



**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**

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
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IEEE Std 802.11nTM-2009
(Amendment to IEEE Std 802.11TM-2007
as amended by IEEE Std 802.11kTM-2008,
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(Amendment to 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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IEEE Computer Society**

Approved 11 September 2009

IEEE-SA Standards Board

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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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 ~~striketrough~~ (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.~~

¹Notes 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.

¹The *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 PPDU: 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 forward 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-UTT). 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 PPDU 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: aggregate MSDU (A-MSDU) aggregation, frame delivery deferral during power save mode, sequence number assignment, fragmentation, encryption, integrity protection, ~~and frame formatting,~~ and aggregate MAC protocol data unit (A-MPDU) aggregation. 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:

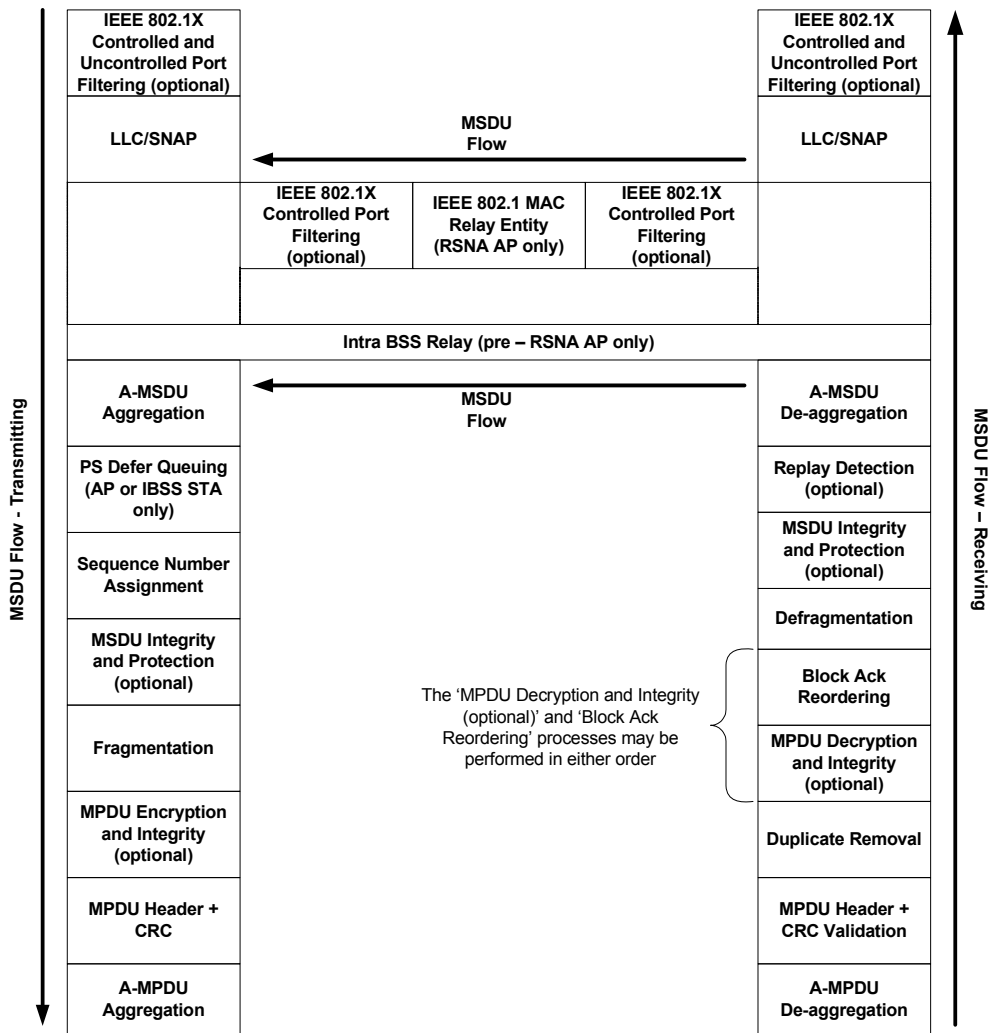


Figure 6-1—MAC data plane architecture

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 eControl 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:.

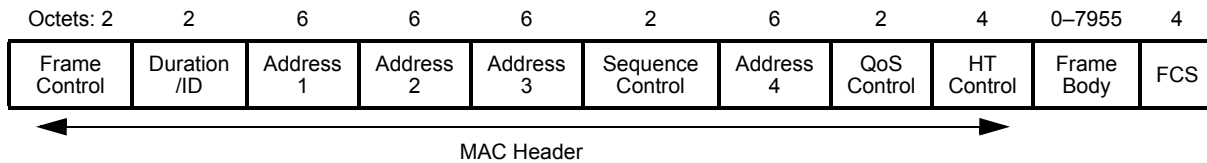


Figure 7-1—MAC frame format

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 <u>0</u>	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 identifier (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
<u>QoS CF-Poll and QoS CF-Ack+CF-Poll frames sent by HC</u> ~~QoS (+)CF-Poll frames sent by HC~~	TID	EOSP	Ack Policy	Reserved	TXOP Limit
<u>QoS Data+CF-Poll and QoS Data+CF-Ack+CF-Poll frames sent by HC</u>	<u>TID</u>	<u>EOSP</u>	<u>Ack Policy</u>	<u>A-MSDU Present</u>	<u>TXOP Limit</u>
<u>QoS Data and QoS Data+CF-Ack frames sent by HC</u>	<u>TID</u>	<u>EOSP</u>	<u>Ack Policy</u>	<u>A-MSDU Present</u>	<u>AP PS Buffer State</u>
<u>QoS Null frames sent by HC</u> ~~QoS Data, QoS Null, and QoS Data+CF-Ack frames sent by HC~~	TID	EOSP	Ack Policy	Reserved	AP PS Buffer State
<u>QoS Data and QoS Data+CF-Ack frames sent by non-AP STAs</u>	<u>TID</u>	<u>0</u>	<u>Ack Policy</u>	<u>A-MSDU Present</u>	<u>TXOP Duration Requested</u>
	<u>TID</u>	<u>1</u>	<u>Ack Policy</u>	<u>A-MSDU Present</u>	<u>Queue Size</u>
<u>QoS Null frames sent by non-AP STAs</u> ~~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.