthValue,
dot11RRMNeighborReportHTTransmitStaggeredSoundingCap       TruthValue,
dot11RRMNeighborReportHTReceiveNDPCap                      TruthValue,
dot11RRMNeighborReportHTTransmitNDPCap                     TruthValue,
dot11RRMNeighborReportHTImplicitTransmitBeamformingCap     TruthValue,
dot11RRMNeighborReportHTTransmitBeamformingCalibration     Unsigned32,
dot11RRMNeighborReportHTExplicitCSITransmitBeamformingCap
                                                           TruthValue,
dot11RRMNeighborReportHTExplicitNonCompressedSteeringCap
                                                           TruthValue,
dot11RRMNeighborReportHTExplicitCompressedSteeringCap      TruthValue,
dot11RRMNeighborReportHTExplicitTransmitBeamformingFeedback
                                                           Unsigned32,
dot11RRMNeighborReportHTExplicitNonCompressedBeamformingFeedbackCap
                                                           Unsigned32,
dot11RRMNeighborReportHTExplicitCompressedBeamformingFeedbackCap
                                                           Unsigned32,
dot11RRMNeighborReportHTTransmitBeamformingMinimalGrouping
                                                           Unsigned32,
dot11RRMNeighborReportHTCSINumberofTransmitBeamformingAntennasSuppt
                                                           Unsigned32,
dot11RRMNeighborReportHTNonCompressedSteeringNumberofTransmitBeamform-
ingAntennasSuppt                                           Unsigned32,
dot11RRMNeighborReportHTCompressedSteeringNumberofTransmitBeamform-
ingAntennasSuppt                                           Unsigned32,
dot11RRMNeighborReportHTCSIMaxNumberofRowsTransmitBeamformingSuppt
                                                           Unsigned32,
dot11RRMNeighborReportHTTransmitBeamformingChannelEstimationCap
                                                           Unsigned32,
dot11RRMNeighborReportHTAntSelectionCap                    TruthValue,
dot11RRMNeighborReportHTExplicitCSIFeedbackBasedTxASELCap
                                                           TruthValue,
dot11RRMNeighborReportHTAntIndicesFeedbackBasedTxASELCap
                                                           TruthValue,
dot11RRMNeighborReportHTExplicitCSIFeedbackBasedCap        TruthValue,
dot11RRMNeighborReportHTAntIndicesFeedbackCap              TruthValue,
dot11RRMNeighborReportHTRxASELCap                          TruthValue,
dot11RRMNeighborReportHTTxSoundingPPDUsCap                 TruthValue,
dot11RRMNeighborReportHTInfoPrimaryChannel                 Integer,
dot11RRMNeighborReportHTInfoSecChannelOffset               Unsigned32,
```

```
    dot11RRMNeighborReportHTInfoSTAChannelWidth             TruthValue,
    dot11RRMNeighborReportHTInfoRIFSMode                    TruthValue,
    dot11RRMNeighborReportHTInfoProtection                  Unsigned32,
    dot11RRMNeighborReportHTInfoNonGreenfieldHTSTAsPresent  TruthValue,
    dot11RRMNeighborReportHTInfoOBSSNonHTSTAsPresent        TruthValue,
    dot11RRMNeighborReportHTInfoDualBeacon                  TruthValue,
    dot11RRMNeighborReportHTInfoDualCTSProtection           TruthValue,
    dot11RRMNeighborReportHTInfoSTBCBeacon                  TruthValue,
    dot11RRMNeighborReportHTInfoLSIGTXOPProtectionSup       TruthValue,
    dot11RRMNeighborReportHTInfoPCOActive                   TruthValue,
    dot11RRMNeighborReportHTInfoPCOPhase                    TruthValue,
    dot11RRMNeighborReportHTInfoBasicMCSSet                 Unsigned32,
    dot11RRMNeighborReportHTSecChannelOffset                Unsigned32,
    dot11RRMNeighborReportExtCapPSMPSupport                 TruthValue,
    dot11RRMNeighborReportExtCapSPSMPSup                    TruthValue,
    dot11RRMNeighborReportExtCapServiceIntervalGranularity  Unsigned32}
```

Insert the following attribute descriptions (23 through 93) into the "dot11RRMNeighborReport TABLE" in Annex Q after attribute dot11RRMNeighborReportMobilityDomain { dot11RRMNeighbor-ReportEntry 22 }:

```
dot11RRMNeighborReportCapHT OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The High Throughput Bit when set to 1 indicates that the AP
        represented by this BSSID is an HT AP including the HT Capabilities
        element in its Beacons and that the contents of that HT
        Capabilities element are identical to the HT Capabilities element
        advertised by the AP sending the report. See 7.3.2.37"
    ::= { dot11RRMNeighborReportEntry 23 }

dot11RRMNeighborReportHTLDPCCodingCap OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The HT LDPC coding capability indicates support for receiving LDPC
        coded packets, set to FALSE if not supported, set to TRUE if
        supported. See 7.3.2.56.2"
    ::= { dot11RRMNeighborReportEntry 24 }

dot11RRMNeighborReportHTSupportedChannelWidthSet OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The HT Supported channel width set indicates which channel widths
        the STA supports, Set to FALSE if only 20 MHz operation is
```

```
          supported, Set to TRUE if both 20 MHz and 40 MHz operation is
          supported. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 25 }

dot11RRMNeighborReportHTSMPowerSave OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT SM Power Save indicates the SM power save mode, set to 0
          for static SM power save mode, set to 1 for dynamic SM power save
          mode, set to 3 for SM power save disabled, the value 2 is reserved,
          See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 26 }

dot11RRMNeighborReportHTGreenfield OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT-greenfield indicates support for the reception of PPDUs
          with HT-greenfield format, set to FALSE if not supported, set to
          TRUE if supported. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 27 }

dot11RRMNeighborReportHTShortGIfor20MHz OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Short GI for 20 MHZ indicates short GI support for the
          reception of 20 MHz packets, set to FALSE if not supported, set to
          TRUE if supported See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 28 }

dot11RRMNeighborReportHTShortGIfor40MHz OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Short GI for 40 MHz indicates short GI support for the
          reception of 40 MHz packets, set to FALSE if not supported, set to
          TRUE if supported. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 29}

dot11RRMNeighborReportHTTxSTBC OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
```



```
          "The HT Tx STBC indicates support for the transmission of PPDUs
          using STBC, set to FALSE if not supported, set to TRUE if
          supported. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 30}

dot11RRMNeighborReportHTRxSTBC OBJECT-TYPE
     SYNTAX Unsigned32
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Rx STBC indicates support for the reception of PPDUs using
          STBC, set to 0 for no support, set to 1 for support of one spatial
          stream, set to 2 for support of one and two spatial streams, set to
          3 for support of one, two, and three spatial streams. See
          7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 31}

dot11RRMNeighborReportHTDelayedBlockAck OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT-delayed Block ACK indicates support for HT-delayed Block
          ACK operation, set to FALSE if not supported, set to TRUE if
          supported. Support indicates that the STA is able to accept an
          ADDBA request for HT-delayed Block ACK. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 32 }

dot11RRMNeighborReportHTMaxAMSDULength OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Maximum A-MSDU length indicates maximum A-MSDU length, set
          to FALSE for 3839 octets, set to TRUE for 7935 octets. See
          7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 33 }

dot11RRMNeighborReportHTDSSCCKModein40MHz OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT DSSS/CCK Mode in 40 MHz indicates use of DSSS/CCK mode in a
          40 MHz capable BSS operating in 20/40 MHz mode, set to FALSE if
          DSSS/CCK in 40 MHz is not allowed, set to TRUE if the DSSS/CCK in
          40 MHz is allowed. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 34 }

dot11RRMNeighborReportHTFortyMHzIntolerant OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
```

```
     STATUS current
     DESCRIPTION
          "The HT Forty MHz Intolerant indicates whether other BSSs receiving
          this information are required to prohibit 40 MHz transmissions, set
          to TRUE to prohibit 20/40 MHz BSS operation, otherwise set to
          FALSE. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 35 }

dot11RRMNeighborReportHTLSIGTXOPProtectionSupport OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT L-SIG TXOP protection support indicates support for the
          LSIG TXOP protection mechanism, set to FALSE if not supported, set
          to TRUE if supported. See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 36 }

dot11RRMNeighborReportHTMaxAMPDULengthExponent OBJECT-TYPE
     SYNTAX Integer (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Maximum A-MPDU Length Exponent indicates the maximum length
          of A-MPDU that the STA can receive. This field is an integer in the
          range 0 to 3. The length defined by this field is equal to 2(13 +
          Maximum A-MPDU Length) - 1 octets. See 7.3.2.56.3"
     ::= { dot11RRMNeighborReportEntry 37 }

dot11RRMNeighborReportHTMinMPDUStartSpacing OBJECT-TYPE
     SYNTAX Integer (0..7)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Minimum MPDU Start Spacing determines the minimum time
          between the start of adjacent MPDUs within an AMPDU, measured at
          the PHY-SAP, set to 0 for no restriction, set to 1 for 1/4 µs, set
          to 2 for 1/2 µs, set to 3 for 1 µs, set to 4 for 2 µs, set to 5 for
          4 µs, set to 6 for 8 µs, set to 7 for 16 µs. See 7.3.2.57.3"
     ::= { dot11RRMNeighborReportEntry 38 }

dot11RRMNeighborReportHTRxMCSBitMask OBJECT-TYPE
     SYNTAX Unsigned32
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Rx MCS Bitmask is a 77 bit subfield that defines a set of
          MCS values, where bit B0 corresponds to MCS 0 and bit B76
          corresponds to MCS 76, set to 0 when the MSC is not supported, set
          to 1 when the MSC is supported. See 7.3.2.56.4"
     ::= { dot11RRMNeighborReportEntry 39}
```

```
dot11RRMNeighborReportHTRxHighestSupportedDataRate OBJECT-TYPE
     SYNTAX Unsigned32
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Highest Supported Data Rate is a 10 bit subfield that
          defines the highest data rate that the STA is able to receive, in
          units of 1 Mb/s, where 1 represents 1 Mb/s, and incrementing by
          1 Mb/s steps to the value 1023, which represents 1023 Mb/s. See
          7.3.2.56.4"
     ::= { dot11RRMNeighborReportEntry 40 }

dot11RRMNeighborReportHTTxMCSSetDefined OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Tx MCS Set Defined indicates if the Tx MCS set is defined,
          set to FALSE if no Tx MCS set is defined, set to TRUE if Tx MSC set
          is defined. See 7.3.2.56.4"
     ::= { dot11RRMNeighborReportEntry 41 }

dot11RRMNeighborReportHTTxRxMCSSetNotEqual OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Tx RX MCS set not equal indicates if the Tx MCS set is
          defined to be equal to the Rx MCS set, set to FALSE where no Tx MCS
          set is defined or where the Tx MCS Set is defined to be equal to
          the RX MCS Set, set to TRUE where the TX MCS set may differ from
          the Rx MCS set. See 7.3.2.56.4"
     ::= { dot11RRMNeighborReportEntry 42 }

dot11RRMNeighborReportHTTxMaxNumberSpatialStreamsSupported OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Tx maximum number spatial streams supported indicates
          maximum number of spatial streams supported when the Tx MCS Set may
          differ from the Rx MCS set, set to 0 where no TX MCS set is defined
          or where the Tx MCS set is defined to be equal to the RX MCS set or
          where the maximum number of spatial streams supported when
          transmitting is 1 spatial stream and the Tx MCS set may differ from
          the Rx MCS set, set to 1 where the maximum number of spatial
          streams supported when transmitting is 2 spatial streams and the Tx
          MCS set may differ from the Rx MCS set, set to 2 where the maximum
          number of spatial streams supported when transmitting is 3 spatial
          streams and the Tx MCS set may differ from the Rx MCS set, set to 3
          where the maximum number of spatial streams supported when
```

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          transmitting is 4 spatial streams and the Tx MCS set may differ
          from the Rx MCS set. See 7.3.2.56.4"
     ::= { dot11RRMNeighborReportEntry 43 }

dot11RRMNeighborReportHTTxUnequalModulationSupported OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
     " The HT Tx UEQM supported indicates whether transmit UEQM is supported
     when the Tx MCS set may differ from the Rx MCS set, set to FALSE where
     no TX MCS set is defined or where the Tx MCS set is defined to be equal
     to the RX MCS set or when UEQM is not supported and the Tx MCS set may
     differ from the Rx MCS set, set to TRUE when UEQM is supported and the
     Tx MCS set may differ from the Rx MCS set. See 7.3.2.56.4"
     ::= { dot11RRMNeighborReportEntry 44 }

dot11RRMNeighborReportHTPCO OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT PCO indicates support for PCO, set to FALSE if not
          supported, set to TRUE if supported. See 7.3.2.56.5"
     ::= { dot11RRMNeighborReportEntry 45 }

dot11RRMNeighborReportHTPCOTransitionTime OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT PCO transition time indicates that the STA can switch
          between 20 MHz channel width and 40 MHz channel width within the
          indicated time, set to 0 for no transition, set to 1 for 400 µs,
          set to 2 for 1.5 ms, set to 3 for 5 ms. For the no transition case
          (set to 0) the PCO active STA does not change its operation channel
          width and is able to receive 40 MHz PPDUs during the 20 MHz phase.
          See 7.3.2.56.5"
     ::= { dot11RRMNeighborReportEntry 46 }

dot11RRMNeighborReportHTMCSFeedback OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT MFB indicates the capability of the STA to provide MFB, set
          to 0 if the STA does not provide MFB, set to 2 if the STA provide
          only unsolicited MFB, set to 3 if the STA can provide MFB in
          response to MRQ as well as unsolicited MFB. Note the value 1 is
          reserved. See 7.3.2.56.5"
     ::= { dot11RRMNeighborReportEntry 47 }
```

```
dot11RRMNeighborReportHTCSupport OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT +HTC support indicates support of the HT Control field, set
          to FALSE if not supported, set to TRUE if supported. See
          7.3.2.56.5"
     ::= { dot11RRMNeighborReportEntry 48 }

dot11RRMNeighborReportHTRDResponder OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT RD responder indicates support for acting as a revere
          direction responder, set to FALSE if not supported, set to TRUE if
          supported. See 7.3.2.56.5"
     ::= { dot11RRMNeighborReportEntry 49}

dot11RRMNeighborReportHTImplictTransmitBeamformingReceivingCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT implicit Transmit Beamforming receiving capable indicates
          whether this STA can receive Transmit Beamforming steered frames
          using implicit feedback, set to FALSE if not supported, set to TRUE
          if supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 50 }

dot11RRMNeighborReportHTReceiveStaggeredSoundingCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT receive staggered sounding capable indicates whether this
          STA can receive staggered sounding frames, set to FALSE if not
          supported, set to TRUE if supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 51 }

dot11RRMNeighborReportHTTransmitStaggeredSoundingCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT transmit staggered sounding capable indicates whether this
          STA can transmit staggered sounding frames, set to FALSE if not
          supported, set to TRUE if supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 52 }

dot11RRMNeighborReportHTReceiveNDPCap OBJECT-TYPE
```

```
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Receive NDP capable indicates whether this receiver can
          interpret NDPs as sounding frames, set to FALSE if not supported,
          set to TRUE if supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 53 }

dot11RRMNeighborReportHTTransmitNDPCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Transmit NDP capable indicates whether this STA can
          transmit NDPs as sounding frames, set to FALSE if not supported,
          set to TRUE if supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 54 }

dot11RRMNeighborReportHTImplicitTransmitBeamformingCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Implicit Transmit Beamforming capable indicates whether
          this STA can apply implicit transmit beamforming, set to FALSE if
          not supported, set to TRUE if supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 55 }

dot11RRMNeighborReportHTTransmitBeamformingCalibration OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Beamforming Calibration indicates that the STA can
          participate in a calibration procedure initiated by another STA
          that is capable of generating an immediate response Sounding PPDU
          and can provide a CSI report in response to the receipt of a
          Sounding PPDU, set to 0 if not supported, set to 1 is the STA can
          respond to a calibration request using the CSI report but cannot
          initiate calibration, set to 3 if the STA can both initiate and
          respond to a calibration request. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 56 }

dot11RRMNeighborReportHTExplicitCSITransmitBeamformingCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT explicit CSI Transmit Beamforming capable indicates whether
          this STA can apply transmit beamforming using SCI explicit feedback
```

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          in its transmission, set to FALSE if not supported, set to TRUE if
          supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 57 }

dot11RRMNeighborReportHTExplicitNonCompressedSteeringCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT explicit noncompressed steering capable indicates whether
          this STA can apply transmit beamforming using noncompressed
          beamforming feedback matrix explicit feedback in its transmission,
          set to FALSE if not supported, set to TRUE if supported. See
          7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 58 }

dot11RRMNeighborReportHTExplicitCompressedSteeringCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT explicit compressed steering capable indicates whether this
          STA can apply transmit beamforming using compressed beamforming
          feedback matrix explicit feedback in its transmission, set to FALSE
          if not supported, set to TRUE if supported. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 59}

dot11RRMNeighborReportHTExplicitTransmitBeamformingFeedback OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT explicit Transmit Beamforming CSI feedback indicates
          whether this receiver can return CSI explicit feedback, set to 0 if
          not supported, set to 1 for delayed feedback, set to 2 for
          immediate feedback, set to 3 for delayed and immediate feedback.
          See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 60 }

dot11RRMNeighborReportHTExplicitNonCompressedBeamformingFeedbackCap OBJECT-
TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Explicit noncompressed beamforming feedback capable
          indicates whether this receiver can return noncompressed
          beamforming feedback matrix explicit feedback, set to 0 if not
          supported, set to 1 for delayed feedback, set to 2 for immediate
          feedback, set to 3 for delayed and immediate feedback. See
          7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 61 }
```



```
dot11RRMNeighborReportHTExplicitCompressedBeamformingFeedbackCap OBJECT-
TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT explicit compressed beamforming feedback capable indicates
          whether this receiver can return compressed beamforming feedback
          matrix explicit feedback, set to 0 if not supported, set to 1 for
          delayed feedback, set to 2 for immediate feedback, set to 3 for
          delayed and immediate feedback. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 62 }

dot11RRMNeighborReportHTTransmitBeamformingMinimalGrouping OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Transmit Beamforming minimal grouping indicates the minimal
          grouping used for explicit feedback reports, set to 0 if the STA
          supports groups of 1 (no grouping), set to 1 to indicate groups of
          1, 2, set to 2 to indicate groups of 1, 4, set to 3 to indicate
          groups of 1, 2, 4. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 63 }

dot11RRMNeighborReportHTCSINumberofTransmitBeamformingAntennasSuppt OBJECT-
TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT CSI number of beamformer antennas supported indicates the
          maximum number of beamformer antennas the beamformee can support
          when CSI feedback is required, set to 0 for single Tx antenna
          sounding, set to 1 for 2 Tx antenna sounding, set to 2 for 3 Tx
          antenna sounding, set to 3 for 4 Tx antenna sounding. See
          7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 64 }

dot11RRMNeighborReportHTNonCompressedSteeringNumberofTransmitBeamformingAnt
ennasSuppt OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT noncompressed steering number of beamformer antennas
          supported indicates the maximum number of beamformer antennas the
          beamformee can support when noncompressed beamforming feedback
          matrix is required, set to 0 for single Tx antenna sounding, set to
          1 for 2 Tx antenna sounding, set to 2 for 3 Tx antenna sounding,
          set to 3 for 4 Tx antenna sounding. See 7.3.2.56.6"
```

```
     ::= { dot11RRMNeighborReportEntry 65 }

dot11RRMNeighborReportHTCompressedSteeringNumberofTransmitBeamformingAntenn
asSuppt OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT compressed steering number of beamformer antennas supported
          indicates the maximum number of beamformer antennas the beamformee
          can support when compressed beamforming feedback matrix is
          required, set to 0 for single Tx antenna sounding, set to 1 for 2
          Tx antenna sounding, set to 2 for 3 Tx antenna sounding, set to 3
          for 4 Tx antenna sounding. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 66 }

dot11RRMNeighborReportHTCSIMaxNumberofRowsTransmitBeamformingSuppt OBJECT-
TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT CSI max number of rows beamformer supported indicates the
          maximum number of rows of CSI explicit feedback from the beamformee
          or calibration responder or transmit ASEL responder that a
          beamformer or calibration initiator or transmit ASEL initiator can
          support when SCI feedback is required, set to 0 for a single row of
          CSI, set to 1 for 2 rows of CSI, set to 2 for 3 rows of CSI, set to
          3 for 4 rows of CSI. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 67 }

dot11RRMNeighborReportHTTransmitBeamformingChannelEstimationCap OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT channel estimation capability indicates the maximum number
          of space-time streams for which channel dimensions can be
          simultaneously estimated when receiving an NDP sounding PPDU or the
          extension portion of the HT-LTFs in a staggered sounding PPDU. Set
          to 0 for 1 space-time stream, set to 1 for 2 space-time streams,
          set to 2 for 3 space-time streams, set to 3 for 4 space-time
          streams. See 7.3.2.56.6"
     ::= { dot11RRMNeighborReportEntry 68 }

dot11RRMNeighborReportHTAntSelectionCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
```

```
        "The HT ASEL capable indicates whether this STA supports ASEL, set
        to FALSE if not supported, set to TRUE if supported. See
        7.3.2.56.7"
    ::= { dot11RRMNeighborReportEntry 69}

dot11RRMNeighborReportHTExplicitCSIFeedbackBasedTxASELCap OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The HT explicit CSI feedback based transmit ASEL capable indicates
        whether this STA has transmit ASEL capability based on explicit CSI
        feedback, set to FALSE if not supported, set to TRUE if supported.
        See 7.3.2.56.7"
    ::= { dot11RRMNeighborReportEntry 70 }

dot11RRMNeighborReportHTAntIndicesFeedbackBasedTxASELCap OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The HT antenna indices feedback based transmit ASEL capable
        indicates whether this STA has transmit ASEL capability based on
        antenna indices feedback, set to FALSE if not supported, set to
        TRUE if supported. See 7.3.2.56.7"
    ::= { dot11RRMNeighborReportEntry 71 }

dot11RRMNeighborReportHTExplicitCSIFeedbackBasedCap OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The explicit CSI feedback capable indicates whether this STA can
        compute CSI and feedback in support of ASEL, set to FALSE if not
        supported, set to TRUE is supported. HT See 7.3.2.56.7"
    ::= { dot11RRMNeighborReportEntry 72 }

dot11RRMNeighborReportHTAntIndicesFeedbackCap OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The HT antenna indices feedback capable indicates whether this STA
        has Rx ASEL capability, set to FALSE if not supported, set to TRUE
        if supported. See 7.3.2.56.7"
    ::= { dot11RRMNeighborReportEntry 73 }

dot11RRMNeighborReportHTRxASELCap OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
```



```
          "The HT receive ASEL capable indicates whether this STA has Rx ASEL
          capability, set to FALSE if not supported, set to TRUE if
          supported. See 7.3.2.56.7"
     ::= { dot11RRMNeighborReportEntry 74 }

dot11RRMNeighborReportHTTxSoundingPPDUsCap OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT transmit sounding PPDUs capable indicates whether this STA
          can transmit sounding PPDUs for ASEL training per request, set to
          FALSE if not supported, set to TRUE if supported. See 7.3.2.56.7"
     ::= { dot11RRMNeighborReportEntry 75 }

dot11RRMNeighborReportHTInfoPrimaryChannel OBJECT-TYPE
     SYNTAX Integer
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info primary channel indicates the channel number of the
          primary channel, encoding: channel number of the primary channel.
          See 7.3.2.57”
     ::= { dot11RRMNeighborReportEntry 76 }

dot11RRMNeighborReportHTInfoSecChannelOffset OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info secondary channel offset indicates the offset of the
          secondary channel relative to the primary channel, set to 1 if the
          secondary channel is above the primary channel, set to 3 if the
          secondary channel is below the primary channel, set to 0 if no
          secondary channel is present. The value 2 is reserved. See
          7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 77 }

dot11RRMNeighborReportHTInfoSTAChannelWidth OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info STA channel width defines the channel widths that may
          be used to transmit to the STA, set to FALSE for a 20 MHz channel
          width, set to TRUE allows use of any channel width in the supported
          channel width set. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 78 }

dot11RRMNeighborReportHTInfoRIFSMode OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
```

```
     STATUS current
     DESCRIPTION
          "The HT Info RIFS mode indicates whether use of RIFS is permitted
          within the BSS, set to FALSE if use of RIFS is prohibited, set to
          TRUE if use of RIFS is permitted. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 79}

dot11RRMNeighborReportHTInfoProtection OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info protection indicates protection requirements of HT
          transmissions. Set to 0 if all STAs detected in the primary or the
          secondary channel or that are a member of this BSS are HT STAs and
          either all STAs that are known by the transmitting STA to be a
          member of this BSS are 20/40 MHz HT in a 20/40 MHz BSS or this BSS
          is a 20 MHz BSS. Set to 1 (nonmember protection mode) if there is
          at least one non-HT STA detected in either the primary or the
          secondary channel or in both the primary and secondary channels and
          that is not known by the transmitting STA to be a member of this
          BSS and all STAs that are known by the transmitting STA to be a
          member of this BSS are HT STAs. Set to 2 if all STAs detected in
          the primary or the secondary channel or that are known by the
          transmitting STA to be a member of this BSS are HT STAs and this
          BSS is a 20/40 MHz BSS and there is at least one 20 MHz HT STA
          associated with this BSS. Set to 3 (non-HT mixed mode) otherwise.
          See 7.3.2.56.2"
     ::= { dot11RRMNeighborReportEntry 80 }

dot11RRMNeighborReportHTInfoNonGreenfieldHTSTAsPresent OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info nongreenfield HT STAs present indicates if any HT STAs
          that are not HT-greenfield capable have associated. Determines when
          a non-AP STA should use HT-greenfield protection. Present in Beacon
          and Probe Response frames transmitted by an AP. Set to FALSE if all
          HT STAs that are associated are HT-greenfield capable, set to TRUE
          if one or more HT STAs that are not HT-greenfield capable are
          associated. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 81 }

dot11RRMNeighborReportHTInfoOBSSNonHTSTAsPresent OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info OBSS non-HT STAs present indicates if the use of
          protection for non-HT STAs by OBSSs is determined to be desirable.
          Present in Beacon and Probe Response frames transmitted by an AP,
```

```
          set to TRUE if the use of protection for non-HT STAs by OBSSs is
          determined to be desirable, set to FALSE otherwise. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 82 }

dot11RRMNeighborReportHTInfoDualBeacon OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info dual beacon indicates whether the AP transmits an STBC
          beacon, set to FALSE if no STBC beacon is transmitted, set to TRUE
          if an STBC beacon is transmitted. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 83 }

dot11RRMNeighborReportHTInfoDualCTSProtection OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info dual CTS protection is used by the AP to set a NAV at
          STAs that do not support STBC and at STAs that can associate solely
          through the secondary beacon, set to FALSE if dual CTS protection
          is not required, set to TRUE if dual CTS protection is required.
          See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 84 }

dot11RRMNeighborReportHTInfoSTBCBeacon OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info STBC beacon indicates whether the beacon containing
          this element is a primary or a STBC beacon, set to FALSE in a
          primary beacon, set to TRUE in a STBC beacon. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 85 }

dot11RRMNeighborReportHTInfoLSIGTXOPProtectionSup OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info L-SIG TXOP protection full support indicates whether
          all HT STA in the BSS support L-SIG TXOP protection, set to FALSE
          if one or more HT STA in the BSS do not support L-SIG TXOP
          protection, set to TRUE if all HT STA in the BSS support L-SIG TXOP
          protection. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 86 }

dot11RRMNeighborReportHTInfoPCOActive OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
```

```
     DESCRIPTION
          "The HT Info PCO active indicates whether PCO is active in the BSS,
          set to FALSE if PCO is not active in the BSS, set to TRUE if PCO is
          active in the BSS. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 87}

dot11RRMNeighborReportHTInfoPCOPhase OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info PCO phase indicates the PCO phase of operation, set to
          FALSE indicates a switch to or continued 20 MHz phase, set to TRUE
          indicates a switch to or continuation of 40 MHz phase. See
          7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 88 }

dot11RRMNeighborReportHTInfoBasicMCSSet OBJECT-TYPE
     SYNTAX Unsigned32
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info Basic MCS Set indicates values that are supported by
          all HT STAs in the BSS. The Basic MSC Set is a bitmap of size 128
          bits. Bit 0 corresponds to MCS 0. A bit is set to 1 to indicate
          support for that MCS, set to 0 otherwise. See 7.3.2.57"
     ::= { dot11RRMNeighborReportEntry 89 }

dot11RRMNeighborReportHTSecChannelOffset OBJECT-TYPE
     SYNTAX Unsigned32 (0..3)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT secondary channel offset indicates the position of the
          secondary channel relative to the primary channel, set to 1 to
          indicate that the secondary channel is above the primary channel,
          set to 3 to indicate the secondary channel is below the primary
          channel, set to 0 to indicate that no secondary channel is present.
          The value 2 is reserved. See 7.3.2.20a"
     ::= { dot11RRMNeighborReportEntry 90 }

dot11RRMNeighborReportExtCapPSMPSupport OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The Extended Capabilities PSMP support indicates support for PSMP
          operation, set to FALSE if PSMP is not supported, set to TRUE if
          PSMP operation is supported. See 7.3.2.27"
     ::= { dot11RRMNeighborReportEntry 91 }

dot11RRMNeighborReportExtCapSPSMPSup OBJECT-TYPE
```



```
     SYNTAX TruthValue
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The HT Info S-PSMP support indicates support for scheduled PSMP,
          set to FALSE when PSMP is supported is set to FALSE and when PSMP
          support is set to 1 if the STA does not support S-PSMP, set to TRUE
          when PSMP support is set to 1 if the STA supports S-PSMP. See
          7.3.2.27"
     ::= { dot11RRMNeighborReportEntry 92 }

dot11RRMNeighborReportExtCapServiceIntervalGranularity OBJECT-TYPE
     SYNTAX Unsigned32 (0..7)
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The Extended Capabilities SI granularity indicates the duration of
          the shortest SI, set to 0 for 5 ms, set to 1 for 10 ms, set to 2 for
          15 ms, set to 3 for 20 ms, set to 4 for 25 ms, set to 5 for 30 ms,
          set to 6 for 35 ms, set to 7 for 40 ms. See 7.3.2.27"
     ::= { dot11RRMNeighborReportEntry 93 }
```

Change the dot11SMTRRMConfig object group in Annex Q as follows:

```
dot11SMTRRMConfig OBJECT-GROUP
     OBJECTS { dot11APChannelReportIndex,
          dot11APChannelReportIfIndex,
          dot11APChannelReportRegulatoryClass,
          dot11APChannelReportChannelList,
          dot11RRMNeighborReportIndex,
          dot11RRMNeighborReportIfIndex,
          dot11RRMNeighborReportBSSID,
          dot11RRMNeighborReportReachability,
          dot11RRMNeighborReportSecurity,
          dot11RRMNeighborReportCapSpectrumMgmt,
          dot11RRMNeighborReportCapQoS,
          dot11RRMNeighborReportCapAPSD,
          dot11RRMNeighborReportCapRRM,
          dot11RRMNeighborReportCapDelayBlockAck,
          dot11RRMNeighborReportCapImmediateBlockAck,
          dot11RRMNeighborReportKeyScope,
          dot11RRMNeighborReportChannelNumber,
          dot11RRMNeighborReportRegulatoryClass,
          dot11RRMNeighborReportPhyType,
          dot11RRMNeighborReportNeighborTSFInfo,
          dot11RRMNeighborReportPilotPeriod,
          dot11RRMNeighborReportPilotMultipleBSSID,
          dot11RRMNeighborReportRRMEnabledCapabilities,
          dot11RRMNeighborReportVendorSpecific,
          dot11RRMNeighborReportRowStatus,
          dot11RRMNeighborReportCapHT,
```

dot11RRMNeighborReportHTLDPCCodingCap,
dot11RRMNeighborReportHTSupportedChannelWidthSet,
dot11RRMNeighborReportHTSMPowerSave,
dot11RRMNeighborReportHTGreenfield,
dot11RRMNeighborReportHTShortGIfor20MHz,
dot11RRMNeighborReportHTShortGIfor40MHz,
dot11RRMNeighborReportHTTxSTBC,
dot11RRMNeighborReportHTRxSTBC,
dot11RRMNeighborReportHTDelayedBlockAck,
dot11RRMNeighborReportHTMaxAMSDULength,
dot11RRMNeighborReportHTDSSCCKModein40MHz,
dot11RRMNeighborReportHTFortyMHzIntolerant,
dot11RRMNeighborReportHTLSIGTXOPProtectionSupport,
dot11RRMNeighborReportHTMaxAMPDULengthExponent,
dot11RRMNeighborReportHTMinMPDUStartSpacing,
dot11RRMNeighborReportHTRxMCSBitMask,
dot11RRMNeighborReportHTRxHighestSupportedDataRate,
dot11RRMNeighborReportHTTxMCSSetDefined,
dot11RRMNeighborReportHTTxRxMCSSetNotEqual,
dot11RRMNeighborReportHTTxMaxNumberSpatialStreamsSupported,
dot11RRMNeighborReportHTTxUnequalModulationSupported,
dot11RRMNeighborReportHTPCO,
dot11RRMNeighborReportHTPCOTransitionTime,
dot11RRMNeighborReportHTMCSFeedback,
dot11RRMNeighborReportHTCSupport,
dot11RRMNeighborReportHTRDResponder,
dot11RRMNeighborReportHTImplictTransmitBeamformingReceivingCap,
dot11RRMNeighborReportHTReceiveStaggeredSoundingCap,
dot11RRMNeighborReportHTTransmitStaggeredSoundingCap,
dot11RRMNeighborReportHTReceiveNDPCap,
dot11RRMNeighborReportHTTransmitNDPCap,
dot11RRMNeighborReportHTImplicitTransmitBeamformingCap,
dot11RRMNeighborReportHTTransmitBeamformingCalibration,
dot11RRMNeighborReportHTExplicitCSITransmitBeamformingCap,
dot11RRMNeighborReportHTExplicitNonCompressedSteeringCap,
dot11RRMNeighborReportHTExplicitCompressedSteeringCap,
dot11RRMNeighborReportHTExplicitTransmitBeamformingFeedback,
dot11RRMNeighborReportHTExplicitNonCompressedBeamformingFeedbackCap,
dot11RRMNeighborReportHTExplicitCompressedBeamformingFeedbackCap,
dot11RRMNeighborReportHTTransmitBeamformingMinimalGrouping,
dot11RRMNeighborReportHTCSINumberofTransmitBeamformingAntennasSuppt,
dot11RRMNeighborReportHTNonCompressedSteeringNumberofTransmitBeamformingAntennasSuppt,
dot11RRMNeighborReportHTCompressedSteeringNumberofTransmitBeamformingAntennasSuppt,
dot11RRMNeighborReportHTCSIMaxNumberofRowsTransmitBeamformingSuppt,
dot11RRMNeighborReportHTTransmitBeamformingChannelEstimationCap,
dot11RRMNeighborReportHTAntSelectionCap,
dot11RRMNeighborReportHTExplicitCSIFeedbackBasedTxASELCap,
dot11RRMNeighborReportHTAntIndicesFeedbackBasedTxASELCap,
dot11RRMNeighborReportHTExplicitCSIFeedbackBasedCap,
dot11RRMNeighborReportHTAntIndicesFeedbackCap,

```
        dot11RRMNeighborReportHTRxASELCap,
        dot11RRMNeighborReportHTTxSoundingPPDUsCap,
        dot11RRMNeighborReportHTInfoPrimaryChannel,
        dot11RRMNeighborReportHTInfoSecChannelOffset,
        dot11RRMNeighborReportHTInfoSTAChannelWidth,
        dot11RRMNeighborReportHTInfoRIFSMode,
        dot11RRMNeighborReportHTInfoProtection,
        dot11RRMNeighborReportHTInfoNonGreenfieldHTSTAsPresent,
        dot11RRMNeighborReportHTInfoOBSSNonHTSTAsPresent,
        dot11RRMNeighborReportHTInfoDualBeacon,
        dot11RRMNeighborReportHTInfoDualCTSProtection,
        dot11RRMNeighborReportHTInfoSTBCBeacon,
        dot11RRMNeighborReportHTInfoLSIGTXOPProtectionSup,
        dot11RRMNeighborReportHTInfoPCOActive,
        dot11RRMNeighborReportHTInfoPCOPhase,
        dot11RRMNeighborReportHTInfoBasicMCSSet,
        dot11RRMNeighborReportHTSecChannelOffset,
        dot11RRMNeighborReportExtCapPSMPSupport,
        dot11RRMNeighborReportExtCapSPSMPSup,
        dot11RRMNeighborReportExtCapServiceIntervalGranularity
        }
    STATUS current
    DESCRIPTION
        "The SMTRRMConfig package is a set of attributes that shall be
        present if the STA supports the Radio Measurement service."
    ::= { dot11Groups 39 }
```

Insert the following annexes (Annex R through Annex T) after Annex P:

Annex R

(normative)

HT LDPC matrix definitions

Table R.1 defines the matrix prototypes of the parity-check matrices for a codeword block length n=648 bits, with a subblock size Z=27 bits.

Table R.1—Matrix prototypes for codeword block length n=648 bits, subblock size is Z = 27 bits

(a) Coding rate R = 1/2.

0	-	-	-	0	0	-	-	0	-	-	0	1	0	-	-	-	-	-	-	-	-	-	-
22	0	-	-	17	-	0	0	12	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-
6	-	0	-	10	-	-	-	24	-	0	-	-	-	0	0	-	-	-	-	-	-	-	-
2	-	-	0	20	-	-	-	25	0	-	-	-	-	-	0	0	-	-	-	-	-	-	-
23	-	-	-	3	-	-	-	0	-	9	11	-	-	-	-	0	0	-	-	-	-	-	-
24	-	23	1	17	-	3	-	10	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-
25	-	-	-	8	-	-	-	7	18	-	-	0	-	-	-	-	-	0	0	-	-	-	-
13	24	-	-	0	-	8	-	6	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-
7	20	-	16	22	10	-	-	23	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-
11	-	-	-	19	-	-	-	13	-	3	17	-	-	-	-	-	-	-	-	-	0	0	-
25	-	8	-	23	18	-	14	9	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
3	-	-	-	16	-	-	2	25	5	-	-	1	-	-	-	-	-	-	-	-	-	-	0

(b) Coding rate R = 2/3.

25	26	14	-	20	-	2	-	4	-	-	8	-	16	-	18	1	0	-	-	-	-	-	-
10	9	15	11	-	0	-	1	-	-	18	-	8	-	10	-	-	0	0	-	-	-	-	-
16	2	20	26	21	-	6	-	1	26	-	7	-	-	-	-	-	-	0	0	-	-	-	-
10	13	5	0	-	3	-	7	-	-	26	-	-	13	-	16	-	-	-	0	0	-	-	-
23	14	24	-	12	-	19	-	17	-	-	-	20	-	21	-	0	-	-	-	0	0	-	-
6	22	9	20	-	25	-	17	-	8	-	14	-	18	-	-	-	-	-	-	-	0	0	-
14	23	21	11	20	-	24	-	18	-	19	-	-	-	-	22	-	-	-	-	-	-	0	0
17	11	11	20	-	21	-	26	-	3	-	-	18	-	26	-	1	-	-	-	-	-	-	0

(c) Coding rate R = 3/4.

16	17	22	24	9	3	14	-	4	2	7	-	26	-	2	-	21	-	1	0	-	-	-	-
25	12	12	3	3	26	6	21	-	15	22	-	15	-	4	-	-	16	-	0	0	-	-	-
25	18	26	16	22	23	9	-	0	-	4	-	4	-	8	23	11	-	-	-	0	0	-	-
9	7	0	1	17	-	-	7	3	-	3	23	-	16	-	-	21	-	0	-	-	0	0	-
24	5	26	7	1	-	-	15	24	15	-	8	-	13	-	13	-	11	-	-	-	-	0	0
2	2	19	14	24	1	15	19	-	21	-	2	-	24	-	3	-	2	1	-	-	-	-	0

(d) Coding rate R = 5/6.

17	13	8	21	9	3	18	12	10	0	4	15	19	2	5	10	26	19	13	13	1	0	-	-
3	12	11	14	11	25	5	18	0	9	2	26	26	10	24	7	14	20	4	2	-	0	0	-
22	16	4	3	10	21	12	5	21	14	19	5	-	8	5	18	11	5	5	15	0	-	0	0
7	7	14	14	4	16	16	24	24	10	1	7	15	6	10	26	8	18	21	14	1	-	-	0

Table R.2 defines the matrix prototypes of the parity-check matrices for a codeword block length n=1296 bits, with a subblock size Z=54 bits.

Table R.2—Matrix prototypes for codeword block length *n*=1296 bits, subblock size is *Z*= 54 bits

(a) Coding rate R = 1/2.

40	-	-	-	22	-	49	23	43	-	-	-	1	0	-	-	-	-	-	-	-	-	-	-
50	1	-	-	48	35	-	-	13	-	30	-	-	0	0	-	-	-	-	-	-	-	-	-
39	50	-	-	4	-	2	-	-	-	-	49	-	-	0	0	-	-	-	-	-	-	-	-
33	-	-	38	37	-	-	4	1	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-
45	-	-	-	0	22	-	-	20	42	-	-	-	-	-	-	0	0	-	-	-	-	-	-
51	-	-	48	35	-	-	-	44	-	18	-	-	-	-	-	-	0	0	-	-	-	-	-
47	11	-	-	-	17	-	-	51	-	-	-	0	-	-	-	-	-	0	0	-	-	-	-
5	-	25	-	6	-	45	-	13	40	-	-	-	-	-	-	-	-	-	0	0	-	-	-
33	-	-	34	24	-	-	-	23	-	-	46	-	-	-	-	-	-	-	-	0	0	-	-
1	-	27	-	1	-	-	-	38	-	44	-	-	-	-	-	-	-	-	-	-	0	0	-
-	18	-	-	23	-	-	8	0	35	-	-	-	-	-	-	-	-	-	-	-	-	0	0
49	-	17	-	30	-	-	-	34	-	-	19	1	-	-	-	-	-	-	-	-	-	-	0

(b) Coding rate R = 2/3.

39	31	22	43	-	40	4	-	11	-	-	50	-	-	-	6	1	0	-	-	-	-	-	-
25	52	41	2	6	-	14	-	34	-	-	-	24	-	37	-	-	0	0	-	-	-	-	-
43	31	29	0	21	-	28	-	-	2	-	-	7	-	17	-	-	-	0	0	-	-	-	-
20	33	48	-	4	13	-	26	-	-	22	-	-	46	42	-	-	-	-	0	0	-	-	-
45	7	18	51	12	25	-	-	-	50	-	-	5	-	-	-	0	-	-	-	0	0	-	-
35	40	32	16	5	-	-	18	-	-	43	51	-	32	-	-	-	-	-	-	-	0	0	-
9	24	13	22	28	-	-	37	-	-	25	-	-	52	-	13	-	-	-	-	-	-	0	0
32	22	4	21	16	-	-	-	27	28	-	38	-	-	-	8	1	-	-	-	-	-	-	0

(c) Coding rate R = 3/4.

39	40	51	41	3	29	8	36	-	14	-	6	-	33	-	11	-	4	1	0	-	-	-	-
48	21	47	9	48	35	51	-	38	-	28	-	34	-	50	-	50	-	-	0	0	-	-	-
30	39	28	42	50	39	5	17	-	6	-	18	-	20	-	15	-	40	-	-	0	0	-	-
29	0	1	43	36	30	47	-	49	-	47	-	3	-	35	-	34	-	0	-	-	0	0	-
1	32	11	23	10	44	12	7	-	48	-	4	-	9	-	17	-	16	-	-	-	-	0	0
13	7	15	47	23	16	47	-	43	-	29	-	52	-	2	-	53	-	1	-	-	-	-	0

(d) Coding rate R = 5/6.

48	29	37	52	2	16	6	14	53	31	34	5	18	42	53	31	45	-	46	52	1	0	-	-
17	4	30	7	43	11	24	6	14	21	6	39	17	40	47	7	15	41	19	-	-	0	0	-
7	2	51	31	46	23	16	11	53	40	10	7	46	53	33	35	-	25	35	38	0	-	0	0
19	48	41	1	10	7	36	47	5	29	52	52	31	10	26	6	3	2	-	51	1	-	-	0

Table R.3 defines the matrix prototypes of the parity-check matrices for a codeword block length n=1944 bits, with a subblock size Z=81 bits.

Table R.3—Matrix prototypes for codeword block length n=1944 bits, subblock size is Z = 81 bits

(a) Coding rate R = 1/2.

57	-	-	-	50	-	11	-	50	-	79	-	1	0	-	-	-	-	-	-	-	-	-	-
3	-	28	-	0	-	-	-	55	7	-	-	-	0	0	-	-	-	-	-	-	-	-	-
30	-	-	-	24	37	-	-	56	14	-	-	-	-	0	0	-	-	-	-	-	-	-	-
62	53	-	-	53	-	-	3	35	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-
40	-	-	20	66	-	-	22	28	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
0	-	-	-	8	-	42	-	50	-	-	8	-	-	-	-	-	0	0	-	-	-	-	-
69	79	79	-	-	-	56	-	52	-	-	-	0	-	-	-	-	-	0	0	-	-	-	-
65	-	-	-	38	57	-	-	72	-	27	-	-	-	-	-	-	-	-	0	0	-	-	-
64	-	-	-	14	52	-	-	30	-	-	32	-	-	-	-	-	-	-	-	0	0	-	-
-	45	-	70	0	-	-	-	77	9	-	-	-	-	-	-	-	-	-	-	-	0	0	-
2	56	-	57	35	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	0	0
24	-	61	-	60	-	-	27	51	-	-	16	1	-	-	-	-	-	-	-	-	-	-	0

(b) Coding rate R = 2/3.

61	75	4	63	56	-	-	-	-	-	-	8	-	2	17	25	1	0	-	-	-	-	-	-
56	74	77	20	-	-	-	64	24	4	67	-	7	-	-	-	-	0	0	-	-	-	-	-
28	21	68	10	7	14	65	-	-	-	23	-	-	-	75	-	-	-	0	0	-	-	-	-
48	38	43	78	76	-	-	-	-	5	36	-	15	72	-	-	-	-	-	0	0	-	-	-
40	2	53	25	-	52	62	-	20	-	-	44	-	-	-	-	0	-	-	-	0	0	-	-
69	23	64	10	22	-	21	-	-	-	-	-	68	23	29	-	-	-	-	-	-	0	0	-
12	0	68	20	55	61	-	40	-	-	-	52	-	-	-	44	-	-	-	-	-	-	0	0
58	8	34	64	78	-	-	11	78	24	-	-	-	-	-	58	1	-	-	-	-	-	-	0

(c) Coding rate R = 3/4.

48	29	28	39	9	61	-	-	-	63	45	80	-	-	-	37	32	22	1	0	-	-	-	-
4	49	42	48	11	30	-	-	-	49	17	41	37	15	-	54	-	-	-	0	0	-	-	-
35	76	78	51	37	35	21	-	17	64	-	-	-	59	7	-	-	32	-	-	0	0	-	-
9	65	44	9	54	56	73	34	42	-	-	-	35	-	-	-	46	39	0	-	-	0	0	-
3	62	7	80	68	26	-	80	55	-	36	-	26	-	9	-	72	-	-	-	-	-	0	0
26	75	33	21	69	59	3	38	-	-	-	35	-	62	36	26	-	-	1	-	-	-	-	0

(d) Coding rate R = 5/6.

13	48	80	66	4	74	7	30	76	52	37	60	-	49	73	31	74	73	23	-	1	0	-	-
69	63	74	56	64	77	57	65	6	16	51	-	64	-	68	9	48	62	54	27	-	0	0	-
51	15	0	80	24	25	42	54	44	71	71	9	67	35	-	58	-	29	-	53	0	-	0	0
16	29	36	41	44	56	59	37	50	24	-	65	4	65	52	-	4	-	73	52	1	-	-	0

Annex S

(informative)

Frame exchange sequences

The text for this new annex was taken from the now deleted 9.12 and has been updated to give a current description of frame exchange sequences. Change Annex S as follows:

S.1 General

The allowable frame exchange sequences are defined using an extension of the EBNF format as defined in ISO/IEC 14977:1996~~(E)~~ [Bb]. The elements of this syntax that are used here are as follows:

- [a] = a is optional.
- {a} = a is repeated zero or more times.
- n{a} = a is repeated *n* or more times. For example*,* 3{a} requires 3 or more “a”. This notation is an extension to ISO/IEC 14977 and equivalent to n*a{a} as defined in that standard.
- ~~a|b = a or b~~ a|b|c|... = selection between mutually exclusive alternatives, a, b, c ....
- () = grouping, ~~so~~e.g., “a (b|c)” is equivalent to “a b | a c”.
- (* a *) = “a” is a comment. Comments are placed before the text they relate to.
- <> = order of frames not relevant*e.g.*. For example, <a b> is either “a b” or “b a”.
- A rule is terminated by a semicolon “;”.
- ~~Whitespace is not significant, but it is used to highlight the nesting of grouped terms.~~The meaning of whitespace is changed from ISO/IEC 14977. Terminals do not contain whitespace, and the concatenate-symbol (comma in ISO/IEC 14977) is replaced by white space. Whitespace appearing between terminals indicates concatenation. Otherwise, whitespace is not significant and is used to highlight the nesting of grouped terms.

Two types of terminals are defined:

- *Frames*. A frame is shown in ~~Bold~~ **bold** and identified by its type/subtype (e.g., **Beacon**, **Data**). Frames are shown ~~in~~ with an initial capital letter.
- *Attributes.* Attributes are shown in ~~italic~~*italic*. An attribute is introduced by the ~~the~~ “+” character. The attribute specifies a condition that applies to the frame that precedes it. Where there are multiple attributes applied, they are generally ordered in the same order of the fields in the frame to which they refer. The syntax a+(b|c) where b and c are attributes is equivalent to (a+b) | (a+c).

Nonterminals of this syntax are shown in a normal font, i.e., a sequence of words joined by hyphens (e.g., cf-frame-exchange-sequence).

The attributes are defined in ~~Table 9.6~~Table S.1.

Table S.1—Attributes applicable to frame exchange sequence definition

Attribute	Description
a-mpdu	Frame is part of an A-MPDU aggregate.
a-mpdu-end	Frame is the last frame in an A-MPDU aggregate.
block-ack	QoS ~~D~~data frame has Ack Policy set to Block Ack.

Table S.1—Attributes applicable to frame exchange sequence definition *(continued)*

Attribute	Description
broadcast	Frame RA is the broadcast address.
CF	Beacon contains a CFP element.
CF-Ack	Data type CF-Ack subtype bit set to 1 or CF-End+CF-Ack frame.
CF-Poll	Data type CF-Poll subtype bit set to 1.
csi	An Action frame carrying channel state feedback (i.e., CSI, uncompressed beamforming, or compressed beamforming feedback matrices).
csi-request	A +HTC frame with the Feedback Request field set to a value > 0.
delayed	BlockAck or BlockAckReq under a delayed policy.
delayed-no-ack	BlockAck or BlockAckReq frame has No Ack policy.
DTIM	Beacon is a DTIM.
frag	Frame has its More Fragments field set to 1.
group	Frame RA has Individual/Group bit set to 1.
HTC	+HTC frame, i.e., a frame that contains the HT Control field, including the Control Wrapper frame. See NOTE.
implicit-bar	QoS data frame in an A-MPDU with Normal Ack policy.
individual	Frame RA has i/g bit set to 0.
last	Frame has its More Fragments field set to 0.
L-sig	L-sig duration not equal to PPDU duration.
action-no-ack	Management frame of subtype Action No Ack.
mfb	A +HTC frame with the MFB field is not set to all ones.
more-psmp	A PSMP frame with the More PSMP field set to 1.
mrq	A +HTC frame with the MRQ subfield set to 1.
ndp-announce	A +HTC frame with the NDP Announcement subfield set to 1.
no-ack	QoS ~~D~~data frame has Ack Policy set to No Ack.
no-more-psmp	A PSMP frame with the More PSMP field set to 0.
normal-ack	QoS ~~D~~data frame has Ack Policy set to Normal Ack.
non-QAP	Frame is transmitted by a non-AP QoS STA.
non-stbc	PPDU TXVECTOR STBC parameter is set to 0.
null	Data type Null Data subtype bit set.
pifs	Frame is transmitted ~~using~~following a PIFS.
psmp-ack	Ack Policy field of QoS data frame is set to PSMP Ack.
QAP	Frame is transmitted by a QoS AP.
QoS	Data type QoS subtype bit set.
RD	Frame includes an HT Control field in which the RDG/More PPDU subfield is set to 1.

Table S.1—Attributes applicable to frame exchange sequence definition *(continued)*

Attribute	Description
self	Frame RA = TA.
sounding	PPDU TXVECTOR SOUNDING parameter is present and set to SOUNDING.
stbc	PPDU TXVECTOR STBC parameter is set to a value >0.
to-ap	Frame is addressed to the AP.
trq	Frame is a +HTC frame with the TRQ field set to 1.
NOTE—A control frame that contains the HT Control field is always transmitted using the control wrapper frame.	

S.2 Basic sequences

The allowable frame exchange sequence is defined by the rule frame sequence. Except where modified by the *pifs* attribute, frames are separated by a SIFS.

(* This rule defines all the allowable frame exchange sequences *)
frame-sequence = ([**CTS**] (**Management** +*broadcast* | **Data** +*group*)) |
([**CTS** | **RTS CTS** | **PS-Poll**] {frag-frame **Ack**} last-frame **Ack**) |
(**PS-Poll Ack**) |
([**Beacon** +*DTIM*] {cf-sequence} [**CF-End** [+*CF-Ack*]])|
hcf-sequence;

(* A frag-frame is a nonfinal part of an individually addressed MSDU or MMPDU *)
frag-frame = (**Data** | **Management**) +*individual* +*frag*;

(* This is the last (or only) part of a an individually addressed MSDU or MMPDU *)
last-frame = (**Data** | **Management**) +*individual* +*last*;

(* A cf-sequence expresses all the sequences that may be generated within a contention free period. The first frame in this sequence is sent by the AP. *)
cf-sequence = (*Broadcast *)
Beacon | **Management** +*broadcast* | **Data** +*group* [+*QoS*] |

(* CF poll with data *)
(**Data**+*individual* +*CF-Poll* [+*CF-Ack*]
(**Data** +*individual* +*CF-Ack* [**Data** +*null* +*CF-Ack*] |
Data +*null* +*CF-Ack*)) |

(* CF poll without data *)
Data +*individual* +*null* +*CF-Poll* [+*CF-Ack*]
(**Data** +*null* |
(**Data** +*individual* (**Data** +*null* +*CF-Ack* | **Ack**)))|

(* individual management *)
(**Management** +*individual* Ack) |

(* All the sequences initiated by an HC *)
hcf-sequence;

S.3 EDCA and HCCA sequences

(* An hcf-sequence represents all the sequences that may be generated under HCCA. The sequence may be initiated by an HC within a CFP, or it may be initiated by a STA using EDCA channel access. *)

hcf-sequence = ([**CTS**] 1{(**Data** +*group* [+*QoS*]) | **Management** +*broadcast*) +pifs} |
([**CTS**] 1{txop-sequence}) |

(* HC only, polled TXOP delivery *)
([**RTS CTS**] non-cf-ack-piggybacked-qos-poll-sequence)

(* HC only, polled TXOP delivery *)
cf-ack-piggybacked-qos-poll-sequence |

(* HC only, self TXOP delivery or termination *)
Data +*self* +*null* +*CF-Poll* +*QoS*;

~~(* A poll-sequence is the start of a polled TXOP, in which the HC delivers a polled TXOP to a STA. The poll may or may not piggyback a CF-Ack according to whether the previous frame received by the HC was a Data frame. *)~~

~~poll-sequence =~~ ~~non-cf-ack-piggybacked-qos-poll-sequence |~~
~~cf-ack-piggybacked-qos-poll-sequence;~~

(* A cf-ack-piggybacked-qos-poll-sequence is the start of a polled TXOP that also delivers a CF-Ack. There are two main variants, polls that deliver data and, therefore, need acknowledgment and polls that do not. *)

cf-ack-piggybacked-qos-poll-sequence =
(qos-poll-requiring-no-ack +*CF-Ack* (
[**CTS** +*self*] polled-txop-content |
polled-txop-termination)) |
(qos-poll-requiring-ack +*CF-Ack* (
Ack (
polled-txop-content |
polled-txop-termination)) |
cf-ack-piggybacked-qos-data-sequence);

(* A non-cf-ack-piggybacked-qos-poll-sequence is the start of a polled TXOP that does not deliver a CF-Ack. Except for this, it is identical to the CF-Ack version. *)

non-cf-ack-piggybacked-qos-poll-sequence =
(qos-poll-requiring-no-ack (
[**CTS** +*self*] polled-txop-content |
polled-txop-termination)) |
(qos-poll-requiring-ack (
Ack (
polled-txop-content |
polled-txop-termination)) |
cf-ack-piggybacked-qos-data-sequence);

(* This sequence is the delivery of a single frame that is the TXOP poll frame that does not require acknowledgment either because the frame carries no data or because the frame carries data that do not require immediate acknowledgment. *)

qos-poll-requiring-no-ack =
Data +*null* +*CF-Poll* +*QoS* |
Data +*individual* +*CF-Poll* +*QoS* +(*no-ack*|*block-ack*);

(* A qos-poll-requiring-ack is the delivery of a single frame that is a TXOP poll frame, but also carries data that require immediate acknowledgment. *)
qos-poll-requiring-ack = **Data** +*individual* +*CF-Poll* [+*CF-Ack*] +*QoS* +*normal-ack*;

(* Polled-txop-content is what may occur after the delivery of a polled TXOP. A QoS STA transmits the first frame in this sequence *)
polled-txop-content = 1{txop-sequence} [polled-txop-termination];

(* A polled-txop-termination may be used by a QoS STA to terminate the polled TXOP. The data frame is addressed to the HC, which regains control of the medium and may reuse any unused polled TXOP duration. *)
polled-txop-termination = **Data** +*individual* +*null* +*QoS* +*normal-ack* **Ack**;

(* A TXOP (either polled or EDCA) may be filled with txop-sequences, which are initiated by the TXOP holder. *)
txop-sequence = (((**RTS CTS**) | **CTS**+*self*) **Data**+*individual*+*QoS*+(*block-ack*|*no-ack*)) |
[**RTS CTS**] (txop-part-requiring-ack txop-part-providing-ack) |
[**RTS CTS**] (**Management**|(**Data**+QAP))+*individual* **Ack** |
[**RTS CTS**] (**BlockAckReq BlockAck**) |
ht-txop-sequence;

(* These frames require acknowledgment *)
txop-part-requiring-ack = **Data**+*individual*[+*null*] |
Data+*individual*[+*null*]+*QoS*+*normal-ack* |
BlockAckReq+*delayed* |
BlockAck+*delayed*;

(* These frames provide acknowledgment to the TXOP-part-requiring-ack *)
txop-part-providing-ack= **Ack** |

(* An HC responds with a new polled TXOP on expiry of current TXOP *)
cf-ack-piggybacked-qos-poll-sequence |

(* An HC responds with CF-Ack and its own data on expiry of TXOP *)
cf-ack-piggybacked-qos-data-sequence |
Data+*CF-Ack*;

(* An HC has received a frame requiring Ack with a duration value indicating the end of the TXOP. The HC continues the CAP by transmitting its own data. *)
cf-ack-piggybacked-qos-data-sequence =
(**Data** +*individual* +*CF-Ack* +*QoS* +(*no-ack*|*block-ack*) polled-txop-content) |
(**Data** +*individual* +*CF-Ack* +*QoS*+*normal-ack* (
Ack polled-txop-content |
Data +*CF-Ack* |
cf-ack-piggybacked-qos-poll-sequence)) ;

Insert the following paragraphs at the end of Annex S:

S.4 HT sequences

(* The ht-txop-sequence describes the additional sequences that may be initiated by an HT STA that is the holder of a TXOP *)
ht-txop-sequence = L-sig-protected-sequence |

ht-nav-protected-sequence |
dual-cts-protected-sequence |
1{initiator-sequence};

(* an L-sig-protected-sequence is a sequence protected using the L-sig TXOP protection feature *)
L-sig-protected-sequence = L-sig-protection-set 1{initiator-sequence} resync-sequence;

(* an ht-nav-protected sequence consists of setting the NAV, performing one or more initiator-sequences and then resetting the NAV if time permits *)
ht-nav-protected-sequence = nav-set 1{initiator-sequence} [resync-sequence] ;

(* a dual-cts-protected-sequence is a sequence protected using the dual CTS protection feature *)
dual-cts-protected-sequence = dual-cts-nav-set 1{initiator-sequence} [dual-cts-nav-reset];

(* a dual-cts-nav-set is an initial exchange that establishes NAV protection using dual CTS protection.
dual-cts-nav-set = (* A dual CTS initiated by a non-AP HT STA that is not STBC-capable, preceded by an optional CTS frame addressed to the AP. *)
(
[**CTS**+*to-ap*+*non-stbc*+*non-QAP* **]**
RTS+*non-stbc*+*non-QAP*
CTS+*non-stbc*+*QAP*
[**CTS**+*stbc*+*pifs*+*QAP*]
) |

(* A dual CTS initiated by a non-AP STA that is STBC-capable, preceded by an optional CTS frame addressed to the AP. *)
(
[**CTS**+*to-ap*+*stbc*+*non-QAP*]
RTS+*stbc*+*non-QAP*
CTS+*stbc*+*QAP*
CTS+*non-stbc*+*QAP*
) |

(* An STBC initiator-sequence (i.e., containing STBC PPDUs) transmitted by the AP is protected by non-STBC CTS to self *)
(**CTS**+*self*+*non-stbc*+*QAP*) |

(* A non-STBC initiator-sequence transmitted by the AP is protected by STBC CTS to self *)
(**CTS**+*self*+*stbc*+*QAP*);

(* a dual-cts-nav-reset resets the NAV in the vicinity of the transmitting non-AP STA, and resets the NAV of both STBC and non-STBC-capable STA in the vicinity of the AP *)
dual-cts-nav-reset = [**CF-End**+*non-QAP*] **CF-End**+*stbc*+*QAP* **CF-End**+*non-stbc*+*QAP*);

(* an ma-no-ack-htc represents an Action No Ack + HTC frame *)
ma-no-ack-htc = **Management**+*action-no-ack*+*HTC;*

(* This is the sequence of frames that establish protection using the L-sig TXOP protection method *)
L-sig-protection-set = **(RTS**+*L-sig*[+*HTC*] **CTS**+*L-sig*[+*HTC*]) |
(Data+*individual*+*L-sig* [+*HTC*][+*null*][+*QoS*+*normal-ack*] **Ack** [+*HTC*] +*L-sig*) |
(1{ **Data**+*L-sig*[+*HTC*]+*individual*+*QoS*+*implicit-bar*+*a-mpdu*}+*a-mpdu-end*
BlockAck+*L-sig*[+*HTC*]
) |

(**BlockAckReq**+*L-sig*[+*HTC*] (**BlockAck**[+*HTC*]|**Ack**[+*HTC*])+*L-sig*) |
(**BlockAck**+*L-sig*[+*HTC*] **Ack**[+*HTC*])+*L-sig*);

(* These are the series of frames that establish NAV protection for an HT sequence *)
nav-set = (**RTS**[+*HTC*] **CTS**[+*HTC*]) |
CTS+*self* |
(Data[+*HTC*]+*individual*[+*null*][+*QoS*+*normal-ack*] **Ack)** |
Data[+*HTC*]+*individual*[+*QoS*+(*block-ack*)] |
Data+*group*[+*null*][+*QoS*] |
(1{ **Data**[+*HTC*]+*individual*+*QoS*+*implicit-bar*+*a-mpdu*}+*a-mpdu-end*
BlockAck[+*HTC*]
) |
(**BlockAckReq**[+*HTC*] (**BlockAck**[+*HTC*]|**Ack**[+*HTC*])) |
(**BlockAck**[+*HTC*] **Ack**);

resync-sequence = **CF-End | (CF-End+***non-QAP* **CF-End+***QAP***)**;

(* This is an initiator sequence. The different forms arise from whether the initiator transmits a frame that requires a BlockAck, and whether it delivers an RDG. When an RDG is delivered, the response is distinguished according to whether it demands a BlockAck response from the initiator. *)
initiator-sequence = (* No BlockAck expected, no RDG *)
burst

(* BlockAckReq delivered, BlockAck expected. No RD *)
(burst-bar (**BlockAck**|**Ack**) [+*HTC*]) |

(* No BlockAckReq delivered, RDG *)
(burst-rd (
burst |
burst-bar initiator-sequence-ba
)
) |

(burst-rd-bar (**BlockAck**|**Ack**) [+*HTC*]) |
(burst-rd-bar (
burst-ba |
burst-ba-bar initiator-sequence-ba
)
) |
ht-ack-sequence |
psmp-burst |
link-adaptation-exchange ;

(* This is the same as the initiator-sequence, except the initiator is constrained to generate a BlockAck response because a previous RD response contained a BlockAckReq *)
initiator-sequence-ba = burst-ba |
(burst-ba-bar (**BlockAck**|**Ack**)[+*HTC*)) |
(burst-ba-rd (
burst |
burst-bar initiator-sequence-ba
)
) |
(burst-ba-rd-bar (**BlockAck**|**Ack**)[+*HTC*]) |
(burst-ba-rd-bar (

burst-ba |
burst-ba-bar initiator-sequence-ba
)
);

(* These are sequences that occur within an ht-txop-sequence that have an ack response *)
ht-ack-sequence = (**BlockAck**+*delayed*[+*HTC*] **Ack**[+*HTC*]) |
(**BlockAckReq**+*delayed*[+*HTC*] **Ack**[+*HTC*]) |
(Data[+*HTC*]+*individual*[+*null*][+*QoS*+*normal-ack*] **Ack**[+*HTC*]**);**

(* A burst is a sequence of 1 or more packets, none of them requiring a response *)
burst = 1{ppdu-not-requiring-response};

(* A burst containing a BlockAckReq *)
burst-bar = {ppdu-not-requiring-response} ppdu-bar;

(* A burst containing a BlockAck *)
burst-ba = ppdu-ba {ppdu-not-requiring-response};

(* A burst containing a BlockAck and BlockAckReq, either in the same packet, or in separate packets. *)
burst-ba-bar = (ppdu-ba {ppdu-not-requiring-response} ppdu-bar) |
ppdu-ba-bar;

(* A burst delivering an RDG *)
burst-rd = {ppdu-not-requiring-response} ppdu-rd;

(* A burst containing a BlockAckReq and delivering an RDG *)
burst-rd-bar = burst ppdu-rd-bar;

(* A burst containing a BlockAck and delivering an RDG *)
burst-ba-rd = (ppdu-ba {ppdu-not-requiring-response} ppdu-rd) |
ppdu-ba-rd;

(* A burst containing a BlockAckReq and BlockAck and delivering an RDG *)
burst-ba-rd-bar = (ppdu-ba {ppdu-not-requiring-response} ppdu-rd-bar) |
ppdu-ba-rd-bar;

(* A PPDU not requiring a response is either a single frame not requiring response, or an A-MPDU of such frames.*)
ppdu-not-requiring-response =
frame-not-requiring-response-non-ampdu |
1{frame-not-requiring-response-ampdu+*a-mpdu*}+*a-mpdu-end*;

(* A frame-not-requiring-response-non-ampdu is a frame that does not require a response and that may be sent outside A-MPDU. It includes frames that do not require a response and that are not allowed within an A-MPDU. *)
frame-not-requiring-response-non-ampdu =
Data[+*HTC*]+*QoS*+*no-ack* |
frame-not-requiring-response-ampdu;

(* A frame-not-requiring-response-ampdu is a frame that does not require a response and can be sent within an A-MPDU. It is one of the delayed Block Ack policy frames sent under No Ack policy, or Data that does not require an immediate ack, or an Action No Ack frame. A frame-not-requiring-response may be included with any of the following sequences in any position, except the initial position when this contains a BlockAck or Multi-TID BlockAck: ppdu-bar, ppdu-ba-bar, ppdu-ba, ppdu-rd, ppdu-rd-bar, ppdu-ba-rd-bar, psmp-ppdu *)

frame-not-requiring-response-ampdu =
BlockAck[+*HTC*]+*delayed-no-ack* |
BlockAckReq[+*HTC*]+*delayed-no-ack* |
Data[+*HTC*]+*QoS*+*block-ack* |
ma-no-ack-htc;

(* A PPDU containing a BlockAckReq is either a non-A-MPDU BlockAckReq, or an A-MPDU containing Data carrying implicit Block Ack request*).

ppdu-bar= **BlockAckReq**[+*HTC*] |
(1{**Data**[+*HTC*]+*QoS*+*implicit-bar*+*a-mpdu*} + *a-mpdu-end*);

(* A PPDU containing both BlockAack and BlockAckReq is an A-MPDU that contains a BlockAck, plus either a BlockAckReq frame, or 1 or more data frames carrying implicit Block Ack request. *)

ppdu-ba-bar= **BlockAck**[+*HTC*]+*a-mpdu*
(
BlockAckReq[+*HTC*]+*a-mpdu* |
1{**Data**[+*HTC*]+*QoS*+*implicit-bar*+*a-mpdu*}
) + *a-mpdu-end;*

(*A PPDU containing BlockAck is either a non-A-MPDU BlockAck, or an A-MPDU containing a BlockAck, and also containing data that does not carry implicit Block Ack request. *)

ppdu-ba= **BlockAck**[+*HTC*] |
(
BlockAck[+*HTC*]+*a-mpdu*
1{**Data**[+*HTC*]+*QoS*+(*no-ack*|*block-ack*)+*a-mpdu*}
) + *a-mpdu-end;*

(* A PPDU delivering an RDG, but not delivering a BlockAckReq is either a data frame, not requiring immediate acknowledgment, or a BlockAck or BlockAckReq, not requiring immediate acknowledgment *).

ppdu-rd= **Data**+*HTC*[+*null*]+*QoS*+(*no-ack*|*block-ack*)+*RD* |
(BlockAck|BlockAckReq)+*HTC*+*delayed-no-ack*+*RD* |
(
1{**Data**+*HTC*+*QoS*+*RD*+*a-mpdu*}
) + *a-mpdu-end*;

(* A PPDU containing a BlockAckReq and delivering an RDG is either an non-A-MPDU BlockAckReq frame, or an A-MPDU containing at least one data frame with RD and implicit-bar. *)

ppdu-rd-bar= **BlockAckReq**+*HTC*+*RD* |
(
1{**Data**+*HTC*+*QoS*+*implicit-bar*+*RD*+*a-mpdu*}
) + a-mpdu-end;

(* A PPDU containing a BlockAck and granting RD is either an unaggregated BlockAck or an A-MPDU that contains a BlockAck and at least one data frame containing RD, but not implicit Block Ack request. *)
ppdu-ba-rd= **BlockAck**+*HTC*+*RD* |
(
BlockAck+*a-mpdu* (
1{**Data**+*HTC*+*QoS*+(*no-ack*|*block-ack*)+*RD*+*a-mpdu*}
)
) + *a-mpdu-end;*

(* A PPDU containing a BlockAck, BlockAckReq and granting RD is an A-MPDU that contains a BlockAck and either an explicit BlockAckReq (and no data frames) or data frames carrying the implicit Block Ack request. The RD attribute is present in all frames carrying an HT Control field, and at least one of these frames is present. This constraint is not expressed in the syntax below. *)
ppdu-ba-rd-bar= (
BlockAck[+*HTC*+*RD*]+*a-mpdu*
BlockAckReq[+*HTC*+*RD*]+*a-mpdu*
) + *a-mpdu-end* |
(
BlockAck[+*HTC*+*RD*]+*a-mpdu*
1{**Data**[+*HTC*+*RD*]+*QoS*+*implicit-bar*+*a-mpdu*}
) + *a-mpdu-end*;

(* A PSMP burst is a sequence of PSMP sequence ending with a last-psmp-sequence *)
psmp-burst = {non-last-psmp-sequence} last-psmp-sequence;
non-last-psmp-sequence = **PSMP**+*more-psmp*+*QAP* downlink-phase uplink-phase;
last-psmp-sequence = **PSMP**+*no-more-psmp*+*QAP* downlink-phase uplink-phase;

(* The downlink phase is a sequence of allocations to STA as defined in the PSMP frame during which they may expect to receive. *)
downlink-phase = {psmp-allocated-time};

(* The uplink phase is a sequence of allocations to STA as defined in the PSMP frame during which they are allowed to transmit *)
uplink-phase = {psmp-allocated-time};

(* During a time allocation, one or more packets may be transmitted of contents defined by psmp-ppdu *)
psmp-allocated-time = 1{psmp-ppdu};

(* The packets that may be transmitted during PSMP are isolated Multi-TID BlockAck or Multi-TID BlockAckReq frames (under an HT-immediate BlockAck policy), BlockAck or BlockAckReq frames (under an HT-delayed or immediate BlockAck policy), isolated data frames, or an A-MPDU containing an optional Multi-TID BlockAck frame and one or more data frames sent under the PSMP Ack Policy, or an A-MPDU containing both Multi-TID BlockAck and Multi-TID BlockAckReq frames, but no data. Any number of Action No Ack frames may be present in either A-MPDU. *)
psmp-ppdu = **Multi-TID BlockAck** | (*HT-immediate*)
Multi-TID BlockAckReq | (*HT-immediate*)
BlockAck | (*HT-delayed or immediate*)
BlockAckReq | (*HT-delayed or immediate*)
Data[+*HTC*]+*individual*+*QoS*+*psmp-ack* |
(
[**Multi-TID BlockAck**+*a-mpdu*]
{**Management**+*action-no-ack*[+*HTC*] }
1{**Data**[+*HTC*]+*individual*+*QoS*+*psmp-ack*+*a-mpdu*};
) + *a-mpdu-end* |

(
Multi-TID BlockAck+*a-mpdu*
{ **Management**+*action-no-ack*[+*HTC*] }
Multi-TID BlockAckReq+*a-mpdu*
) + *a-mpdu-end*;

(* A link adaptation exchange is a frame exchange sequence in which on-the-air signaling is used to control or return the results of link measurements so that the initiator device can choose effective values for its TXVECTOR parameters. *)
link-adaptation-exchange =
mcs-adaptation |
implict-txbf |
explicit-txbf;

(* An mcs-adaptation exchange includes an MCS measurement request and subsequent MFB. The MRQ and MFB may be present in any +HTC frame. The exchange can occur either as a fast exchange, in which the feedback is supplied in a response frame, an exchange in which the response is supplied along with some other data frame within the same TXOP, or an exchange in which the response is supplied in a subsequent TXOP won by the MCS responder. Only the fast response is shown in the syntax that follows. The sequences shown below are representative examples only and are not exhaustive.*)
mcs-adaptation =
(* RTS/CTS *)
(**RTS**+*HTC*+*mrq* **CTS**+*HTC*+*mfb*) |

(* non-aggregated Data/Ack *)
(**Data**+*HTC*+*QoS*+*mrq*+*normal-ack* **Ack**+*HTC*+*mfb*) |

(* non-aggregated BlockAck *)
(**BlockAckReq**+*HTC*+*mrq* (**BlockAck**+*HTC*+*mfb* | **Ack**+*HTC*+*mfb*)) |

(* aggregated data with implicit Block Ack request and MRQ *)
(
(
1{**Data**[+*HTC*]+*mrq* [+*rdg*] +*QoS*+*implicit-bar*+*a-mpdu*}
) + *a-mpdu-end*
(
(* Unaggregated BlockAck response *)
BlockAck+*HTC* +*mfb* |

(* Aggregated BlockAck response *)
(
BlockAck[+*HTC*+*mfb*] +*a-mpdu*
1{**Data**[+*HTC*+*mfb*]+*QoS*+(*no-ack*|*block-ack*)+*a-mpdu*}
) + *a-mpdu-end*
)
);

(* An implicit-txbf (implicit transmit beamforming) starts with the transmission of a request to sound the channel. The initiator measures the channel based on the sounding packet and updates its beamforming feedback matrices based on its observations of the sounding packet. No channel measurements are sent over the air.*)
implict-txbf =
(**RTS**+*HTC*+*trq* (**CTS**+*sounding* | **CTS**+*HTC*+*ndp-announce* **NDP**)) |
(**Data**+*HTC*+*trq*+*QoS*+*normal-ack*

(**Ack**+*sounding* | **Ack**+*HTC*+*ndp-announce* **NDP**)
) |
(**BlockAckReq**+*HTC*+*trq*
(**BlockAck**+*sounding* |
BlockAck+*HTC*+*ndp-announce* **NDP**
)
) |
(**BlockAck**+*HTC*+*trq*+*delayed*
(**Ack**+*sounding* |
Ack+*HTC*+*ndp-announce* **NDP**
)
)
(* The trq/sounding protocol also operates within aggregates. In this case the TRQ is carried in all +HTC frames (of which there has to be at least one) within the TRQ initiator's transmission. The response PPDU either is a sounding PPDU, or carries at least one +HTC frame with an ndp-announce, in which case the following PPDU is an NDP sounding PPDU. The following syntax is an simplified representation of this sequnce. *)
(**[BlockAck**+*HTC*+*trq*+*a-mpdu*] {**Data**+*HTC*+*trq*+*QoS*+*a-mpdu*}+*a-mpdu-end*)
(
([**BlockAck**+*HTC*+*a-mpdu*]
{**Data**+*HTC*+*QoS*+*a-mpdu*}+*a-mpdu-end*+*sounding*)
) |
(
([**BlockAck**+*HTC*+*ndp-announce*+*a-mpdu*]
{**Data**+*HTC*+*ndp-announce*+*QoS*+*a-mpdu*}+*a-mpdu-end*)
) **NDP** |
(**BlockAck**+*HTC*+*sounding*) |
(**BlockAck**+*HTC*+*ndp-announce NDP*);

(* During operation of explicit transmit beamforming (explicit-txbf), there are three encodings of feedback information. These are not distinguished here and are all identified by the *csi* attribute. The feedback position may be immediate, aggregate, or delayed. Immediate feedback follows a SIFS after a CSI request, identified by the *csi-request* attribute. Aggregate feedback occurs during an aggregate within the same TXOP and may accompany data frames in the same PPDU. Delayed feedback occurs during a subsequent TXOP during which the CSI responder is TXOP intiator. Only immediate feedback is described in the syntax below. The frame indicating any *csi-request* is carried in a sounding PPDU or followed by an NDP. The CSI response is carried in an Action No Ack frame, which may be aggregated with the CTS, BlockAck, or Ack response frame. *)
explicit-txbf = (
(**RTS**+*HTC*+*csi-request*+*sounding* |
(**RTS**+*HTC*+*csi-request*+*ndp-announce* **NDP**))
(**CTS**+*a-mpdu*
Management+*action-no-ack*+*HTC*+*csi*+*a-mpdu-end*)
) |
(**Data**+*HTC*+*csi-request*+*QoS*+*normal-ack*+*sounding* |
(**Data**+*HTC*+*csi-request*+*QoS*+*normal-ack*+*ndp-announce* **NDP))**
(**Ack**+*a-mpdu*
Management+*action-no-ack*+*HTC*+*csi*+*a-mpdu-end*)
) |
(**BlockAckReq**+*HTC*+*csi-request*+*sounding* |
BlockAckReq+*HTC*+*csi-request*+*ndp-announce* **NDP**)
(**BlockAck**+*a-mpdu*

Management+*action-no-ack+HTC+csi+a-mpdu-end*)

) |

(**BlockAckReq**+*HTC+csi-request+delayed+sounding* |
(**BlockAckReq**+*HTC+csi-request+ndp-announce+delayed* **NDP**))
(**Ack**+*a-mpdu*
Management+*action-no-ack+HTC+csi+a-mpdu-end*)

) ;

Annex T

(informative)

Additional HT information

T.1 Waveform generator tool

As an informative extension to this standard, the waveform generator tool has been written to model the PHY transmission process described in Clause 17, Clause 19, and Clause 20.

The waveform generator can be downloaded from the public IEEE 802.11 document website. The waveform generator code may be found in document 11-06/1715, and the waveform generator description may be found in document 11-06/1714.

The purpose of the tool is to promote common understanding of complex PHY algorithms, facilitate device interoperability by providing reference test vectors, and assist researchers in industry and academia to develop next generation wireless solutions.

The code is written in the MATLAB computing language and can be configured to generate test vectors for most PHY configurations, defined by this standard. Instructions on how to configure and run the Tool are specified in the documentation files that are supplied with the code. A command line interface and graphic user interface (GUI) exist to configure the tool. For consistency with this standard, the configuration interface is made very similar to the TXVECTOR parameters defined in 20.2.2.

The waveform generator tool produces test vectors for all transmitter blocks, defined in Figure 20-2 and Figure 20-3, generating reference samples in both frequency and time domains. Outputs of the tool are time domain samples for all transmitting chains.

T.2 A-MPDU deaggregation

This subclause contains a description of the deaggregation process. Other implementations are also possible.

The receiver checks the MPDU delimiter for validity based on the CRC. It can also check that the length indicated is within the value of the LENGTH parameter indicated in RXVECTOR.

If the MPDU delimiter is valid, the MPDU is extracted from the A-MPDU. The next MPDU delimiter is expected at the first multiple of 4 octets immediately after the current MPDU. This process is continued until the end of the PPDU is reached.

If the MPDU delimiter is not valid, the deaggregation process skips forward 4 octets and checks to see whether the new location contains a valid MPDU delimiter. It continues searching until either a valid delimiter is found or the end of the PSDU is reached based on the value of the LENGTH parameter indicated in the RXVECTOR.[1]

[1] This procedure will occasionally wrongly interpret a random bit-pattern as a valid delimiter. When this happens, the MAC will attempt to interpret a random MPDU. The MAC will discard it with a high probability based on a bad MAC CRC check.

An A-MPDU parsing (deaggregation) algorithm is expressed (as a C programming language snippet) in Figure T.1.

```
void Parse_A_MPDU (int length)
{
  int offset = 0; /* Octet offset from start of PSDU */
  while (offset+4 < length)
  {
    if (valid_MPDU_delimiter(offset) &&
        get_MPDU_length(offset) <= (length -(offset+4)))
    { /* Valid delimiter */

      /* Receive the MPDU */
      Receive_MPDU(offset+4, get_MPDU_length(offset));

      /* advance by MPDU length rounded up to a multiple of 4 */
      offset += 4 + 4*((get_MPDU_length(offset)+3)/4);
    }
    else /* Invalid delimiter */
    {
      /* Advance 4 octets and try again */
      offset += 4;
    }
  }
}
```

NOTE 1—This algorithm is not optimized for efficiency.

NOTE 2—The delimiter signature can be used to reduce the amount of computation required while scanning for a valid delimiter. In this case, the receiver tests each possible delimiter for a matching Delimiter Signature field. Only when a match is discovered does it then check the CRC.

Figure T.1—A-MPDU parsing

T.3 Example of an RD exchange sequence

Figure T.2 shows an example of the operation of the RD rules, defined in 9.15.

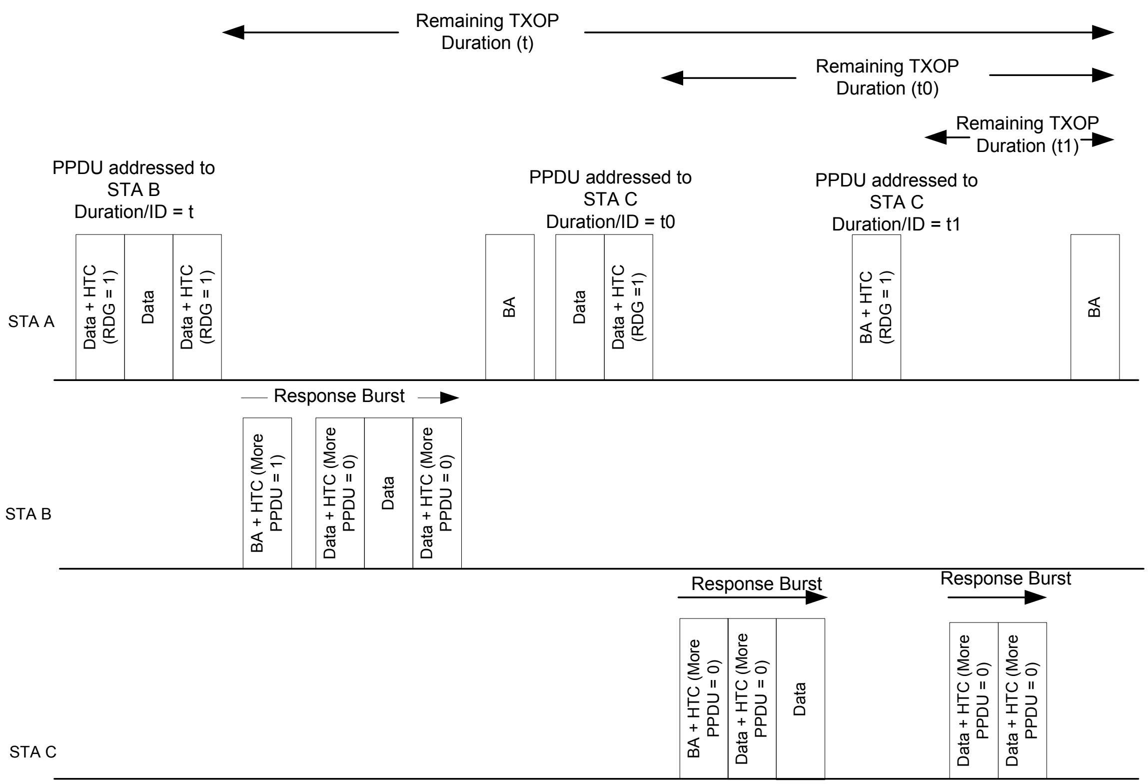

Figure T.2—Example of RD exchange sequence showing response burst

The following is a summary of Figure T.2:

a) STA A (acting as RD initiator) transmits a PPDU containing MPDUs addressed to STA B (acting as RD responder). The Ack Policy field of the QoS data MPDUs in this PPDU is set to Implicit Block Ack Request. One or more MPDUs within this PPDU include an HT Control field with the RDG/More PPDU subfield set to 1, indicating an RDG. The Duration/ID field of MPDUs within the PPDU contains the remaining duration of the TXOP, t µs.

b) STA B (the RD responder) responds with the transmission of a +HTC BlockAck frame in which the RDG/More PPDU subfield is set to 1, indicating that another PPDU will follow a SIFS or RIFS interval after the end of the PPDU containing the BlockAck MPDU.

c) STA B transmits a PPDU (the second PPDU of an RD response burst) to STA A, with the Ack Policy field of its QoS data MPDUs set to Implicit Block Ack Request and containing one or more +HTC MPDUs in which the RDG/More PPDU subfield is set to 0, indicating that this is the last PPDU in the response burst.

d) STA A (the RD initiator) regains control of the TXOP and transmits a BlockAck MPDU addressed to STA B to acknowledge the MPDUs transmitted by STA B in the RD response burst.

e) STA A (the RD initiator) transmits a PPDU containing MPDUs addressed to STA C (acting as RD responder). The Ack Policy field of the QoS data MPDUs in this PPDU is set to Implicit Block Ack. This PPDU includes one or more +HTC MPDUs in which the RDG/More PPDU subfield is set to 1, indicating an RDG. The Duration/ID field of MPDUs in the PPDU contains the remaining duration of the TXOP, t0 µs.

f) STA C (the RD responder) transmits a PPDU to STA A, containing one or more +HTC MPDUs with the RDG/More PPDU subfield set to 0, indicating that this is the last PPDU in the response burst. This PPDU contains a BlockAck MPDU that is a response to the Implicit Block Ack request of the previous PPDU, plus QoS data MPDUs with the Ack Policy field set to Implicit Block Ack.

g) STA A (the RD initiator) regains control of the TXOP and transmits a BlockAck MPDU to STA C that acknowledges the MPDUs transmitted by STA C. This PPDU contains one or more +HTC MPDUs with the RDG/More PPDU subfield set to 1, indicating an RDG. The Duration/ID field of MPDUs in the PPDU contains the remaining duration of the TXOP, t1 µs.

h) STA C (the RD responder) transmits a PPDU to STA A, containing QoS data +HTC MPDUs with the Ack Policy field set to Implicit Block Ack Request and the RDG/More PPDU subfield set to 0. This is the only PPDU in the RD response burst.

i) STA A transmits a BlockAck MPDU to STA C that acknowledges the MPDUs transmitted by STA C in the RD response burst.

T.4 Illustration of determination of NDP addresses

Determination of NDP SA and DA are illustrated in Figure T.3 and Figure T.4.

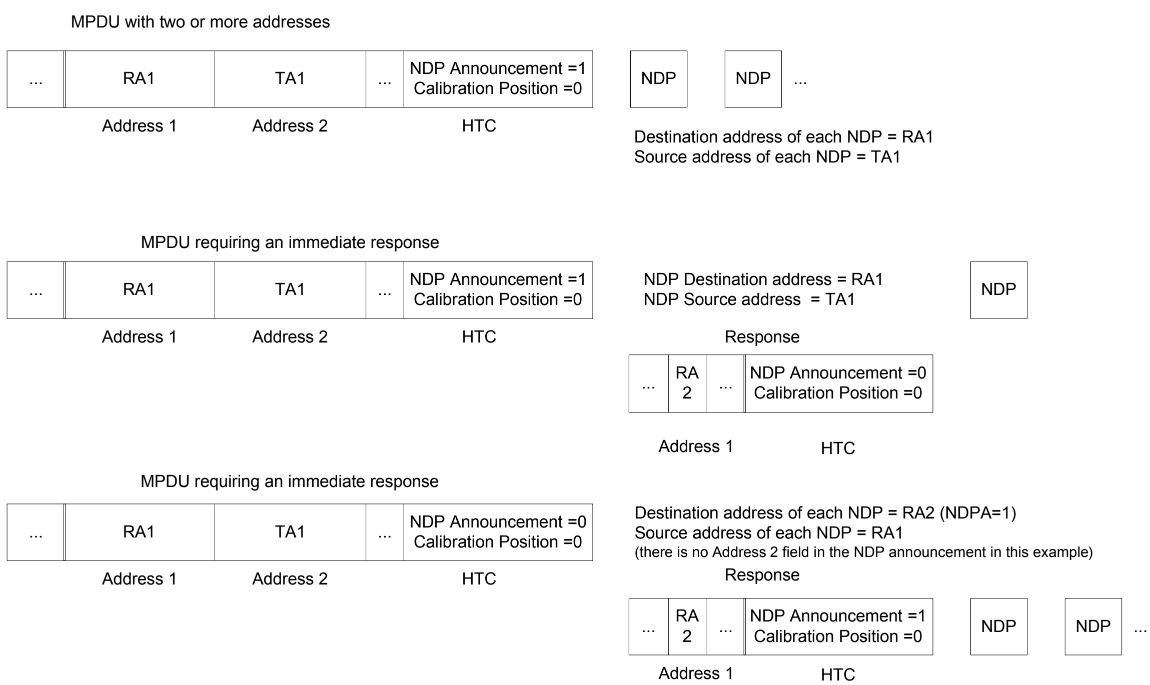

Figure T.3—Determination of NDP source and destination for unidirectional NDP sequences

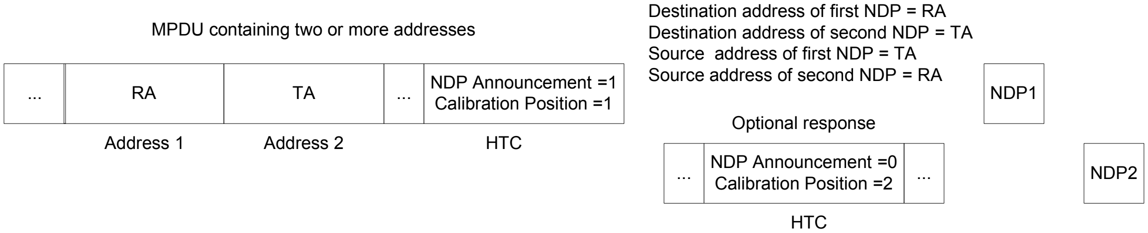

Figure T.4—Determination of NDP source and destination for bidirectional NDP sequence

T.5 20/40 MHz BSS establishment and maintenance

T.5.1 Signaling 20/40 MHz BSS capability and operation

A BSS that occupies 40 MHz of bandwidth and that is administered by an HT AP is called a 20/40 MHz BSS.

An HT AP that has its dot11FortyMHzOperationImplemented MIB variable set to TRUE will set the Supported Channel Width Set subfield of the HT Capabilities element to a nonzero value and may optionally operate a 20/40 MHz BSS. The Supported Channel Width Set subfield of the HT Capabilities element that is transmitted by the AP indicates the possible operating mode of the BSS and of the AP, but the value in this field is not an indication of the current operating channel width of either the AP or the BSS.

An HT AP signals the operating width of the BSS through the Secondary Channel offset field of the HT Operation element. A nonzero value in this field indicates that a secondary channel exists; in other words, the BSS is a 20/40 MHz BSS. A value of zero in this field indicates that the BSS is operating as a 20 MHz BSS.

An HT AP that has its dot11FortyMHzOperationEnabled MIB variable set to TRUE will set its STA Channel Width field of the HT Operation element to a nonzero value. This field signals the current operating mode of the AP, not the BSS. An HT AP may operate a 20/40 MHz BSS while it is operating as a 20 MHz device. Such a situation would support, for example, 40 MHz bandwidth DLS traffic among associated STAs, but only 20 MHz bandwidth traffic between STAs and the AP.

T.5.2 Establishing a 20/40 MHz BSS

Before starting a 20/40 MHz BSS, an 40-MHz-capable HT AP is required by the rules defined in 11.14.5 to examine the channels of the current regulatory domain to determine whether the operation of a 20/40 MHz BSS might unfairly interfere with the operation of existing 20 MHz BSSs. The AP (or some of its associated HT STAs) is required to scan all of the channels of the current regulatory domain in order to ascertain the operating channels of any existing 20 MHz BSSs and 20/40 MHz BSSs. This type of scanning is called *OBSS scanning*. The particulars of OBSS scanning are controlled by the following MIB attributes:

— dot11FortyMHzOptionImplemented
— dot112040BSSCoexistenceManagementSupported
— dot11FortyMHzIntolerant
— dot11BSSWidthTriggerScanInterval
— dot11BSSWidthChannelTransitionDelayFactor
— dot11OBSSScanPassiveDwell
— dot11OBSSScanActiveDwell

— dot11OBSSScanPassiveTotalPerChannel
— dot11OBSSScanActiveTotalPerChannel
— dot11OBSSScanActivityThreshold

Specific values for these MIB attributes are provided to set minimum scan times for passive scanning of each channel, and a separate minimum time is provided for active scanning of each channel. A total minimum amount of scanning per channel is required before a determination can be made to allow the operation of a 20/40 MHz BSS.

The rules that are applied when determining whether a 20/40 MHz BSS can be established are intended to avoid a full or partial overlap of the secondary channel of the 20/40 MHz BSS with an existing primary channel of either a 20 MHz BSS or a 20/40 MHz BSS. The lack of partially overlapping channels in the 5 GHz band allows these rules to be written as recommendations, while in the 2.4 GHz band, they are requirements.

An additional constraint on establishing a 20/40 MHz BSS includes the allowance for any IEEE 802.11 device to explicitly prohibit the operation of the 20/40 BSS mode due to other considerations. For example, if an IEEE 802.15.1 WPAN device is operating in the area, that device is likely to be unable to communicate successfully with a paired receiver if the number of available IEEE 802.15.1 WPAN channels falls below a given threshold. Operation of a 20/40 MHz BSS in the 2.4 GHz band can contribute to the reduction of the number of available IEEE 802.15.1 WPAN channels, possibly pushing the available channels below that threshold.

To promote sharing of the spectrum resource under such circumstances, it might be desirable to prohibit the operation of a 20/40 MHz BSS. As such, the 20/40 BSS coexistence mechanism allows a STA to transmit management frames containing a value of 1 for the Forty MHz Intolerant field. (The MIB attribute dot11FortyMHzIntolerant determines the setting of the value of the Forty MHz Intolerant field in transmitted frames, and the setting of the value of the MIB attribute is beyond the scope of this standard.) Receivers of such frames on any channel in the band are not allowed to establish a 20/40 MHz BSS anywhere in the band for a duration of dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTriggerScanInterval seconds. To effect this requirement, monitoring STAs and APs maintain a countdown timer to indicate that a prohibition is in force. The countdown timer is reloaded with the value dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTriggerScanInterval seconds each time that the STA or AP observes a management frame containing a value of 1 for the Forty MHz Intolerant field. STAs communicate changes in their countdown counter (i.e., transitions between a zero value and a nonzero value) to their associated AP through the 20 MHz BSS Width Request field of the 20/40 BSS Coexistence Management frame.

T.5.3 Monitoring channels for other BSS operation

Some of the STAs that are associated with a 20/40 MHz BSS are required to perform monitoring in order to ensure that the conditions which allowed the establishment of the 20/40 MHz BSS do not change to conditions that would disallow the existence of the 20/40 MHz BSS.

Monitoring STAs keep a local record of channels that are in use by other BSSs. STAs that receive Beacon frames determine the primary channel by examining the DS Parameter Set element. Secondary channel existence and channel information are determined by examining the Secondary Channel Offset field of the 20/40 BSS Coexistence element. Monitoring STAs also record receptions of frames that contain a value of 1 for the Forty MHz Intolerant field. Any changes to the local record that would create a prohibition against 20/40 MHz BSS operation are immediately reported to the associated AP through the transmission of a 20/40 BSS Coexistence Management frame (i.e., with the 20 MHz BSS Width Request field set to 1). The reception of a 20 MHz BSS Width Request field set to 1 at the AP causes the AP to switch the BSS to 20 MHz operation immediately.

Any change of a channel in use that had not previously been in use is also reported immediately within a 20/40 BSS Coexistence Management frame. The AP examines the new in-use channel information to determine whether any changes in BSS width operation are required (i.e., to see if any changes have occurred that indicate an overlap of the secondary channel). If a change to 20 MHz BSS operation is required, the change occurs immediately.

Conditions that prevent the operation of a 20/40 MHz BSS might be transient. If the number of channels in use is reduced or all STA signaling 40 MHz intolerance leave the area, an AP might choose to revert to 20/40 MHz operation, if allowed to do so. However, the conditions that allow 20/40 MHz BSS operation have to persist for a period of dot11BSSWidthChannelTransitionDelayFactor × dot11BSSWidthTrigger-ScanInterval seconds before a STA can signal that the conditions have changed, and the same period of time has elapsed before an AP can resume 20/40 MHz BSS operation.

STAs that do not monitor channels through OBSS scanning and do not report any channel information or received Forty MHz Intolerant field information to their associated AP are listed here:

— non-HT STAs
— HT STAs that are exempt from scanning as specified in 11.14.6
— HT APs, once the 20/40 MHz BSS is established
— HT STAs that are associated with an AP whose BSS is operating on a channel that is not in the 2.4 GHz band
— HT STAs that are associated with an HT AP that is not 40-MHz-capable (as indicated by a value of zero in the Supported Channel Width Set subfield of the HT Capabilities element)

All other HT STAs that are associated with a 40-MHz-capable HT AP whose BSS is operating on a channel in the 2.4 GHz band monitor channels through OBSS scanning and report any channel information or received Forty MHz Intolerant field information to their associated AP.

All MIB attributes that are employed by the 20/40 BSS Coexistence mechanism are maintained by the AP, which has the ability to provide updates to the MIB attribute values to the associated STA by transmitting an OBSS Scan Parameters element.

