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Joint Proposal: High throughput extension to the 802.11 Standard: MAC

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Abstract

This document contains the MAC layer parts of the 802.11 TGn Joint Proposal Technical Specification.

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1 References

[1] TGn Sync Proposal Technical Specification doc.: IEEE 802.11-05/1095r44

[2] IEEE Std 802.11®-1999 (Reaff 2003)
Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

[3] WWiSE Proposal: High throughput extension to the 802.11 Standard doc.: IEEE 802.11-05/0149r1

[4] IEEE P802.11e/D13.0, January 2005

2 Definitions

Aggregate: A PSDU transported by the PHY with an aggregate attribute indicating that it contains multiple MPDUs.

Downlink transmission: period of time described by a PSMP frame and which is intended to be used for the reception of frames by PSMP receivers.

Initiator: A STA that holds a TXOP and transmits the first frame in a frame exchange sequence including aggregate PPDUs.

LongNAV: A MAC-layer protection mechanism that protects multiple PPDUs exchanged within a TXOP

Mixed Mode: A mode of operation of an HT BSS in which there are co-channel legacy devices present.

OFDM Format: Definition of subcarrier frequencies relative to the channel center frequency, and specification of data bearing and pilot subcarriers.

Originator: A STA that sends data using the Block ACK mechanism.

Phased Coexistence Operation: A BSS mode with alternating 20 MHz and 40 MHz phases controlled by a PCO AP.

Preamble: Portions of the 802.11 HT PPDU used for PHY synchronization and channel estimation.

Power Save Multi-Poll: MAC control frame that provides time schedule to be used by the PSMP transmitter and PSMP receivers. The scheduled time begin immediately subsequent to the transmission of the PSMP frame.

Pure Mode: A mode of operation of a BSS in which there are no legacy devices.

Receiver: Any STA receiving the current PPDU.

Recipient: A STA that receives data directed to it using the Block ACK mechanism.

Reserved field: Any field that is defined, but not used by the current spec. This field shall be zeroed by transmitter and ignored by receiver

Responder: A STA that responds to an initiator in a frame exchange sequence including aggregates

SIGNAL FIELD: Portion of the 802.11 HT PHY PPDU that contains "Rate" and "Duration", part of the PLCP header.

Sub-PSMP: a PSMP sequence that follows a SIFS interval after the current one.

Symbol: Typically refers to an OFDM symbol, which is a collection of sub-carriers (or tones)

Uplink transmission: Period of time described by a PSMP frame and which is intended to be used for the transmission of frames by a PSMP receiver.

Zero-length frame: A PSDU with zero-length for its MAC portion.

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3 Abbreviations and acronyms

Term	Description
ABF-MIMO	Advanced Beamforming MIMO (Transmit Beamforming with Spatial water filling techniques on Multiple Spatial Streams)
ACK	Acknowledgement
AGC	Automatic Gain Control
AP	Access Point
AS	Antenna Selection
ASC	Antenna Selection Control
ASI	Antenna Selection Indication
BF-MIMO	Beamforming MIMO (Basic Transmit Beamforming on Multiple Spatial Streams)
CAP	Controlled Access Phase
CDD	Cyclic Delay Diversity
CRC	Cyclic Redundancy Check
CSI	Channel State Information
CSIT	Channel State Information at the Transmitter
CTS	Clear to Send
DLP	Direct Link Protocol
DLT	Down Link Transmission
ERP	Extended Rate PHY
FCS	Frame Check Sequence
GF	Green Field
GI	Guard Interval
HC	Hybrid Controller
HT	High Throughput
HT-LTF	High Throughput Long Training Field
HT-SIG	High Throughput Signal Field
HT-STF	High Throughput Short Training Field
IE	Information Element
LLC	Logical Link Control
L-LTF	Legacy Long Training Field

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L-SIG	Legacy Signal Field
L-STF	Legacy Short Training Field
MAC	Medium Access Controller
MCS	Modulation Coding Scheme – includes modulation order (BPSK, QPSK, 16-QAM, 64-QAM) and FEC code rate (1/2, 2/3, 3/4, 5/6)
MIMO	Multiple input, multiple output (Both transmitter and receiver have multiple antennas for signaling over a point-to-point link)
MISO	Multiple input, single output (transmitter has multiple antennas but receiver has a single antenna)
MPDU	MAC protocol data unit
MRC	Maximum Ratio Combining (a technique to maximize received SNR using antenna signal combining).
MRQ	MCS Request
MSDU	MAC service data unit
MTBA	Multiple TID Block Ack
MTBAR	Multiple TID Block Ack Request
NAV	Network Allocation Vector (a MAC-level carrier-sense)
N_{RX}	Number of Receive Antennas
N_{SD}	Number of Data Subcarriers
N_{SS}	Number of Spatial Streams
N_{TX}	Number of Transmit Antennas
OFDM	Orthogonal Frequency Division Multiplexing
PCO	Phased Coexistence Operation
PHY	Physical Layer
PLCP	PHY layer convergence protocol
PPDU	PHY protocol data unit
PSDU	PHY service data unit
PSMP	Power Save Multi-Poll
QAP	QoS access point
QoS	Quality of service
QSTA	QoS station
RD	Reverse Direction
RDG	Reverse Direction Grant
RIFS	Reduced inter-frame spacing
RSSI	Receive Signal Strength Indicator
RTS	Request to send

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RX	Receiver
SAP	Service Access Point
SF	Signal Field
SIFS	Short inter-frame spacing
SIMO	Single input, multiple output (transmitter has a single antenna, receiver has multiple antennas)
SISO	Single input, single output (both transmitter and receiver have a single antenna)
SNR	Signal to Noise Ratio
SRA	Single Receiver Aggregate – an aggregate that contains MPDUs for a single receiver address.
STA	Station
STBC	Space-Time Block Code
SVD	Singular Value Decomposition: For an arbitrary matrix $A = USV^H$
TBD	To be determined
TC	Traffic Category
TGe	802.11 Task Group e - Quality of Service
TGn	802.11 Task Group n - Enhancements for Higher Throughput
TS	Traffic Stream
TSID	Traffic Stream Identifier
TSPEC	Traffic specification
TX	Transmitter
TXOP	Transmission opportunity
ULT	Up Link Transmission
ZLF	Zero Length Frame (as measured at the MAC)

4 Introduction

4.1 Conventions

All fields described as reserved shall be set to zero by the transmitter and ignored by the receiver.

The features described in this document are classified as mandatory or optional. A STA may only use an optional feature where the use of that feature has been negotiated by the signaling described in this document. Mandatory features may be used without any prior negotiation.

The term HT STA is used to refer to a STA that is compliant to this specification and supports its mandatory features.

The definition of each feature may provide additional explanation of the meaning of mandatory and optional in relation to that particular feature.

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Note: in keeping with the 802.11 specification, the term non-AP STA refers to a STA that is not an AP. The term STA includes both non-AP STA and AP devices.

Note: The terms AP and STA are used throughout rather than QAP and QSTA for consistency.

4.2 PHY Enhancements Requiring MAC Signaling

Table *1* lists those PHY enhancements that need MAC level signaling. Use of these features is determined through the HT capabilities element

Table 1 – PHY Enhancements Requiring MAC Negotiation

#	PHY enhancements	Comments
1.	Supported MCS set	Defines the MCS values supported by a STA. An MCS set contains a bitmap of size 128 bits. Bit 0 maps to MCS 0. A bit is set to indicate support for that MCS. See PHY section for a list of MCSs.
2.	Supported Channel Width Set	20 MHz only or 40/20 MHz channel support
3.	Advanced Coding	Optional
4.	Green Field	Optional
5.	Beam forming	Optional
6.	Short GI	Optional
7.	STBC	Optional

4.3 General description of MAC enhancements

The proposed MAC enhancements assume a baseline specification defined by IEEE 802.11 standard 0 and its later amendments, (a, b, d, e, g, h, j). The purpose of these enhancements is to significantly improve throughput, providing a throughput of at least 100Mbps using mandatory features only, as measured at the MAC data service access point (SAP).

The new or modified MAC features defined by this proposal and required levels of support are defined in *Table 2*.

Table 2 – MAC Enhancements and Requires Levels of Support

#	MAC enhancements	Required Level of Support
1.	A Frame Aggregation format that allows aggregation of multiple MPDUs in one PSDU. (A-MPDU)	Mandatory Recipient shall receive an A-MPDU aggregation that is not greater than the negotiated size. Minimum separation of MPDUs in an A-MPDU is negotiable (MPDU Density). Frames requiring an ACK can only be sent as a legacy PPDU or an HT non-aggregate PPDU. Only single receiver address aggregation is supported.

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2.	A Frame aggregation format that allows aggregation of multiple MSDUs in one MPDU (A-MSDU)	Mandatory Recipient shall receive and deaggregate an A-MSDU. The recipient supports one of two maximum lengths at its option.
3.	Block Ack Mechanism	Mandatory when A-MPDU is used. HT stations shall support BA.
4.	N-Immediate BA	Mandatory
5.	N-Delayed BA including No ACK on BA/BAR	Optional
6.	Compressed bitmap BA	Mandatory
7.	Implicit BA request by asserting "Normal ACK" of an MPDU aggregated in PSDU	Mandatory at Recipient
8.	Recipient Partial State	Mandatory under N-Immediate BA
9.	Security	Open and CCMP only
10.	Long NAV reservation with CF-end for NAV release	Mandatory Receiver shall respect this type of protection.
11.	PHY level spoofing	Mandatory. The length field of the L-SIG field of a mixed mode packet shall have a value equivalent to the duration of the current PPDU when L-SIG TXOP protection is not used.
12.	MIMO power save	Mandatory to honor any MIMO power save notifications
13.	Reduce MIMO capability	Mandatory to honor any Reduced MIMO capability notifications
14.	Mechanisms to manage coexistence of 20 and 40 MHz channels.	Mandatory Both transmitter and receiver shall support
15.	Channel management and channel selection methods.	Mandatory Both transmitter and receiver shall support
16.	RIFS Protection	Mandatory
17.	Green Field Protection	Mandatory
18.	Power Save Multiple Poll	Support of PSMP is optional; however use of PSMP by AP is mandatory for Multiple RAs packet transmission with RIFS or SIFS to support PSMP capable STA. (See 6.11).
19.	Multiple TID Block ACK	MTBA is the only BA mechanism that shall be used during a PSMP sequence.
20.	STBC Control Frames	STBC Control Frames allow stations to associate beyond the non-STBC range.
21.	L-SIG TXOP Protection	Optional TXOP protection through L-SIG.

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22.	PCO	Optional PCO is an optional BSS mode with alternating 20 MHz phase and 40 MHz phase controlled by PCO AP. A PCO capable STA may associate with the BSS as a PCO STA.
23.	Transmit beamforming	Optional feature
24.	Fast Link Adaptation	Optional MCS request and response
25.	Implicit feedback	Optional request and response of Responder's sounding
26.	CSI feedback	Optional request and response of CSI
27.	ZLF sounding	Optional use of Zero Length frame as sounding frame
28.	Calibration	Optional calibration support
29.	Reverse Direction	Optional support of Responder's data transfer
30.	Antenna Selection	Optional support of Antenna selection

5 Frame Formats

This clause specifies the format of new HT frames.

Reserved fields and subfields shall be transmitted as zeroes and shall be ignored by an HT receiver

5.1 MAC Frame Formats

5.1.1 HT Control Field

The HT Control Field may be included in any frame except a non-QoS Data frame. The presence of the HT control field in frames carried in a HT PPDU is indicated by setting the order bit in the MAC header. The HT Control Field appears last in the MAC Header, excluding any security fields. An MPDU that contains the HT control field is referred to as a +HTC frame. The format of the 4-octet HT Control Field is shown in Figure 1.

#	B0-B15	B16-17	B18-19	B20-21	B22-23	B24	B25-29	B30	B31
	Link Adaptation Control	Calibration Position	Calibration Sequence	Feedback request	CSI/ Steering	ZLF Announcement	Reserved	AC Constraint	RDG/More PPDU
# Bits	16	2	2	2	2	1	5	1	1

Figure 1 – HT Control field

	B0	B1	B2*	B3-B5	B6-B8	B9-15
	MA	TRQ	MRQ	MRS/ASI	MFS	MFB/ASC
# Bits	1	1	1	3	3	7

Figure 2 – Link Adaptation Control field

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Subfields of the Link Adaptation Control field are defined in Table 3.

Table 3 – Link Adaptation Control Subfields

Field	Meaning	Definition
MA	MA payload	When the MA field is set to 1, the payload of the QoS Null Data MPDU is interpreted as a payload of management action frame. This is described in 5.4.13
TRQ	Sounding Request	'1' = Request to responder to transmit a sounding PPDU
MRQ	MCS Request	'1' = Request for MCS feedback
MRS	MRQ Sequence Identifier	Set by sender to any value in the range '000'-'110' to identify MRQ. Invalid if MRQ = '0'
MFS	MFB Sequence Identifier	Set to the received value of MRS. See note. Set to '111' for unsolicited MFB
MFB	MCS Feedback	Link adaptation feedback containing recommended MCS Default "all-ones" value indicates no feedback or not available

At each MCS Request (MRQ = '1') the sender includes the MRS in the transmitted HT Control Field. The responder includes the received MRS value in the MFS field of the corresponding response frame. In the case of a delayed response, this allows the sender to correlate the MCS Feedback with the MCS request. When the responder provides unsolicited MCS feedback, it sets MFS = '111'. When a responder immediately responses but is unable to provide MCS feedback it shall set MFB to "all-ones". When a responder is unable to provide an immediate response to MRQ and sets MFB to all-ones it also sets MFS = 111.

Table 4 – Antenna Selection Indication

ASI	Antenna Selection Indication	MRQ = '0', and ASI = '111' indicates antenna selection training.
ASC	Antenna Selection Control	When MRQ='0' and ASI='111', serves as ASC.

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For antenna selection training the seven bits of the ASC subfield have the structure indicated in Figure 3 and Table 5.

	B9~B11	B12~B15
	Command	Data
# Bits	3	4

Figure 3 – ASC Subfield

Table 5 – The Command and Data Parts in ASC Subfield

Command (B9~B11)	Meaning of Command	Data (B12~B15)	
000	Transmit Antenna Selection Sounding Indication (TXASSI)	Number of remaining sounding PPDUs	
001	Transmit Antenna Selection Sounding Request (TXASSR)	Reserved	
010	Receive Antenna Selection Sounding Indication (RXASSI)	Number of remaining sounding PPDUs	
011	Receive Antenna Selection Sounding Request (RXASSR)	Total number sounding PPDUs required	
100	Number of covered antennas in MIMO CSI Matrices feedback	0000	CSI for first 4 antennas if total number of antennas greater than 4. Or, CSI for all the antennas if total number of antennas equal or less than 4.
		0001	CSI for remaining antennas other than first 4 if total number of antennas greater than 4
		Others	Reserved
110	No feedback, AS training failure	Reserved	
111	Reserved	Reserved	

In the Transmit/Receive Antenna Selection Sounding Indication command the values in the data field represent 0- no sounding remaining (non ZLF only), 1- one remaining, ... , 7-seven remained, 8 - eight remaining (ZLF only), 9-15 – reserved.

The ZLF enumeration is different because the ZLF actually follows the frame with HTC field. The ZLF announcement bit shall be set to indicate following ZLF sounding.

The Calibration Position and Calibration Sequence fields are defined in Table 6.

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Table 6 – Calibration Control Subfields

Field	Meaning	Definition
Calibration Position	Position in Calibration Sounding Exchange Sequence	00 = Default: Not a calibration frame. 01 = Calibration Start 10 = Sounding Response 11 = Sounding Complete
Calibration Sequence	Calibration Sequence Identifier	Incremented each time a new calibration procedure is started. The field is included in each frame within the calibration procedure and its value is unchanged for the frame exchanges during one calibration procedure.

The default value of the Calibration Position field when not in a Calibration Sounding Exchange sequence is '00'.

A frame in which the Calibration Position field is set to '10' or '11' must be transmitted in a sounding PPDU, i.e., the number of HT-LTFs must be equal to the number of transmit antennas.

The Calibration Sequence field is incremented each time the calibration procedure is started between any two STAs. The field is included in each frame within the calibration procedure and its value is unchanged for the frame exchanges during the entire calibration procedure.

The Feedback Request field contains position of the feedback: Immediate feedback means SIFS after PPDU that contains Request; Aggregated means feedback aggregated with any other response in the same TxOP; Unsolicited feedback means that the feedback may be sent in the TxOP obtained by the Responder.

Table 7 – Feedback request

Field	Meaning	Definition
Feedback request	Position of the CSI feedback	00 – No request 01 – Unsolicited feedback only 10 – Immediate feedback 11 – Aggregated feedback

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Table 8 – CSI/Steering

Field	Meaning	Definition
CSI/Steering	Type of feedback	00 – CSI 01 – uncompressed Steering Matrix 10 – compressed Steering Matrix 11 – Reserved

Table 9 – ZLF Announcement

Field	Meaning	Definition
ZLF Announcement	The ZLF Announcement indicates that a ZLF will be transmitted after the frame (according to the rules described in section 6.18).	0 – no ZLF will follow 1 – ZLF will follow

The RDG/More PPDU Field of the HT Control field is interpreted differently when transmitted by an initiator or a responder. Third party STA do not need to interpret this bit.

Table 10 – RDG/More PPDU

RDG/More PPDU Value	In MPDU transmitted by Initiator	In MPDU transmitted by responder
0	No reverse grant	The PPDU carrying the MPDU is the last transmission by the responder.
1	A reverse grant is present, as defined by the Duration/ID field.	The PPDU carrying the MPDU is followed by another PPDU.

Table 11 – AC Constraint

AC Constraint Field Value	Description
0	The response may contain data from any TID
1	The response may contain data only from the same AC as the last Data received from the initiator

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5.2 Control frames

No new subtypes of control frames are defined, however, the Block Ack frame is modified to contain compressed image of scoreboard. Multiple TID Block Ack (MTBA) and Multi TID Block Ack request (MTBAR) are modifications of BA and BAR subtype MPDU's respectively.

5.2.1 Block Ack (BA) MPDU

This section defines modifications to the BA frame introduced in 802.11e.

The BA of compressed format is mandatory for all HT devices.

BA negotiated between HT STAs shall always use the compressed format.

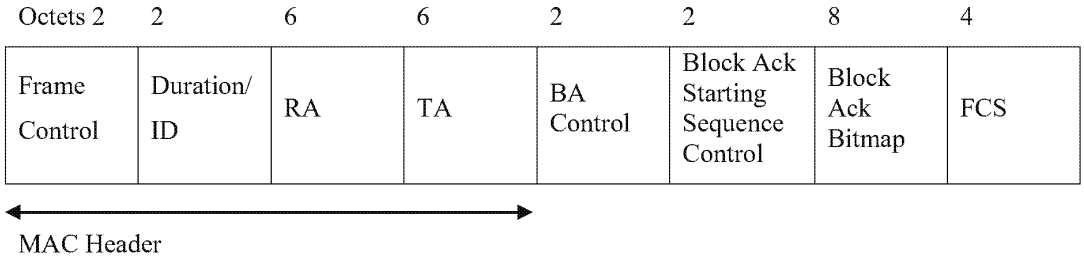


Figure 4 – Compressed BA MPDU

Only the BA control and Block Ack Bitmap fields are modified.

The BA Control Field is shown in Figure 5.

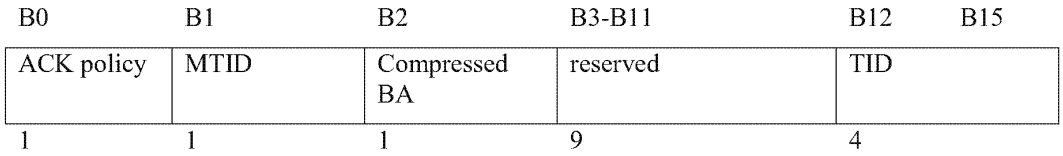


Figure 5 – BA Control field

Table 12 – Interpretation of the BA Bitmap

Compressed BA	BitMap size (byte)	Bitmap interpretation	Comments
0	128	Legacy 802.11e interpretation	N/A for HT devices
1	8	Each bit set acknowledges the successful reception of a single MSDU in order of sequence number	No fragmentation

A block ack agreement established between two HT peers using Delayed BA policy is referred to as an N-Delayed BA.

A block ack agreement established between two HT peers using Immediate BA policy is referred to as an N-Immediate BA.

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The ACK policy field in BAR and BA is only defined for N-Delayed BA. It is reserved under N-Immediate BA.

Table 13 – Ack Policy Field in BAR and BA for N-Delayed BA

Bits	Meaning
Bit 0	
0	Normal acknowledgement. The addressee returns an ACK. The Ack Policy field is set to this value in all directed Block Ack Request and Block Ack frames in which the sender requires immediate acknowledgement.
1	No Acknowledgement The addressee sends no immediate response upon receipt of the frame. The Ack Policy is set to this value in all Block Ack Req and Block Ack frames in which the sender does not require immediate explicit acknowledgement.

The MTID field selects between BA and MTBA formats. When set to 0, it indicates the frame is a BA. When set to 1, it indicates that the frame is a MTBA as defined in section 5.2.4.

5.2.2 Format of BAR MPDU

B0	B1	B2	B3-B11	B12 B15
ACK policy	MTID	Compressed BA	Reserved	TID
1	1	1	9	4

Figure 6 – BAR Control field

The Ack Policy and Compressed BA fields have the same meaning as defined in section 5.2.1

The MTID field selects between BAR and MTBAR formats. When set to 0, it indicates the frame is a BAR. When set to 1, it indicates that the frame is a MTBAR as defined in section 5.2.3.

5.2.3 Multiple TID Block Acknowledgement Request

MTBAR is a control frame of the BAR subtype. It is used only during PSMP sequences. The MTID field distinguishes this variant.

Bytes:	2	2	6	6	2	2	2	4
	Frame control	Duration/ID	RA	TA	BAR Control	Per TID Info	BA Starting Sequence	FCS
	MAC Header					Repeat for each TID		

Figure 7 – MTBAR Frame Format

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Bits	B0	B1	B2	B3-B12	B13-B15
	Ack Policy	MTID = 1	Compressed = 1	Reserved	TID_Range

Figure 8 – BAR Control field in MTBAR Frame

The number of TIDs present in the MTBAR is given by (TID_Range + 1), i.e. a value of 2 in the TID_Range field means that there are 3 TIDs values present.

The Per TID info subfield in Figure 6 is shown in detail in Figure 8

Bits	B0-B11	B12-B15
	Reserved	TID Value

Figure 9 – PER TID Info Field

5.2.4 Multiple TID Block Acknowledgement

MTBA is a control frame of the BA subtype. It is used only during PSMP sequences. The MTID field distinguishes this variant.

Bytes	2	2	6	6	2	2	2	8	8
	Frame Control	Duration / ID	RA	TA	BA Control	BA Control per TID	BA Starting Sequence Control	BA Bitmap	FCS
	MAC Header					Repeat for each TID			

Figure 10 – Multiple TID Block Acknowledgement (BA_MTID) frame format

	B0	B1	B2	B3-B12	B13-B15
	ACK policy	MTID	Compressed BA	Reserved	TID_Range
Value	0	1	1	0	0-7

Figure 11 – BA Control field

The number of TIDs present in the MTBA is given by (TID_Range + 1), i.e. a value of 2 in the TID_Range field means that there are 3 TID records present in the bitmap.

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Bits	B0-B11	B12-B15
	Reserved	TID Value

Figure 12 – BA control per TID

5.3 Management Frame formats

5.3.1 HT Capabilities

Element ID = (TBD)

The HT Capabilities field shall be present in any frame containing a supported rates element.

Support for any optional features or behavior will be declared through a STA's capabilities or management elements

Table 14 – HT Capabilities

Capability	Contents
HT Supported	Indicates that the device is an HT device, supporting all the mandatory features of this document. This capability is indicated by the presence of the HT capability element.
Supported MCS set	Defines the MCS values supported by a STA. An MCS set contains a bitmap of size 128 bits. Bit 0 maps to MCS 0. A bit is set to indicate support for that MCS. See PHY section for a list of MCSs.
Advanced Coding Capability	It has the same format as the field defined in PHY section, where a bit set as one indicates support.
Short GI for 20 MHz	Contains: 0 not supported 1 supported
Short GI for 40 MHz	Contains: 0 not supported 1 supported
STBC	Transmitter and receiver capabilities are defined separately
MIMO Power Save	Contains: 00 Don't send MIMO sequences (enter static MIMO power save mode) 01 need to precede MIMO sequences by RTS (enter dynamic MIMO power save mode) 10 NA 11 No limitation on MIMO sequence usage

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Capability	Contents
Supported Channel Width Set	Contains: 0 for a device only capable of 20MHz operation 1 for a device capable of both 20MHz and 40MHz operation.
Green Field capability	Contains: 0 device is not able to receive PPDUs with GF preamble 1 device is able to receive PPDUs with GF preamble
Maximum A-MPDU factor	Use to calculate the maximum A-MPDU size that can be received by the STA.
Maximum A-MSDU Length	Indicates the maximum A-MSDU size that can be received by the STA.
MPDU density	No more than one MPDU start shall be allowed within the time limit described in the MPDU maximum density field. 000- no restriction 001- 1/8 μsec, 010- 1/4 μsec , 011- 1/2 μsec , 100- 1 μsec , 101- 2 μsec , 110- 4 μsec, 111- 8 μsec. This limitation shall be measured at the PHY_SAP; the number of bytes between the start of two consecutive MPDUs in A-MPDU shall be equal or greater than MPDU-density*PHY-bit-rate/8
N-Delayed BA	Contains: 0 device does not support N-Delayed BA 1 device supports N-Delayed BA
DSSS/CCK at 40 MHz mode	Contains: In beacon and probe response 0 - BSS does not allow use of DSSS/CCK rates – No ERP IE shall be signaled in this mode. The AP shall not include DSSS/CCK rates in the Supported Rates IE. 1- BSS does allow use of DSSS/CCK rates In association request 0-device will not use DSSS/CCK rates 1-device will use DSSS/CCK rates
PSMP support	Contains: In beacon and probe response 0 BSS does not support use of PSMP 1 BSS does support use of PSMP In association request and re-association request 0 device will not use PSMP 1 device will use PSMP

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Capability	Contents
STBC Control Frame support	Contains: In beacon and probe response 0 BSS does not support STBC Control frames 1 BSS does support STBC Control frames In association request 0 device does not support STBC control frames 1 device does support STBC control frames
L-SIG TXOP Protection support	Contains: 0 not supported 1 supported
PCO	Resides in Extended HT Capability info Contains: 0 not supported 1 supported
Transition Time	Transition Time indicates that AP/STA can transit between 20 MHz channel width and 40 MHz channel width modes within the specified time with high probability (value TBD) The value contained in the operating transition time bits of AP is dynamic - the value of these bits may change at any time during the lifetime of the association of any STA
TxBF Capability	This field indicates support of implicit and explicit feedbacks transmit beamforming capabilities.
MCS Feedback on receiver	Resides in Extended HT Capability info
CSI feedback on receiver	Resides in Extended HT Capability info
AS Capability	This field indicates support of transmit or receive antenna selection capabilities

5.3.1.1 HT Capability element

The HT Capability element contains a number of subfields that are used to advertise optional HT capabilities at an HT device. The length of this element is not fixed to allow extension. The size of this element depends on the number of fields that are included. Additional fields may be described in later revisions of this specification, but the fields will always appear in the order shown, with new fields appearing at the end of the existing fields. STA which find a length which exceeds the sum total of the lengths of the fields of which they are aware shall ignore the fields beyond their knowledge. The HT Capability element is present in beacons, association and re-association request frames and in probe response frames. The presence of the HT Capability element indicates that the device is an HT device. The HT Capability element is defined in Figure 13.

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Octet	1	1	2	1	16	1	4	1
	Element ID	Length (25)	HT Capabilities Info	MAC HT Parameters Info	Supported MCS set	Extended HT Capability Info	TxBF capabilities	AS capabilities

Figure 13 – HT Capability element format

5.3.1.2 HT Capability Info field

The HT Capabilities Info field is 2 octets in length, and contains capability information bits

B0	B1	B2-B3	B4	B5	B6	B7	B8-B9
Advanced coding capability	Supported channel width set	MIMO Power Save	Green Field	Short GI for 20 MHz	Short GI for 40 MHz	Tx STBC	Rx STBC

B10	B11	B12	B13	B14	B15
Delayed BA	Maximal A-MSDU size	DSSS/CCK mode at 40 MHz mode	PSMP support	STBC Control Frame support	L-SIG TXOP Protection support

Figure 14 – HT Capabilities Info field

The advanced coding capability field indicates support for advanced coding if its value is 1.

The Short GI for 20 MHz field indicates support for 20 MHz packets if its value is 1.

The Short GI for 40 MHz field indicates support for 40 MHz packets if its value is 1.

The Tx STBC field indicates support STBC by transmitter if its value is 1

The Rx STBC field indicates support STBC by receiver.

B8-B9	Meaning
00	No Rx STBC support
01	Rx support of one spatial stream
10	Rx support of one and two spatial streams
11	Rx support of one, two and three spatial streams

Figure 15 – Rx STBC

The supported channel width set indicates {20} if its value is 0, and {20, 40} if its value is 1.

The dynamic MIMO Power Save mode indicates that STA or AP asks for assistance to switch to MIMO from being in steady state of single Rx chain. Such a STA or AP needs that any MIMO sequence shall be preceded by RTS/CTS. The static MIMO power save mode indicates that station or AP ask not to send MIMO sequences.

The GF field indicates ability to receive frames with Green Field preamble.

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Delayed BA – 0 not supported, 1 supported, should be agreed from both sides.

Maximal A-MSDU size – 0- 3839 bytes, 1- 7935 bytes

DSSS/CCK rates in 40 MHz capable BSS: If this field is 0 in the beacon and probe response then in this BSS only HT compatible Stations shall be associated, and 11g compatible devices shall not be associated. The beacon shall be sent under OFDM basic rate. If this field is 1 the 11g legacy devices may be associated. The HT station with this field 1 in association request shall be not associated with BSS that contains 0 in beacon or probe response.

The PSMP support field indicates support if set to 1.

The STBC Control Frame support field indicates that STBC control frames are supported if set to 1.

The L-SIG TXOP Protection support field indicates whether the HT QAP and the HT Station is capable of supporting the L-SIG field on specific frames which contain duration longer than the remaining packet duration.

5.3.1.3 MAC HT parameters Info field

B0-B1	B2-B4	B5-B7
Maximum Rx A-MPDU Factor	**MPDU density**	**Reserved**

Figure 16 – MAC HT Parameters Info field

The Maximum Rx A-MPDU length indicates the maximum length of A-MPDU that the STA can receive. The Maximum Rx A-MPDU defined by this field is equal to $2^{13+\text{Maximum Rx PSDUFactor}}$ bytes, where Maximum Rx A-MPDU Factor shall be between 0 and 3.

MPDU density: No more than one MPDU start shall be allowed within the time limit described in the MPDU maximum density field. 000- no restriction 001- 1/8 μsec, 010- 1/4 μsec , 011- 1/2 μsec , 100- 1 μsec , 101- 2 μsec , 110- 4 μsec, 111- 8 μsec. This limitation shall be measured at the PHY_SAP; the number of bytes between the start of two consecutive MPDUs in A-MPDU shall be equal or greater than MPDU-density*PHY-bit-rate/8

5.3.1.4 Supported MCS set

Octet	0 - 8	9	9	10-15
Bit	B0-B76		B77-B79	
	Indicates supported MCS if set		**Reserved**	

The maximum number of supported MCSs is 77

Note: the supported MCS set includes the mandatory MCSs.

5.3.1.5 Extended HT Capabilities Info field

Bit	B0	B1-B2	B3-B7	B8-B9	B10-B15
	PCO	**Transition Time**	**Reserved**	**MCS feedback**	**Reserved**

Figure 17 – Extended HT Capabilities Info field

The PCO bit in Extended HT Capabilities Info field indicates support for PCO if set to 1. PCO capable AP shall set this field to 1 to indicate that it can operate its BSS as PCO BSS. PCO capable STA shall set

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this field to 1 to indicate that it can operate as PCO STA when Transition Time field in the Extended HT Capabilities Info field meets the intended transition time of PCO AP

Transition Time indicates that AP/STA can transit between 20 MHz channel width and 40 MHz channel width within the specified time with high probability. However, AP/STA may stay on 40 MHz channel width to transmit 20 MHz frames in 20 MHz phase.

Note: The actual value to be allocated to bits in Transition Time field is TBD.

MCS feedback:

00 STA does not provide MCS Feedback

01 Reserved

10 STA provides only unsolicited MCS Feedback.

11 STA can provide MCS Feedback in response to MRQ as well as unsolicited MCS Feedback

5.3.1.6 Transmit Beamforming Capability

The TxBF Capability field is defined in Figure 18.

B0	B1	B2	B3	B4	B5	B6 –B7	B8	B9
TxBF capable	Receive staggered sounding capable	Transmit staggered sounding capable	Receive ZLF capable	Transmit ZLF capable	Implicit TxBF capable	Calibration	Explicit CSI TxBF capable	Explicit uncompressed steering matrix capable

B10-B12	B13-B15	B16-B18	B19-B20	B21-B22	B23-B24	B25-B31
Explicit BF CSI feedback	Explicit uncompressed Steering Matrix feedback	Explicit compressed Steering Matrix feedback	CSI number of beamformer antennae	Uncompressed steering matrix of beamformer antennae	Compressed steering matrix of beamformer antennae	Reserved

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Figure 18 – TxBF Capability Field

Tx Beamforming capable	0 incapable 1 capable	Indicates whether or not this station wants to receive steered frame
Receive staggered sounding capable	0 incapable 1 capable	Indicates whether or not this station can receive staggered sounding frames.
Transmit staggered sounding capable	0 incapable 1 capable	Indicates whether or not this station can transmit staggered sounding frames per TRQ.
Receive ZLF capable	0 incapable 1 capable	Indicates whether or not this receiver can interpret ZLF frames as sounding frames.
Transmit ZLF capable	0 incapable 1 capable	Indicates whether or not this station can transmit ZLF frames as sounding frames.
Implicit TxBF capable	0 incapable 1 capable	Indicates whether or not this station can apply Implicit transmit beamforming.
Calibration	00 incapable 01 limited capability of being involved in calibration, but cannot apply reciprocity correction vector received from initiator, and cannot initiate calibration 10 limited capability of being involved in calibration, cannot apply reciprocity correction vector received from initiator, but can initiate calibration 11 Fully capable	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 MIMO Channel Measurement Report in response to the receipt of a Sounding PPDU. Also indicates the capability of applying reciprocity correction vector received from initiator of calibration sequence When 'Implicit TxBF capable' bit sets to 1, this field shall be 11.
Explicit CSI TxBF capable	0 incapable 1 capable	Indicates whether or not this station can apply transmit beamforming using CSI explicit feedback in its transmission
Explicit uncompressed Steering Matrix capable	0 incapable 1 capable	Indicates whether or not this station can apply transmit beamforming using uncompressed steering matrix explicit feedback in its transmission
Explicit BF CSI feedback	000 incapable 001 unsolicited feedback capable 010 immediate feedback capable 100 aggregated feedback capable	Indicates whether or not this receiver can return CSI explicit feedback. Any combination of those 3 bits is allowed

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Explicit uncompressed Steering Matrix feedback	000 incapable 001 unsolicited feedback capable 010 immediate feedback capable 100 aggregated feedback capable	Indicates whether or not this receiver can return uncompressed Steering Matrix explicit feedback. Any combination of those 3 bits is allowed
Explicit compressed Steering Matrix feedback	000 incapable 001 unsolicited feedback capable 010 immediate feedback capable 100 aggregated feedback capable	Indicates whether or not this station can apply transmit beamforming using explicit compressed Steering Matrix feedback. The station shall be able both to compress and to use a compressed steering matrix on its transmission for TXBF. Any combination of those 3 bits is allowed
CSI number of beamformer antennae support	00 support single TX antenna sounding 01 support 2 TX antenna sounding 10 support 3 TX antenna sounding 11 support 4 TX antenna sounding	The maximum number of beamformer antennae the beamformee can support when CSI feedback is required
Uncompressed steering matrix number of beamformer antennae support	00 support single TX antenna sounding 01 support 2 TX antenna sounding 10 support 3 TX antenna sounding 11 support 4 TX antenna sounding	The maximum number of beamformer antennae the beamformee can support when uncompressed steering matrix feedback is required
Compressed steering matrix number of beamformer antennae support	00 support single TX antenna sounding 01 support 2 TX antenna sounding 10 support 3 TX antenna sounding 11 support 4 TX antenna sounding	The maximum number of beamformer antennae the beamformee can support when compressed steering matrix feedback is required

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5.3.1.7 Antenna Selection Capability

The AS Capability field is defined in Figure 19 – Antenna Selection Capability Field where setting a bit indicates the corresponding AS capability

B0	B1	B2	B3	B4	B5	B6	B7
Antenna Selection Capable	Explicit CSI feedback based TX AS capable	Antenna indices feedback based TX AS capable	Explicit CSI feedback capable	Antenna indices feedback capable	RX AS capable	Transmit sounding PPDUs capable	Reserved

Figure 19 – Antenna Selection Capability Field

Antenna Selection capable	0 incapable 1 capable	Indicates whether or not this station supports Antenna Selection
Explicit CSI feedback based TX AS capable	0 incapable 1 capable	Indicates whether or not this STA has TX AS capability based on explicit CSI feedback
Antenna indices feedback based TX AS capable	0 incapable 1 capable	Indicates whether or not this STA has TX AS capability based on antenna indices feedback
Explicit CSI feedback capable	0 incapable 1 capable	Indicates whether or not this STA can compute CSI and feedback to support the peer to do AS
Antenna indices feedback based TX AS capable	0 incapable 1 capable	Indicates whether or not this STA can conduct antenna indices selection computation and feedback the results to support the peer to do AS
RX AS capable	0 incapable 1 capable	Indicates whether or not this STA has RX AS capability
Transmit sounding PPDUs capable	0 incapable 1 capable	Indicates whether or not this STA can transmit sounding PPDUs for AS training per request

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5.3.2 Additional HT Information Elements

Element ID (TBD)

The AP will signal information in new information elements to manage the BSS.

This information is defined in the table below.

The length of this element is not fixed to allow extension. The size of this element depends on the number of fields that are included. Additional fields may be described in later revisions of this specification, but the fields will always appear in the order shown, with new fields appearing at the end of the existing fields. STA which find a length which exceeds the sum total of the lengths of the fields of which they are aware shall ignore the fields beyond their knowledge.

Table 15 – Additional HT Information Elements

Name	Description	Use
Control Channel	Channel number of the control 20MHz channel (1 byte)	In a mixed mode, all broadcast and non-aggregated control frames are sent so that they can be received by a legacy device operating on the control channel.
Extension Channel Offset	Values: 01= extension channel above the control channel 11= extension channel below the control channel 00= indicates no extension channel is present.	To locate the 40MHz channel in combination with the control channel
Recommended transmission channel Width	Values: 0 = use 20 MHz channel (control) 1= use any channel width enabled under Supported channel width set	Defines the channel widths that may be used by Station under related Supported Channel Width Set.

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Name	Description	Use
Operating Mode	00= Pure, no protection 01= there may be legacy devices in both the control and the extension channel, protection is optional in BSS 10 = No legacy stations are associated in the BSS, however, at least one 20MHz HT station is associated. Transmissions in 40MHz channel shall be protected in this 20/40 MHz capable BSS. 11 =Mixed: there are legacy devices associated with this BSS, protection shall be used in the BSS. Transmission in 40MHz channel as well as transmission of HT devices in 20Mhz channel shall be protected in 20/40 MHz capable BSS	Beacon is always sending in legacy mode
Basic MCS set	An MCS set contains a bitmap of size 128 bits. Bit 0 maps to MCS 0. A bit is set to indicate support for that MCS.	Present in Beacon/Probe Response frames to indicate what MCS values shall be supported by all devices in the BSS. Legacy basic rates shall be used if this field is zeroed.
STBC Basic MCS	Any single STBC MCS	Present in Beacon/Probe Response frames to indicate what MCS shall be used for STBC control frames and STBC Beacon
RIFS mode	0= Use of RIFS prohibited, 1=Use of RIFS permitted.	The AP shall set this parameter to 1 if there are no APSD legacy devices associated, otherwise this parameter shall be set to 0.
Controlled Access Only	0 = not only PSMP 1= PSMP only	Indicates whether an AP wants to associate PSMP enabled stations only
Service Interval Granularity	000 – 5ms 001 – 10ms 010 – 15ms 011 – 20ms 100 – 25ms 101 – 30ms 110 – 35ms 111 – 40 ms	Size in us of the shortest Service Interval. Size of the actual Service interval that Station is requesting shall be multiples of this value; used under scheduled PSMP only

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Name	Description	Use
Dual CTS Protection	0 = Regular use of RTS/CTS 1 = Dual CTS protection is used	Dual CTS protection is used by the AP to set a NAV at stations which do not support STBC and at stations which can associate solely through the secondary (STBC) beacon.
Secondary Beacon	0 = Primary Beacon 1 = Secondary Beacon	Indicates whether this beacon is a primary or a secondary beacon. The secondary beacon has half a beacon period shift relative to the primary beacon. In probe responses, this field shall not be interpreted and set to 0.
L-SIG TXOP Protection Full Support	0 = Not full support 1 = Full Support	This field should not be set to 1 if the L-SIG TXOP Protection bit is not set to 1 by all HT BSS members and the QAP.
PCO active	0 = PCO is not activated in the BSS 1 = PCO is activated in the BSS	Present in Beacon/Probe Response frames to indicate the information related to PCO BSS operation status. Non PCO STA regards the BSS as 40/20 MHz BSS and may associate with the BSS as in normal.
PCO phase request	This bit indicates which PCO phase to use. It is only applicable to Beacon frame. 0 = switch to 20 MHz phase / keep 20 MHz phase 1 = switch to 40 MHz phase / keep 40 MHz phase	This bit is only applicable to Beacon frame
Non-GF Devices Present	This field is used by the AP to indicate if any HT devices that are not GF capable have associated. 0 = All HT devices that are associated are GF capable 1 = one or more HT devices that are not GF capable have associated	Present in Beacon and Probe response frames to indicate when a non-AP STA should use GF Protection

Control Access Only field explanation. The QAP may support in BSS the PSMP access only. This approach may allow separation of multimedia and data oriented BSSs. If the QAP supports the PSMP access only it can assert the Controlled Access Only bit. The PSMP aware station may decide to associate or not with such BSS thus shorten the scanning time.

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Octets:	1	1	1	1				
Bit				B0 B1	B2	B3	B4	B5-B7
	Element ID	Length (>=22)	Control Channel	Extension Channel Offset	Recomm-ended transmis-sion Width Set	RIFS mode	Controlled access only	Service Interval Granularity

2			2							16
B0-B1	B2	B3-B15	B0-B6	B7	B8	B9	B10	B11	B12-B15	
Operating Mode	Non-GF Devices Present	Reserved	Basic STBC MCS	Dual STBC protect-tion	Second-ary beacon	L-SIG TXOP Protectio n Full Support	PCO active	PCO phase	Reserved	Basi MCS set

Figure 20 – Additional HT Information element format

5.4 Management Action Frames

5.4.1 Recommended Transmission Channel Width Management Action Frame

The format of the Recommended Transmission Channel Width management action frames is defined in Table 16 – Recommended Transmission Channel Width

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Table 16 – Recommended Transmission Channel Width

Order	Information	Name	Value
1	Category	HT	TBD
2	Action	Set Recommended transmission Channel Width	0
3	Channel Width	Channel Width	0 = use 20 MHz channel (control) 1= use any channel width enabled under Supported channel width set

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This frame can be sent by both non-AP STA and AP. If an AP wishes to receive 20 MHz packets, it will broadcast this management action frame to all stations. In addition, the AP indicates its current recommended transmission channel width in the Additional HT Information Elements in the beacon.

5.4.2 MIMO Power Save Management Action Frame

The format of the MIMO Power Save Management Action frame is defined in Table 17 – MIMO Power Save.

Table 17 – MIMO Power Save

Order	Information	Name	Value
1	Category	HT	TBD
2	Action	MIMO Power Save	1
3	Enable/Disable	Enable/Disable MIMO Power Save	1 = Enable 0 = Disable
4	Mode	MIMO Power Save Mode	0= static, don't send MIMO packets 1= dynamic, ok to send MIMO packets if preceded by RTS

The dynamic power save feature may be also activated at association by setting the MIMO Power Save field in the HT capability element, thus allowing a STA to remain in single Rx chain mode after association.

5.4.3 PCO Phase Request Management Action Frame

PCO Phase Request is a management action frame of category High Throughput to announce the phase change between 20 MHz and 40 MHz. Its body contains the following fields.

Table 18 – PCO Phase Request

Order	Information	Name	Value
1	Category	HT	TBD
2	Action	PCO Phase Request	3
3	PCO Phase	PCO Phase	0 = switch to 20 MHz phase / keep 20 MHz phase 1= switch to 40 MHz phase / keep 40 MHz phase

This frame may be only sent by PCO AP. When PCO AP requests PCO STAs to change PCO phase, PCO AP shall either broadcast this frame or set phase switch bit of PCO field of additional HT field in beacon. When this signals a switch from 20 MHz phase to 40 MHz phase, the duration of this frame shall be set

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so that it covers the total of a transition time from 20 MHz channel width to 40 MHz channel width, an intended duration of 40 MHz phase and a transition time from 40 MHz channel width to 20 MHz channel width. When this signals a switch from 40 MHz phase to 20 MHz phase, the duration of this frame shall be set so that it covers the requirement transition time of the BSS. PCO AP may broadcast this frame to advertise the current PCO phase.

5.4.4 MIMO Channel Measurement frame

This management action frame is of category High Throughput. It contains the following fields.

Table 19 – MIMO Channel Measurement

Order	Information	Name	Size	Value
1	Category	HT	1	TBD
2	Action	MIMO Channel Measurement Report	1	4
3	Transmit Beamforming Control	Transmit Beamforming Control	2	See text.
4	MCMR Segment Sequence	MCMR Segment Sequence	1	See text
5	Explicit Feedback Sequence	Explicit Feedback Sequence	1	Unused
6	MIMO Channel Measurement Report	MIMO Channel Measurement Report	$3 \times Ns \times Ni \times Nr$	See text

Here:

Ns = Number of subcarriers in the Sounding HT-LTF

Nr = Number of antennas at the STA transmitting the MIMO Channel Measurement

Ni = Number of antennas at the STA to which the frame is directed

Table 20 – Transmit beamforming control field

B0-B1	B2-B3	B4-B5	B6	B7	B8-B11	B12-B15
Nr	Ni	Calibration Sequence	Calibration Complete	Explicit Channel Feedback	Explicit Feedback Format	Reserved

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The Transmit Beamforming Control field (2 octets) consists of:

Nr (2 bits): Number of antennas at the STA transmitting the MIMO Channel Measurement Report

Ni (2 bits): Number of antennas at the STA to which the frame is directed

Calibration Sequence (2 bits). The value of this field is unchanged for the frame exchanges during one calibration procedure.

Calibration Complete (1 bit). The Calibration Complete bit is set to '1' if the STA transmitting the MIMO Channel Measurement frame(s) declares the calibration procedure complete without requiring the other STA to transmit a Reciprocity Correction Vector frame.

Explicit Channel Feedback (1 bit). Set to 0.

Explicit Feedback Format (4 bits). Unused.

Reserved (4 bits).

The MCMR Segment Sequence (1 octet) contains the segment sequence number when the MIMO Channel Measurement Report has been segmented. The MCMR Segment Sequence of the first segment is 0. The complete MIMO Channel Measurement Report contains $Ns \times Ni \times Nr$ complex coefficients.

Table 21 – Complex Coefficient Representation

B0-B11	B12-B23
Real part represented as twos complement	Imaginary part represented as twos complement

Each complex coefficient (3 octets) is represented by its 12-bit twos complement real and 12-bit twos complement imaginary parts (see Table 21 – Complex Coefficient Representation). Hence the total length of the complete MIMO Channel Measurement Report is $3 \times Ns \times Ni \times Nr$ octets. The order of channel coefficients is as follows:

40 MHz:

For each subcarrier in the following order: (-58, …-2, 2, …, +58), include

{

For each of *Ni* antennas at the initiating STA in order: (1, …, *Ni*)

{

Include *Nr* complex coefficients one for each antenna at the receiving STA in order: (1, …, *Nr*)

}

}

20 MHz:

For each subcarrier in the following order: (-28, …-1, 1, …, +28), include

{

For each of *Ni* antennas at the initiating STA in order: (1, …, *Ni*)

{

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Include *Nr* complex coefficients one for each antenna at the receiving STA in order: (1, …, *Nr*)

}

}

The complete MIMO Channel Measurement Report may need to be transmitted using more than one MAC frame. In the mandatory configuration with *Ns* = 114, *Ni* = 2, *Nr* = 2, there will be 1368 octets (456 coefficients) in a single MIMO Channel Measurement Report element. The maximum length of the MIMO Channel Measurement Report field is 5472 octets (1824 coefficients) for the case with *Ns* = 114, *Ni* = 4, and *Nr* = 4. If the MIMO Channel Measurement Report is longer than 1368 octets, the first 1368 octets are included in the first frame (MCMR Segment Sequence = 0) and the remaining octets are included in subsequent frames (MCMR Segment Sequence = 1, 2, etc.).

5.4.5 Reciprocity Correction frame

This management action frame is of category High Throughput. It contains the following fields.

Table 22 – Reciprocity Correction

Order	Information	Name	Size	Value
1	Category	HT	1	TBD
2	Action	Reciprocity Correction	1	5
3	Transmit Beamforming Control	Transmit Beamforming Control	2	See text.
4	MCMR Segment Sequence	MCMR Segment Sequence	1	See text
5	Explicit Feedback Sequence	Explicit Feedback Sequence	1	Unused
6	Reciprocity Correction Vector	Reciprocity Correction Vector	3 × *Ns* × *Nr*	See text

Here:

Ns = Number of subcarriers in the Calibration Training symbols

Nr = Number of antennas at the STA to which this frame is directed

The Transmit Beamforming Control field (2 octets) consists of the following fields:

Nr (2 bits): Number of antennas at the STA transmitting the MIMO Channel Measurement Report

Ni (2 bits): Number of antennas at the STA to which the frame is directed

Calibration Sequence (2 bits):

Calibration Complete (1 bit). The Calibration Complete bit is set to '1'.

Reserved (1 bit)

Explicit Feedback Format (4 bits).

Reserved (4 bits).

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The values of the three fields *Nr*, *Ni*, and Calibration Sequence are set to the same values as in the received MIMO Channel Measurement Report.

The Reciprocity Correction Vector contains *Ns* × *Nr* complex coefficients. Each complex coefficient (3 octets) is represented by its 12-bit twos complement real and 12-bit twos complement imaginary parts (see Table 21 – Complex Coefficient Representation). The order of correction vector coefficients is as follows:

40 MHz:

For each subcarrier in the following order: (-58, …-2, 2, …, +58), include

{

Include *Nr* complex coefficients one for each antenna at the receiving STA in order: (1, …, *Nr*)

}

20 MHz:

For each subcarrier in the following order: (-28, …-1, 1, …, +28), include

{

Include *Nr* complex coefficients one for each antenna at the receiving STA in order: (1, …, *Nr*)

}

The maximum length of the Correction Vector field corresponds to *Ns* = 114, *Nr* = 4 is 1368 octets.

5.4.6 MIMO CSI Matrices frame

This frame is of category High Throughput. It contains the following fields.

Table 23 – MIMO CSI Matrices

Order	Information	Name	Size	Value
1	Category	HT	1	TBD
2	Action	MIMO CSI Matrices Message	1	6
3	CSI Matrices Control	CSI Matrices Control	2	See text.
4	MCMR Segment Sequence	MCMR Segment Sequence	1	Unused
5	Explicit Feedback Sequence	Explicit Feedback Sequence	1	See text
6	CSI Matrices Report	CSI Matrices Report	see text	See text

Table 24 – CSI - Matrices control field

B0-B1	B2-B3	B4-B5	B6	B7	B8-B11	B12-B15

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Nc	Nr	reserved	reserved	Explicit Channel Feedback	Explicit Feedback Format	Reserved

The CSI Matrices Control field (2 octets) consists of:

Nc (2 bits): Number of columns in each CSI matrix (Number of transmit antennas in the STA transmitting into the channel).

Nr (2 bits): Number of rows in each CSI matrix.

Calibration Sequence (2 bits): Reserved.

Calibration Complete (1 bit): Reserved.

Explicit Feedback Format (4 bits). See Table 25 – Explicit Feedback Format Field for CSI Matrix FeedbackReserved (4 bits).

Table 25 – Explicit Feedback Format Field for CSI Matrix Feedback

Field	Length	Values	Meaning
Grouping	2 bits	00	*Ng*=1 (No Grouping)
		01	Ng=2
		10	Ng=4
		11	reserved
Coefficients Size (*Nb*)	2 bits	00	4 bits
		01	5 bits
		10	6 bits
		11	8 bits

Each CSI Matrices feedback has a unique sequence number encoded in the explicit feedback sequence field. This is incremented between measurements.

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A CSI matrix H for a single carrier has the following structure:

Table 26 – Matrix coding

Field	Size
Carrier Matrix Amplitude	3 bits
Real Part of element $H_{1,1}$	Nb bits
Imaginary Part of element $H_{1,1}$	Nb bits
Real Part of element $H_{1,2}$	Nb bits
Imaginary Part of element $H_{1,2}$	Nb bits
…	
Real Part of element $H_{1,Nc}$	Nb bits
Imaginary Part of element $H_{1,Nc}$	Nb bits
…	
Real Part of element $H_{Nr,1}$	Nb bits
Imaginary Part of element $H_{Nr,1}$	Nb bits
Real Part of element $H_{Nr,2}$	Nb bits
Imaginary Part of element $H_{Nr,2}$	Nb bits
…	
Real Part of element $H_{Nr,Nc}$	Nb bits
Imaginary Part of element $H_{Nr,Nc}$	Nb bits

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The CSI matrices report for 20MHz has the following structure:

Table 27 – CSI matrices report for 20MHz

Field	Size	Meaning
SNR in Rx channel 1	8 bits	Signal to Noise Ratio in the first Rx chain of the STA sending the report.
…		
SNR in Rx channel *Nr*	8bits	Signal to Noise Ratio in the *Nr*'th Rx chain of the STA sending the report.
CSI Matrix for Carrier -26	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
CSI Matrix for Carrier -26+*Ng*	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
…		
CSI Matrix for carrier -1	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
CSI Matrix for carrier 1	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
CSI Matrix for carrier 1+*Ng*	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
…		
CSI Matrix for carrier 26	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix

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The CSI matrices report for 40MHz has the following structure:

Table 28 – CSI matrices report for 40MHz

Field	Size	Meaning
SNR in Rx channel 1	8 bits	Signal to Noise Ratio in the first Rx chain of the STA sending the report.
…		
SNR in Rx channel *Nr*	8bits	Signal to Noise Ratio in the *Nr*'th Rx chain of the STA sending the report.
CSI Matrix for Carrier -58	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
CSI Matrix for Carrier -58+*Ng*	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
…		
CSI Matrix for carrier -2	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
CSI Matrix for carrier 2	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
CSI Matrix for carrier 2+*Ng*	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix
…		
CSI Matrix for carrier 58	3+2× *Nb*×*Nc*×*Nr* bits	CSI Matrix

The size of the CSI Matrix report is *Nr*×8+*Ns*×(3+2×*Nb*×*Nc*×*Nr)* bits. The number of subcarriers sent *Ns* is a function of *Ng* and whether matrices for 40MHz or 20MHz are sent. The values of *Ns* for all the options are in the next table:

Table 29 – Number of matrices

Ng	*Ns* 20MHz	*Ns* 40Mhz
1	56	114
2	30	58
4	16	30

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5.4.7 MIMO Uncompressed Steering Matrices frame

This frame is of category High Throughput. It contains the following fields.

Table 30 – MIMO Uncompressed Steering Matrices

Order	Information	Name	Size	Value
1	Category	HT	1	TBD
2	Action	MIMO Uncompressed Steering Matrices Message	1	7
3	CSI Matrices Control	CSI Matrices Control	2	See text.
4	MCMR Segment Sequence	MCMR Segment Sequence	1	Unused
5	Explicit Feedback Sequence	Explicit Feedback Sequence	1	See text
6	Steering Matrices Report	Steering Matrices Report	see text	See text

The CSI Matrices Control field (2 octets, see Table 24 – CSI - Matrices control field) consists of:

Nc (2 bits): Number of columns in each steering matrix

Nr (2 bits): Number of rows in each steering matrix.

Calibration Sequence (2 bits): Reserved.

Calibration Complete (1 bit): Reserved.

Explicit Feedback Format (4 bits). See Table 31 – Explicit Feedback Format Field for Uncompressed Steering Matrix Feedback.

Reserved (4 bits).

Table 31 – Explicit Feedback Format Field for Uncompressed Steering Matrix Feedback

Field	Length	Values	Meaning
Grouping	2 bits	00	*Ng*=1 (No Grouping)
		01	Ng=2
		10	Ng=4
		11	reserved
Coefficients Size (*Nb*)	2 bits	00	4 bits
		01	5 bits
		10	6 bits
		11	8 bits

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Each Steering Matrices feedback has a unique sequence number encoded in the explicit feedback sequence field. This is incremented between measurements.

A steering matrix V for a single carrier has the following structure:

Table 32 – Matrix coding

Field	Meaning
Real Part of element $V_{1,1}$	*Nb* bits
Imaginary Part of element $V_{1,1}$	*Nb* bits
Real Part of element $V_{1,2}$	*Nb* bits
Imaginary Part of element $V_{1,2}$	*Nb* bits
…	
Real Part of element $V_{1,Nc}$	*Nb* bits
Imaginary Part of element $V_{1,Nc}$	*Nb* bits
…	
Real Part of element $V_{Nr,1}$	*Nb* bits
Imaginary Part of element $V_{1,Nc}$	*Nb* bits
Real Part of element $V_{Nr,2}$	*Nb* bits
Imaginary Part of element $V_{Nr,2}$	*Nb* bits
…	
Real Part of element $V_{Nr,Nc}$	*Nb* bits
Imaginary Part of element $V_{Nr,Nc}$	*Nb* bits

The uncompressed steering matrices report for 20MHz has the following structure:

Table 33 – Uncompressed steering matrices report for 20MHz

Field	Size	Meaning
SNR	8 bits	Average Signal to Noise Ratio in the STA sending the report.
Steering Matrix for Carrier -26	$2\times Nb\times Nc\times Nr$ bits	Steering Matrix
Steering Matrix for Carrier -26+*Ng*	$2\times Nb\times Nc\times Nr$ bits	Steering Matrix
…		
Steering Matrix for carrier -1	$2\times Nb\times Nc\times Nr$ bits	Steering Matrix
Steering Matrix for carrier 1	$2\times Nb\times Nc\times Nr$ bits	Steering Matrix
Steering Matrix for carrier 1+*Ng*	$2\times Nb\times Nc\times Nr$ bits	Steering Matrix
…		
Steering Matrix for carrier 26	$2\times Nb\times Nc\times Nr$ bits	Steering Matrix

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The uncompressed steering matrices report for 40MHz has the following structure:

Table 34 – Uncompressed Steering matrices report for 40MHz

Field	Size	Meaning
SNR	8 bits	Average Signal to Noise Ratio in the STA sending the report.
Steering Matrix for Carrier -58	2× *Nb*×*Nc*×*Nr* bits	Steering Matrix
Steering Matrix for Carrier -58+*Ng*	2× *Nb*×*Nc*×*Nr* bits	Steering Matrix
…		
Steering Matrix for carrier -2	2× *Nb*×*Nc*×*Nr* bits	Steering Matrix
Steering Matrix for carrier 2	2× *Nb*×*Nc*×*Nr* bits	Steering Matrix
Steering Matrix for carrier 2+*Ng*	2× *Nb*×*Nc*×*Nr* bits	Steering Matrix
…		
Steering Matrix for carrier 58	+2× *Nb*×*Nc*×*Nr* bits	Steering Matrix

For example in a 20MHz channel and *Ng=4* steering matrices are sent on carrier -26, -22, -18, -14, -10, -6, -2, -1, 1, 5, 9, 13, 17, 21, 25, 26.

The size of the Steering Matrix report is 8+*Ns*×(2×*Nb*×*Nc*×*Nr)* bits. The number of subcarriers sent *Ns* is a function of *Ng* and whether matrices for 40MHz or 20MHz are sent. The values of *Ns* for all the options is in the next table:

Table 35 – Number of matrices

Ng	*Ns* 20MHz	*Ns* 40Mhz
1	56	114
2	30	58
4	16	30

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5.4.8 Compressed Steering Matrices Feedback frame

This frame is of category High Throughput. It contains the following fields.

Table 36 – CSI Feedback

Order	Information	Name	Size	Value
1	Category	HT	1	TBD
2	Action	Compressed Steering Matrices Feedback	1	8
3	CSI Matrices Control	CSI Matrices Control	2	See text.
4	MCMR Segment Sequence	MCMR Segment Sequence	1	Unused
5	Explicit Feedback Sequence	Explicit Feedback Sequence	1	See text
6	Quantized Steering Matrices Feedback Information	Quantized Steering Matrices Feedback Information	Variable	See text

The size of the Quantized Steering Matrices Feedback Information field depends on the values in the format field in the CSI Matrices control field.

The Transmit Beamforming Control field (2 octets) consists of the following fields:

Nc (2 bits): Number of columns in the steering matrix V.

Nr (2 bits): Number of rows in the steering matrix V.

Calibration Sequence (2 bits): Unused

Calibration Complete (1 bit). Unused

Reserved (1 bit)

Explicit Feedback Format (4 bits). See Table 37 – Explicit Feedback Format Field for compresed Steering Matrix feedback

.

Reserved (4 bits).

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Table 37 – Explicit Feedback Format Field for compresed Steering Matrix feedback

Field	Length	Values	Meaning
Grouping	2 bits	00	*Ng*=1 (No Grouping)
		01	Ng=2
		10	Ng=4
		11	reserved
Codebook information	2 bits	00	1 bit for ψ, 3 bits for ϕ
		01	2 bits for ψ, 4 bits for ϕ
		10	3 bits for ψ, 5 bits for ϕ
		11	4 bits for ψ, 6 bits for ϕ

Each compressed steering matrix feedback has a unique sequence number encoded in the explicit feedback sequence field. This is incremented between measurements.

Quantized CSI Feedback Information field is defined as:

> Data: Channel matrix elements indexed in order by data subcarrier index and angle. This simplifies the interpolation angles between subcarriers, if grouping other than 1 is employed. The explanation on how these angles are generated from the steering matrix V is given in section *Compressed Steering Matrix Feedback* in the PHY spec.

The angles are sent in order according to this table:

V(f)	# of params	The order of angles to be fedback
2x1	2	ϕ11, ψ21
2x2	2	ϕ11, ψ21
3x1	4	ϕ11, ϕ21, ψ21, ψ31,
3x2	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
3x3	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
4x1	6	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41
4x2	10	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42
4x3	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43
4x4	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43

The angles are quantized according to the following formulae:

$$\psi = \frac{k\pi}{2^{b_\psi+1}} + \frac{\pi}{2^{b_\psi+2}} \text{ where } k = 0,1,\ldots,2^{b_\psi} - 1$$

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$$\phi = \frac{k\pi}{2^{b_\phi - 1}} + \frac{\pi}{2^{b_\phi}} \text{ where } k = 0,1,...,2^{b_\phi} - 1$$

and b_ϕ is the number of bits used to quantize ϕ and b_ψ is the number of bits used to quantize ψ.

(See Table 37 – Explicit Feedback Format Field for compresed Steering Matrix feedback

All angles are transmitted LSB to MSB.

Example: 2x2, 20MHz, no grouping, bits for each ψ = 3, bits for each ϕ=5. Each ψ_{ij} over all tone indices has 168 bits. Each ϕ_{ij} over all tone indices has 280 bits.

bits	b1..b5	b6..b10	…	b276..b280	b281..b283	b284..b286	…	b446..b448
data	$\phi_{11}(f_{-28})$	$\phi_{11}(f_{-27})$	…	$\phi_{11}(f_{28})$	$\psi_{21}(f_{-28})$	$\psi_{21}(f_{-27})$	…	$\psi_{21}(f_{28})$

Example: 4x2, 40MHz, 4 tone grouping, ψ=2, ϕ = 4. Each ϕ_{ij} over all tone indices has 56 bits. Each ψ_{ij} over all tone indices has 112 bits.

bits	b1..b4	…	b113..b116	…	b337..b338	…	b505..b508	…	b839..b840
data	$\phi_{11}(f_{-56})$	…	$\phi_{21}(f_{-56})$	…	$\psi_{21}(f_{-56})$	…	$\phi_{32}(f_{-56})$	…	$\psi_{42}(f_{-56})$

5.4.9 Antenna Selection Indices Feedback Frame

This frame is of category High Throughput. It contains the following fields.

Table 38 – Antenna Selection Indices Feedback

Order	Information	Name	Size	Value
1	Category	HT	1	TBD
2	Action	Antenna Selection Indices Feedback	1	9
3	Antenna Selection Indices	Antenna Selection Indices	1	See text.

Bit 0 through bit 7 in the Antenna Selection Indices field are corresponding to antennas with indices 0 through 7 respectively. The value of "1" in a bit represents the corresponding antenna is selected, and the value of "0" indicates the corresponding antenna is not selected.

5.4.10 ADDBA

Fragmentation is not supported under compressed BA. The ADDBA Buffer Size subfield contains the number of buffers at the receiver. In an ADDBA request frame, the Buffer Size subfield is advisory and the Recipient sets up this number sending the ADDBA response.

Note: each buffer is capable of holding a maximum size A-MSDU supported by the device.

5.4.11 PSMP

Power Save Multiple Poll is of type/subtype Management Action Frame. Address type – broadcast

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The PSMP parameter set is used to describe the DLT and ULT which immediately follows the PSMP frame.

The frame body of this frame is defined in Figure 21 The PSMP parameter set field is followed by zero or more STA Info fields..

Order	Information	Name	Value
1	Category	HT	TBD
2	Action	PSMP	2
3	PSMP Parameter Set		
4 .. end	STA Info Repeated N_STA times		

Figure 21 – Format of the PSMP Management Action Field

	N_STA	More PSMP	PSMP Sequence Duration
Bits:	5	1	10

Figure 22 – PSMP Parameter Set format

The N_STA field indicates the number of STA Info fields present.

The More PSMP field when set to 1 indicates whether this PSMP sequence will be followed immediately by another PSMP sequence. When set to 0 it indicates that the current PSMP sequence is the last in current the service period.

The PSMP Sequence Duration field indicates the duration of the current PSMP exchange which is described by the PSMP frame, in units of 8us, relative to the end of the PSMP frame. Therefore, this field can describe a PSMP exchange of up to 8 ms in duration. Any Sub-PSMP starts a SIFS interval after the indicated duration.

	TSIDs set	STA ID	DLT Start Offset	DLT Duration	ULT Start Offset	ULT Duration
Bits:	8	16	11	8	11	10

Figure 23 – STA Info Field Format

The STA ID field indicates the AID value for BSS mode of operation and 16 LBs of MAC address in IBSS mode of operation.

Broadcast and Multicast data can be transmitted using PSMP by setting STA_ID to a specific value 0.

The DLT Start Offset field indicates the start of the PPDU which has the DL data of the STA. The offset is specified relative to the end of the PSMP frame. It is given as an integer number of 4us. If no DLT is scheduled for a STA, but a ULT is scheduled for that STA, then the DLT Duration is set to null (0).

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The DLT Duration field indicates the end of DL data of a STA relative from the start of the PSDU that has the first MPDU destined to the STA. It contains a duration in units of 16us. If no ULT is scheduled for a STA, but a DLT is scheduled for that STA, then the ULT Duration is set to null (0).

Note: The Station does not expect transmissions directed to this Station PPDU which start after the DLT Duration expiration. The Station completes receiving any PPDU directed to this Stationwhich starts before the end of the DLT. If no frames directed toward a STA begin within DLT Duration from the DLT start offset time for that STA, then the STA assumes that no MPDU directed toward it is forthcoming during this DLT.

The ULT Start Offset field indicates the start of the ULT. The first ULT is scheduled to begin after a SIFS interval from the end of the last DLT described in the PSMP. The offset is specified relative to the end of the PSMP frame. It is specified in units of 4us. If no ULT is scheduled for a STA, but a DLT is scheduled for that STA, then the ULT Start Offset is set to null (0).

The ULT Duration field indicates the maximum length of a ULT for a STA. ULT duration is specified in units of 4 us. If no ULT is scheduled for a STA, but a DLT is scheduled for that STA, then the ULT duration is set to null (0). All transmissions by the STA within the current PSMP lie within the indicated ULT.

The TSIDs set field presents the AP recommendation to the STA containing the TSIDs for which data can be transmitted in the ULT resources. Each bit in this field represents a TSID, where the bit position is equal to TSID - 8. For example bit2 represents TSID=10. If one more bits are set, the AP is recommending that the STA use the ULT for the indicated TSIDs.

All frames sent within a PSMP exchange have the Duration/ID field set to the remaining duration of the TxOP. Note: this includes control frames.

5.4.12 ADDTS request and response

5.4.12.1 TSPEC

A new value is defined for the Access policy subfield of the TS Info field to indicate PSMP Access policy.

The reserved code of the Access Policy field in TS Info is used to encode PSMP access.

Bit7	Bit 8	Usage
0	0	PSMP

Figure 24 – PSMP Access Policy

Under PSMP Access policy, the Ack policy of the TS Info field shall be set to Block Acknowledgment, which indicates use of MTBA during PSMP.

5.4.13 QoS Null Embedding of Management Action

A QoS Null + HTC frame with the MA field of the HTC set to 1 carries a Management Action frame payload. In this case, the Ack Policy field of the QoS Control field shall be either Normal Ack or No Ack.

The TSID field is undefined in this case.

The payload shall not be fragmented.

The sequence number is undefined.

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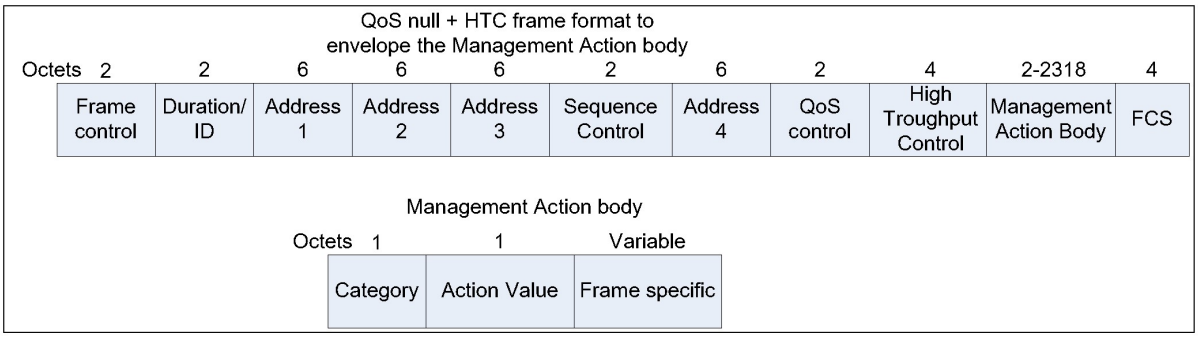


Figure 25 – QoS Null envelope for Management Action body

Note: this mechanism may be used to embed channel state feedback in an aggregate as part of an aggregate exchange sequence. Section 6.20.2 explains in details using of this format for Explicit feedback.

5.4.14 Ack policy in QoS control field of QoS data frames

There is definition of the Ack policy field of .11e (7.1.3.5) that covers the MTBA/PSMP case

Bits in QoS Control field		Meaning
Bit 5	Bit 6	
0	1	Scheduled acknowledgement under MTBA/PSMP agreement

Figure 26 – Ack policy field under PSMP agreement

This value of the Ack policy field indicates that the acknowledgement for DLT data is expected in the current ULT, and acknowledgement for the ULT data is expected in the next DLT. Acknowledgement takes the form of an MTBA transmission.

5.4.15 Use of QoS Control Field to carry resource request

A STA may indicate the state of its transmit queues (either the number of bytes, or a requested TXOP duration) using the QoS control field. If it receives an ULT that is not long enough to transmit data from its queues, it may transmit a QoS Null containing information about the state of its transmit queues.

The AP may use this information to schedule ULT in a Sub-PSMP.

5.5 A-MPDU and A-MSDU aggregation formats

5.5.1 Usage Constraints

A STA shall not transmit an A-MSDU to a peer that exceeds its peer's Maximal A-MSDU size capability.

The MSDU shall not exceed 2304 byes in length at the MAC Data SAP.

The A-MPDU maximum length is 65535 bytes.

The Duration fields in the MAC Headers of MPDUs in an aggregate shall all carry the same value.

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5.5.2 Aggregated MPDU format (A-MPDU)

An A-MPDU consists of a number of MPDU delimiters each followed by an MPDU.

Except when it is the last MPDU, padding octets are appended to make each section a multiple of 4 octets in length.

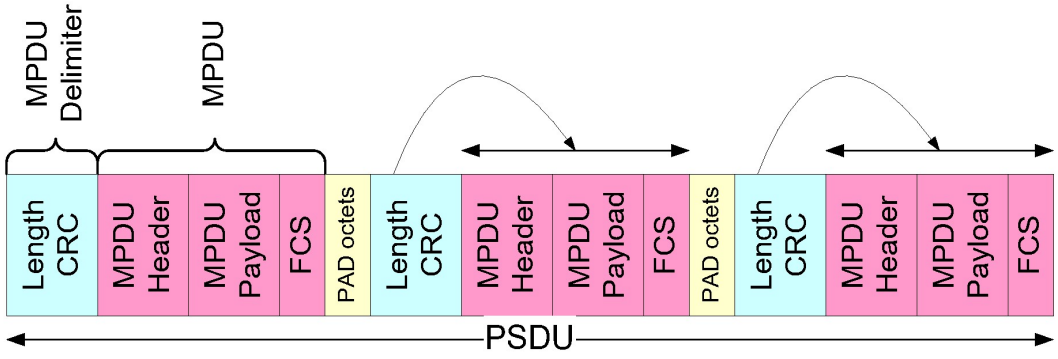


Figure 27 – A-MPDU format

The MPDU delimiter is 4 octets in length and contains the fields defined below:

Table 38 – MPDU delimiter Fields

MPDU delimiter Field	Delimiter bits position	Size (bits)	Description
Reserved	3:0	4	0
MPDU length	15:4	12	Length of the MPDU in octets
CRC	23:16	8	8-bit CRC of the preceding 16-bits.
Unique pattern	31:24	8	Unique pattern that may be used to detect an MPDU delimiter when scanning for a delimiter. The unique pattern is set to the ASCII value for character 'N'.

The purpose of the MPDU delimiter is to robustly delimit the MPDUs within the aggregate. Robust in this case means that the structure of the aggregate can usually be recovered when one or more MPDU delimiters are received with errors. Individual delimiters have the same BER as the surrounding MPDUs, and so can be lost. The Duration fields in the MAC Headers of all MPDUs in an aggregate carry the same value.

Note, a delimiter with MPDU length zero is valid. This can be used to introduce padding between MPDUs to satisfy the MPDU density limit requirement or at the end of the A-MPDU.

5.5.2.1 CRC

The 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 shall be the one's complement of the remainder generated by the modulo 2 division of the protected bits by the polynomial

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$$x^8 + x^2 + x^1 + 1$$

where the shift-register state shall be preset to all-ones. This field shall be sent MSB first.

5.5.2.2 De-aggregation (Informative)

The receiver checks the MPDU delimiter for validity based on the CRC. It may also check that the length indicated is within the PSDU HT-LENGTH indicated in RXVECTOR.

If the MPDU delimiter is valid, the MPDU is extracted from the aggregate. 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 if 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 RXVECTOR PSDU HT length field. [1]

This algorithm is expressed in the following pseudo-code (note, this is not optimized for efficiency):

```
Parse A-MPDU(length)
{
      Int offset = 0;   /* Byte offset from start of PPDU */
      While (offset+4 < length)
      {
            If valid_MPDU_delimiter(offset) &&
                  get_MPDU_length(offset) <= negotiated_MPDU_limit &&
                  get_MPDU_length(offset) <= (length - (offset+4))
            {
                  /* Valid delimiter */
                  Receive_MPDU(offset+4, get_MPDU_length(offset));
                  /* advance multiple of 4 bytes */
                  offset += 4 + 4*((get_MPDU_length(offset)+3)/4);
            }
            Else
            {
                  /* delimiter invalid, advance 4 bytes and try again */
                  offset += 4;
            }
      }
}
```

Note: the unique pattern can be used to reduce computation required while scanning for a valid delimiter. In this case the receiver tests each possible delimiter for a matching unique pattern. Only when a match is discovered does it then check the CRC.

[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 based on a bad MAC CRC check. The overall effect may be to lose one or more MPDUs from the aggregate very infrequently.

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5.5.3 A-MPDU Contents

An A-MPDU aggregate is a sequence of MPDUs carried in a single PPDU carrying the aggregate attribute. All its MPDUs shall be addressed to the same receiver address.

The aggregate may only contain MPDUs as described below.

Table 39 – Single Receiver Aggregation MPDUs using N-Immediate BA

MPDU	Description	Comments
BA	Block ACK MPDUs	BA may be non-aggregate frame (see BA explanation)
QoS Data	Data MPDUs sent under Block-ACK policy.	One TID per aggregation
QoS null	Can be sent out of any BA agreement	This may be used to carry a Management Action frame under MA embedding. This supports explicit feedback and channel calibration

Table 40 – Single Receiver Aggregation MPDUs using N-Delayed BA

MPDU	Description	Comments
BA	Block ACK MPDUs with no ACK policy	
QoS Data	Data MPDUs sent under Block-ACK policy.	
QoS null	Can be sent out of any BA agreement	This may be used to carry a Management Action frame under MA embedding. This supports explicit feedback and channel calibration
BAR	Block ACK Requests with no ACK policy. No implicit BAR allowed	

Table 41 – Single Receiver Aggregation MPDUs using MTBA/PSMP

MPDU	Description	Comments
MTBA	Contains acknowledgement for data received under MTBA ack policy in the previous ULT/DLT	At most one
QoS Data	Data MPDUs sent under MTBA/PSMP Ack policy.	Multiple TIDs allowed
MTBAR	Contains block ack request for data transmitted during PSMP exchange	At most one with "No-ack" policy
QoS null	Can be sent out of any BA agreement	This may be used to carry a Management Action frame under MA embedding. This supports explicit feedback and channel calibration

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5.5.4 Aggregated MSDU Format (A-MSDU)

This section describes the format of Aggregated MSDU (A-MSDU). The purpose of the A-MSDU is to allow multiple MSDUs being sent to the same receiver to be aggregated and sent in a single MPDU, which improves the efficiency of the MAC layer, particularly when there are many small MSDUs such as TCP acknowledgement. Support for A-MSDU is mandatory at the receiver. However, the transmitter is free to use A-MSDU or not based on information such as traffic characteristics and link conditions.

The structure of a Data MPDU containing an A-MSDU, which is a sequence of *n* MSDU sub-frames. Each sub-frame consists of a sub-frame header followed by an MSDU and 0-3 bytes of padding. Each sub-frame (except the last) is padded so that its length is a multiple of 4 bytes. The last sub-frame has no padding.

The sub-frame header contains three fields: Destination Address (DA), Source Address (SA), and Length. [2] The DA and SA fields are interpreted as described below. The length field contains the length in bytes of the MSDU.

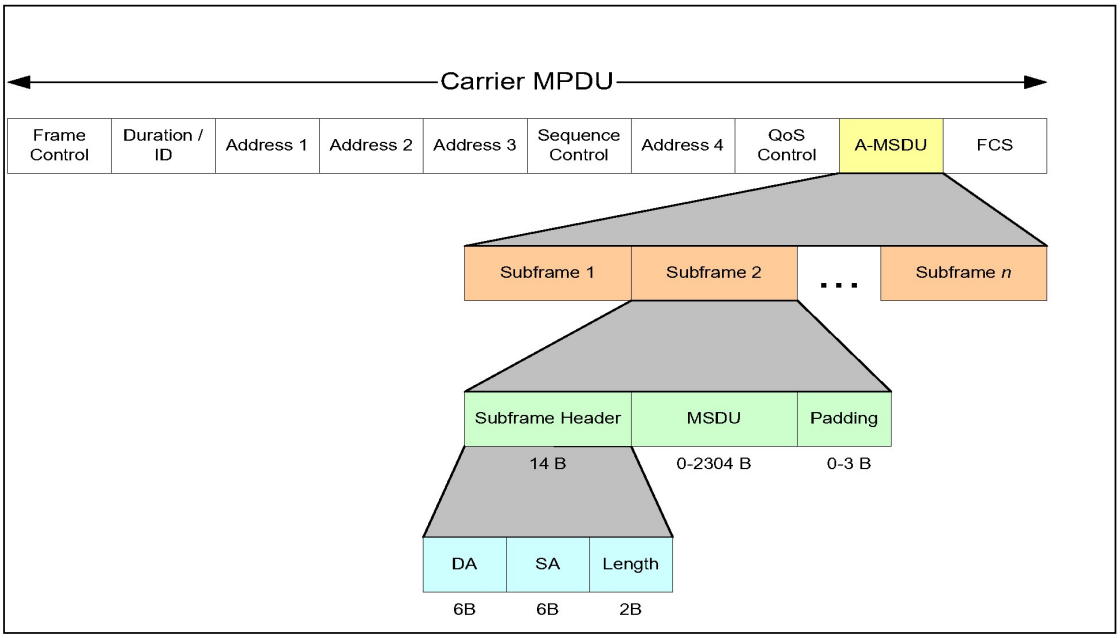


Figure 28 – A-MSDU Structure

[2] Note, these fields are arranged in the same order as the 802.3 frame format.

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The MPDU containing the A-MSDU is one of the QoS data subtypes. This MPDU is treated as a regular MPDU and is encrypted as a single unit under CCMP. The presence of the A-MSDU is signaled by a bit in the QoS control field, whose contents are described in the table:

Table 42 – 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	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 and QoS 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 and QoS CF-Ack frames sent by non-AP STAs	TID	0	Ack Policy	Reserved	TXOP duration requested
	TID	1	Ack Policy	Reserved	Queue size

The DA and SA are passed between the MAC and its service client in the MAC service primitives. The mapping of DA, SA to the addresses in the MPDU header is described by the following tables. It is possible to have different DA and SA in the same A-MSDU as long as they all map to the same receiver address.

Table 43 – Address fields for unicast MPDU containing A-MSDU

To DS	From DS	Address 1	Address 2	Address 3	Address 4
0	0	DA	SA	BSSID	X
0	1	DA	BSSID	BSSID	X
1	0	BSSID	SA	BSSID	X
1	1	RA	TA	BSSID	BSSID
Note: X = not present					

After A-MSDU aggregation, the A-MSDU is treated like any other MSDU. It is transported using one QoS Data subtypes that support this format (listed above).

A-MSDU lifetime shall be set to be the maximum lifetime of the constituent MSDUs. An A-MSDU may be transmitted until its lifetime expires or it is received correctly at the receiver. This implicitly allows an

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MSDU which is a constituent of an A-MSDU to potentially be transmitted after the expiration of its lifetime, superseding other rules to the contrary.

6 MAC sub-layer functional description

6.1 Aggregation Exchange Sequences and related rules

6.1.1 Basic sequence (informative)

The following is a typical sequence of A-MPDUs may be transmitted during a TXOP.

A-MPDU + SIFS + BA + SIFS + A-MPDU + SIFS + BA + SIFS

BA can be transmitted within the TXOP.

6.1.2 Retransmission (informative)

Failed MPDUs can be retransmitted in the same TxOP as part of following A-MPDUs or in a subsequent TXOP.

6.1.3 Protection mechanisms

6.1.3.1 MAC layer protection

The following techniques may be used to achieve protection using a MAC layer technique:

- A contention-free-period of a beacon containing a CF parameter set.
- The HC may deliver a polled TXOP to an HT STA. The whole of the TXOP is protected by the duration field in the QoS CF-poll.
- The HC uses its privileged channel access (after a PIFS) and starts a CAP with transmission of a CTS-to-self MPDU.
- A TXOP may be started with an RTS/CTS exchange, providing NAV protection of the duration specified in these control MPDUs.
- A TXOP may be started with a DATA/ACK exchange providing NAV protection of the specified duration

6.1.3.1.1 Long NAV

When a STA holds a TXOP, it may set a long NAV value intended to protect multiple PPDUs using a single protection MAC layer protection exchange, e.g., RTS/CTS.

The STA may be able to accurately predict the duration of these PPDUs, in which case it can set duration values in a protection exchange accurately.

However, it may not be able to predict the duration accurately. Setting a longer NAV allows it to respond to the following events:

- Retries of failed transmissions in the current exchange
- Adaptation of transmit parameters by training feedback during the current exchange
- Transmission of MSDUs arriving at the MAC Data SAP during the current exchange

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LongNAV protection is defined as selecting a duration value, limited by the remaining duration in the current TXOP and setting the NAV to this value using one of the MAC layer protection techniques. The duration field in aggregated MPDUs shall contain the remaining duration of TxOP (referenced to the end of the PPDU carrying the MPDU). All single frames sent in the TxOP by Initiator or Responder shall contain remaining of TxOP in the duration field.

An example in the following figure shows use of LongNAV

In this example, an RTS/CTS exchange establishes NAV protection of the TXOP.

There then follows a sequence of transmissions of aggregates and Block ACK responses from the responder.

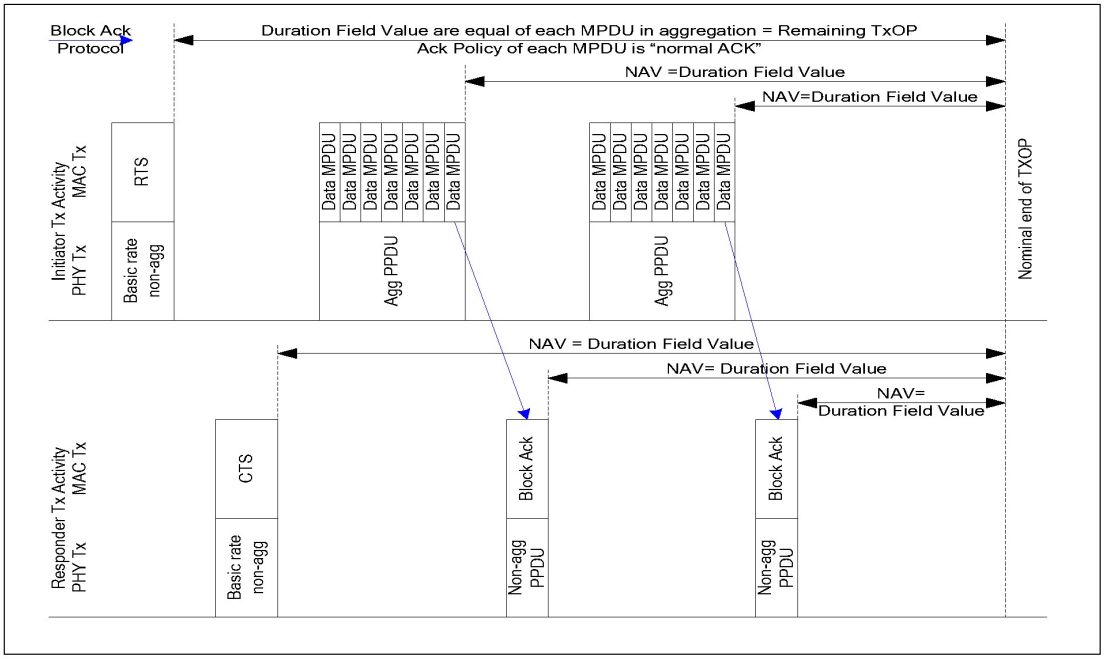


Figure 29 – Example of LongNAV Operation

6.1.3.1.2 Truncation of TXOP

In the case when a STA gains access to the channel using EDCA and uses LongNAV to protect a duration value, and then runs out of MPDUs to transmit, the STA may transmit a CF-End provided that the remaining duration is long enough to transmit this MPDU. By transmitting the CF-END frame, the STA is explicitly indicating the completion of its TXOP.

This shall be interpreted by HT STAs and is interpreted by legacy STAs as a NAV reset – i.e. they reset their NAV timer to zero at the end of the PPDU containing this MPDU. [3] After receiving a CF-End with a matching BSSID, the AP may respond with a CF-End after SIFS.

[3] Note, the transmission of a single CF-End MPDU by the initiator resets the NAV of devices hearing the initiator. There may be devices that could hear the responder that had set their NAV that do not hear this NAV reset. Those devices will be prevented from contending for the medium until the original NAV reservation expires

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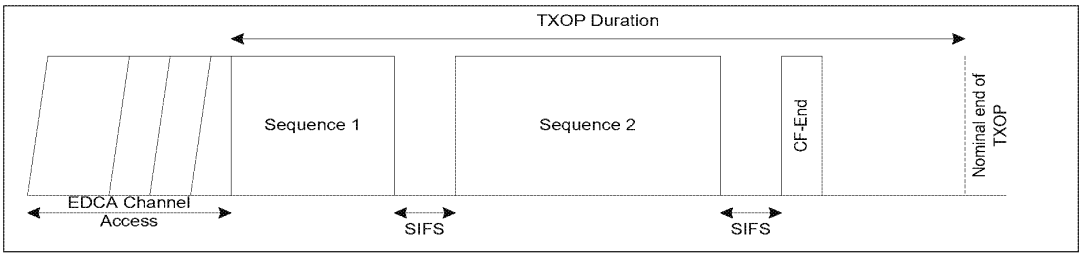


Figure 30 – Example of TXOP Truncation

In the example above the device accesses the medium using EDCA channel access and then engages in two sequences of PPDUs in the initiator role. Each sequence may include multiple PPDUs sent and received.

At the end of the second sequence, the initiator has no more data that it can send that fits within the TXOP, so it truncates the TXOP by transmitting a CF-End MPDU.

HT STAs and legacy STAs that receive this MPDU 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, because a CCA can not be reset through the transmission of a MAC frame.

This avoids potential unfairness or a capture effect for legacy devices.

6.1.3.2 L-SIG TXOP Protection

A Rate of 6 Mbps shall be used in L-SIG. The L-SIG field of HT frames with a Mixed Mode PHY header shall contain a value that causes legacy devices to defer transmission for a period of time corresponding to the length of the rest of the packet, with exceptions defined in this section...

A STA shall indicate whether it supports L-SIG TXOP Protection in its L-SIG TXOP Protection Support capability field in association requests and probe responses.

The AP determines whether all HT STA in its BSS support L-SIG TXOP Protection and indicates this in the L-SIG TXOP Protection Full Support bit of its HT Information Element. This bit shall not be set to 1 when any HT station is associated that does not support L-SIG TXOP Protection.

An infrastructure STA may use L-SIG TXOP Protection if its AP sets L-SIG TXOP Protection Full Support to 1.

Note: A STA can always use L-SIG TXOP Protection if its AP sets this bit to 1 because the AP has already checked that all possible peers of the STA support L-SIG TXOP Protection.

A STA should not use L-SIG TXOP Protection if its peer does not support it.

Note: this means that the STA should check its intended peer (unless the previous rule tells it it doesn't have to) to see if it supports L-SIG TXOP protection. A STA might not want to go through the expense of a probe request/response the first time round. But once lack of support for L-SIG TXOP protection has been determined, use of this technique does not achieve adequate protection.

Under L-SIG TXOP Protection operation, the L-SIG field with a Mixed Mode PHY header shall contain a duration value equivalent (except in the case of RTS as described below) to the MAC duration included in the MAC header. An L-SIG field that contains a value that does not directly represent the actual duration of the frame is called an L-SIG Duration.

Legacy devices are not able to receive any subsequent PPDU that starts during the L-SIG duration. Therefore, no frame shall be transmitted to a legacy receiver during an L-SIG protected TXOP.

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L-SIG TXOP Protection should not be used and the Implementers of L-SIG TXOP Protection are advised to include a NAV based fallback mechanism, if it is determined that the mechanism fails to effectively suppress legacy transmissions. How this is determined is outside the scope of this document.

TXOP truncation is not allowed in combination with L-SIG TXOP Protection, because the legacy device receiving state cannot be reset through the transmission of a MAC frame. This implies that CF-End frames shall not be transmitted to truncate a NAV that is established through the use of L-SIG TXOP Protection. This avoids potential unfairness or a capture effect involving legacy devices.

6.1.3.2.1 L-SIG TXOP Protection Rules at the Initiator

Under L-SIG TXOP Protection rules, an initiator may use RTS/CTS to establish protection.

Under L-SIG TxOP Protection operation, the L-SIG field of an RTS with a Mixed Mode PHY header shall contain a duration value that protects RTS_frame + (RTS_MM_Preamble_Length - Legacy_Preamble_Length)

Stations shall use an accurate prediction of the TXOP duration inside the Duration field of the MAC header to avoid inefficient use of the channel capability.

If the RTS/CTS handshake succeeds (i.e. upon reception of a L-SIG TXOP Protection CTS addressed to the initiator), all mixed mode PPDUs transmitted inside an L-SIG TXOP Protection protected TXOP shall contain an L-SIG Duration up to the endpoint of the MAC Duration.

The initiator should send a CF_End MPDU carried in a basic rate legacy PPDU, SIFS after the L-SIG TXOP protected period. This enables third party devices to terminate EIFS procedure to avoid potential unfairness or a capture effect.

6.1.3.2.2 L-SIG TXOP Protection Rules at the Responder

On receiving an RTS frame addressed to itself, a responder that asserted the L-SIG TXOP Protection support bit upon association, may generate an L-SIG TXOP Protection CTS frame with the L-SIG Duration = (MAC Duration of RTS – SIFS – L-Preamble).

After transmission of an L-SIG TXOP Protection CTS the responder's mixed mode PPDU transmissions shall contain an L-SIG Duration up to the endpoint of the MAC Duration.

A STA may only transmit a response frame containing an L-SIG Duration in response to a frame that also contained an L-SIG duration.

6.1.3.2.3 L-SIG TXOP Protection Rules at Third Party HT

An HT receiver that asserted the L-SIG TXOP Protection support bit upon association, and that receives an L-SIG protected PPDU in which it can not decode a MAC duration shall update it's NAV to a value equal to L-SIG duration – HT-SIG duration. This NAV update operation takes place at the termination of the time/length value represented in the HT-SIG field.

6.1.4 RIFS Protection

All stations at the BSS shall protect RIFS sequences when there is at least one legacy station associated with this BSS.

6.1.5 Green Field Protection

All stations in the BSS shall protect Green Field PPDUs when there is at least one legacy or non-GF station associated with this BSS.

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6.1.6 Reverse direction

6.1.6.1 Aggregation Exchanges

During a reverse direction transmit sequence, the initiator STA may transmit PPDUs and obtain response PPDUs from a single (responder) STA during the exchange.

The reverse direction mechanism enables the generation of a response burst, which may contain one or more PPDUs. The More PPDU field in the HT Control field is used to indicate non-final PPDUs.

Under the reverse direction rules, the responder may only generate a response containing more than one PPDU or containing Data if the RDG field is set to 1 in the previous PPDU.

The response starts a SIFS after the end of the PPDU containing RDG=1. Any PPDUs in a response burst are separated by SIFS or RIFS. The RIFS rules are the same as in the straight direction: the use of RIFS is limited as defined in Table 3 – Additional HT Information Elements. RIFS use will be allowed if there are no APSD legacy devices associated, otherwise its use is forbidden.

When a PPDU is not the final PPDU of a response burst, an HT Control field carrying the More PPDU field set to 1 shall be present in every MPDU capable of carrying the HT Control field. The last response PPDU shall have the "More PPDU" field set to 0 in all HT control MPDUs contained in that PPDU.

During a response burst, only the responder may transmit – i.e. there are no transmissions by other STA, including the initiator. See the figure below for an example of this:

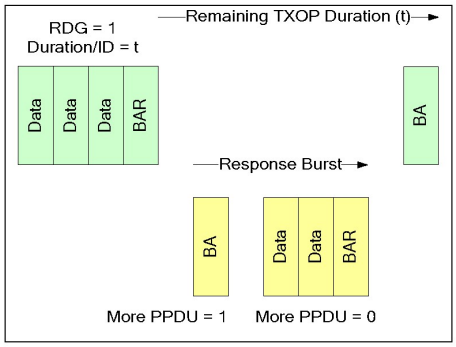


Figure 31 – Example of RD Operation showing response burst

The 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 the PPDU carrying the RDG.

6.1.6.2 Bi-Directional Data Exchange Rules

Transmission of an MPDU by an initiator with the RDG flag set to 1 (either transmitted by itself, or as part of an aggregation) indicates that the remaining TXOP duration is available for a response burst.

When the initiator sets the RDG flag to 1, it shall set the AC Constraint field to 1 if the TXOP was gained through the EDCA channel access mechanism, and shall set it to 0 otherwise.

If the AC Constraint field is set to 1, the responder shall transmit Data MPDUs of only the same AC as the last Data MPDU received from the initiator. If the AC Constraint field is set to 0, the responder may transmit Data MPDUs of any TID.

The responder shall not transmit any MPDUs that are not addressed to the initiator.

The RDG/More PPDU field shall be set to the same value in all HT Control fields present in a PPDU.

Subject to TXOP constraints, after transmitting a PPDU containing the RDG field set to 1:

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- **Normal Continuation:** The initiator may transmit its next PPDU a minimum of a SIFS after receiving a response PPDU with the "More PPDU" flag set to 0.
- **Error Recovery:** The initiator may transmit its next PPDU when the medium is sensed idle for PIFS (this is a continuation of the current TXOP). If the initiator receives a PPDU that does not carry the "More PPDU" flag, it shall not transmit any earlier than a PIFS.

Note: after transmitting a PPDU containing a reverse direction grant, if the response is corrupted so that the state of the "More PPDU" flag is unknown, the previous paragraph does **not** allow transmission after SIFS. Transmission may occur a PIFS after deassertion of carrier sense, unless a later response PPDU is correctly received containing "More PPDU" set to 0.

Note: after transmitting a PPDU not containing a reverse direction grant, the state of the "More PPDU" flag does not affect the behavior of the initiator. If the response is corrupted (i.e. PPDU length known, but MPDU CRC failure), the initiator continues transmissions after a SIFS (subject to TXOP constraints).

Note: the latter point is permitted by 802.11e. It shows that error recovery of the RDG mechanism is the responsibility of the initiator.

6.1.6.3 Constraints regarding responses

The first PPDU of any response burst shall contain any response MPDUs as required to respond to the previous PPDU.

Only the last PPDU of a response burst may contain an MPDU requiring an immediate response.

The initiator may interpret the presence of any frame in a response PPDU requiring an immediate response as an implicit indication of "More PPDU==0".

After transmitting a PPDU containing More PPDU set to 0, the responder shall not transmit any more PPDUs within the current response burst.

Note: if the responder transmits a PPDU that expects a transmission by the initiator after SIFS, and no such transmission is detected, the responder has to wait for either another reverse direction grant or its own TXOP before it can retry the exchange.

6.2 Aggregation Exchange Sequences and related rules

6.2.1 Embedding of Management Action Frames (Informative)

The QoS Null + HTC (MA=1) mechanism allows a management action payload to be embedded as part of an aggregate provided its ack policy is set to "no ack".

This mechanism allows channel state information to be embedded as part of an aggregate exchange.

6.3 Multirate support

The Supported MCS Set and indicated MCS values relate to HT format PPDUs only.

The rate of control frames shall be selected from the legacy basic rates in the legacy BSS's basic rate set, and they shall be transmitted using the legacy or legacy duplicate PPDU format. STBC control frames shall be transmitted using the STBC Basic MCS.

Multicast/broadcast frames shall be transmitted accordingly to legacy rules. If the STBC Control Frame support bit is enabled the secondary STBC beacon shall be transmitted by STBC Basic MCS and

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multicast frames shall be repeated by Basic STBC MCS signaled in the Additional HT Information element.

6.3.1 Legacy Basic Rate calculation

This section defines how to convert a HT MCS to a legacy basic rate.

It is calculated by using the modulation and coding rate of the related HT PPDU.

For example if an HT PPDU transmission uses QAM and coding rate of ¾ it means, the related legacy rate is 54 Mbps.

The following rules shall be used to calculate the related legacy Basic Rate:

- Legacy_Reference_Rate = Table 44 (Modulation, Coding rate)
- The Legacy Basic Rate is the highest rate in the BSSBasicRateSet that is less than or equal to the Legacy_Reference_Rate of the immediately previous frame in the frame exchange sequence

Table 44 – Legacy Rate reference

Modulation	Coding rate (R)	Legacy reference rate (Mbits/s)
BPSK	½	6
BPSK	¾	9
QPSK	½	12
QPSK	¾	18
16-QAM	½	24
16-QAM	¾	36
64-QAM	2/3	48
64-QAM	¾	54
64-QAM	5/6	54

6.4 Use of Compressed bitmap

The bit "Compressed Bitmap BA" shall be asserted in all BA and BAR and MTBA and MTBAR sent from one HT STA to another HT STA.

6.5 N-Delayed BA negotiation

N-Delayed BA is an optional feature. A STA declares support for N-Delayed BA in its HT capabilities.

A STA shall not attempt to create a BA agreement under N-Delayed BA policy unless its intended peer declares support for this feature.

6.6 N-Immediate BA extensions

This section defines an extension to the BA feature introduced in 802.11e to support operation on immediate BA agreements established between HT peers.

The N-Immediate extensions simplify immediate BA use with A-MPDU aggregates and reduce recipient resource requirements. They are:

- Use of "normal ack" policy in QoS Data frame to solicit ACK in response to non-aggregate PPDU and BA in response to aggregate PPDU

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- Use of BAR to solicit immediate BA and update SSN when MSDU life time expires
- Compressed Block Ack bitmap format
- Allow the recipient to maintain partial bitmap state. The same memory holding BA state may be used to collect state from different Originators. This record may be reset if the recipient receives transmission of a different originator.

6.6.1 BA Extension Architecture

The extended BA rules are explained in terms of the extension architecture contained in this section.

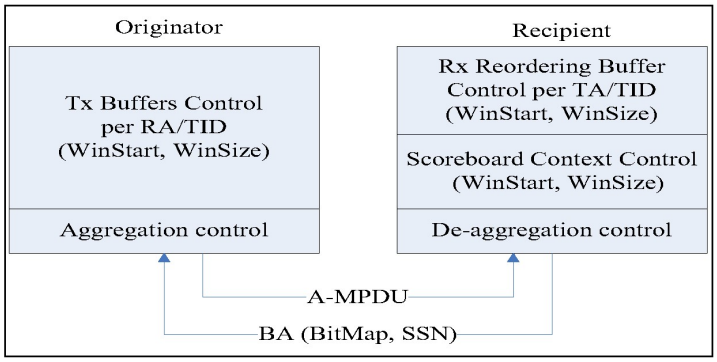


Figure 32 – Extended BA Architecture

The Originator contains a Tx Buffer control that uses WinStart, WinSize to submit MPDUs for transmission and releases the Tx Buffers getting related Block Acknowledgements from Recipient.

WinStart and WinSize are the starting position (sequence number) of the transmit window and the number of buffers negotiated in the BA agreement.

The Aggregation control creates aggregated frames, it may adjust the ack policy field of transmitted QoS Data frames according to the rules defined this section in order to solicit BA responses.

The recipient contains the Rx Reordering Buffer per TA/TID with related control state. This block is responsible for indicating received MSDUs to upper layers in sequence according to received SN. It maintains its own state independent of the Scoreboard Context control to perform this reordering as specified in 802.11e.

For N-Immediate BA agreements, the recipient chooses either full state or partial state operation (this is known only to the recipient). The Scoreboard Context Control stores an acknowledgement bitmap per established N-immediate BA agreement under full state operation or the current context of the partial state under partial state operation. This entity provides the bitmap and SSN to be sent in BA responses to the Originator.

The de-aggregation control entity separates frames aggregated in an A-MPDU.

Each received MPDU is analyzed by the Scoreboard context control, as well by Rx reordering buffer control.

6.6.2 Rx reordering buffer control

WinStart is initialized from the ADDBA SSN value.

On receiving a data MPDU an uninterrupted sequence of complete MSDUs starting from SN = WinStart shall be indicated using the MA-UNITDATA.indication primitive.

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WinStart is then updated to the SN of the last released MSDU plus one.

When a BAR is received, any complete MSDUs with lower sequence numbers than the SSN of the BAR shall be indicated using the MA-UNITDATA.indication primitive.

The recipient shall indicate MSDUs starting with the SSN sequentially until there is an incomplete MSDU in the buffer or a gap in the sequence number. The recipient shall always indicate MSDUs to its MAC Client in order of increasing sequence number.

6.6.3 Scoreboard context control in full state

The scoreboard context control in full state shall maintain a block acknowledgement record as defined in 802.11e. This state includes a bitmap, indexed by sequence number, a starting sequence number WinStart and the maximum window size (WinSize) established during BA setup.

WinEnd is defined as the highest SN in the Transmission Window: WinEnd = WinStart + WinSize -1.

For each received data MPDU received with sequence number SN:

- If WinEnd>=SN >= WinStart, the bit in SN position shall be set to one
- If SN >WinEnd, bits related to MPDUs with numbers from WinEnd+1 to SN shall be set to zero, WinStart is updated to WinStart=SN-WinSize +1, the bitmap at SN shall be set to one.

Note, comparisons are circular modulo 2^12.

6.6.4 Scoreboard context control in partial state

In the partial state the Responder retains the current state while it receives data from the same Originator.

When a different Originator starts transmission the partial state may be discarded and the resources re-used to store the new context.

In partial state operation, WinStart is determined by the SN of received MPDUs, and the next MPDU may validly contain a SN that is lower than the former one. This can happen due to out of order MPDUs or because a previous MPDU transmission with lower SN is not successful. The originator may transmit an MPDU with SN that is lower than any previously sent but must satisfy the constraint (highest_SN – lowest_SN) <= WinSize (determined by the negotiated buffer size).

The scoreboard context control of partial state shall maintain WinStart (the lowest SN received), WinEnd (the highest SN in the bitmap), originator address, TID, and a record of the size of Re-ordering Buffer Size indexed by received MPDU sequence control value. WinEnd = WinStart + WinSize -1.

For each received MPDU:

- If WinEnd>=MPDU SN >= WinStart, set the bit in SN position
- If MPDU SN >WinEnd, reset bits related to MPDUs with numbers from WinEnd+1 till SN, set new WinStart=SN-WinSize +1, set bit in the bitmap at SN
- If MPDU SN < WinStart, set new WinStart = SN, set bit in this position.

Note, comparisons are circular modulo 2^12.

6.6.5 Scoreboard context control of BA

The WinStart is used as SSN when it is necessary to transmit a BA as response to A-MPDU containing one or more QoS Data MPDUs with Ack-Policy = Normal ACK.

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6.6.6 Scoreboard context control of BAR

Under N-Immediate BA policy, the recipient shall respond to a BAR, with a BA frame. In the BA 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 sets bits in the Block Ack bitmap corresponding to all other MPDUs to 0.

The status of MPDUs that are lower than WinStart shall be reported as successfully received (i.e., the corresponding bit in the bitmap shall be set to 1).

WinStart is set to the SSN from BAR.

If a BAR is received and no matching partial state is available, the recipient shall send a "null" BA with an all 0 bitmap.

Note, comparisons are circular modulo 2^12.

6.6.7 Originator's behavior

A block of data may be sent in a single A-MPDU where each data MPDU has "normal ack" policy. The originator expects to receive a BA response if at least one data frame makes it through. If the BA is lost, the originator may use BAR to solicit immediate BA or it may retransmit the data frames.

Any BAR shall be sent as an un-aggregated packet.

The originator may send an aggregate with "block ack" policy if it doesn't require a BA response immediately following the A-MPDU.

All frames within an A-MPDU aggregate shall have the same ack policy setting.

After sending aggregated data under "normal ack" policy, the originator only needs to send a BAR when it discards a data MPDU due to exhausted MSDULifetime. The purpose of the BAR is to shift the recipient window past the hole in the SN space created by the discarded data.

6.6.8 Maintaining the BA state at the originator

If the originator gets a BA in response to BAR it shall maintain BA state as required by 802.11e.

If the originator gets a BA in response to N-immediate BAR, it shall in addition:

- Not update the status of MPDUs with sequence numbers between WinStart and SSN of BA
- Not update the status of MPDUs that have been already positively acknowledged

Note: The last can happen while getting responses from partial state recipient.

6.6.9 Originator's support of Responder's partial state

The originator shall solicit a BA as the last activity directed to that recipient in the current TxOP. .

6.7 N-Delayed BA extensions

This section defines an extension to the BA feature introduced in 802.11e to support operation on delayed BA agreements established between HT peers.

The N-Delayed extensions simplify its use in A-MPDU aggregate and reduce resource requirements. They are:

- Use of "no-ack" in BA/BAR where an immediate response is not required
- Use of compressed Block Ack bitmap format

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6.7.1 Operation of N-Delayed BA

The No Ack feature of the BAR and BA frame may be used under an N-Delayed BA agreement.

No Ack asserted in a BAR or BA transmission means that no acknowledgement is expected to these control frames. Transmitting a BAR/BA frame under N-Delayed BA policy with this flag clear indicates that an Ack MPDU response is expected after a SIFS.

Setting of the "no-ack" flag is dynamic, and can change from PPDU to PPDU.

Setting of the "no-ack" flag is independent for the BAR/BA associated with a N-Delayed BA agreement. All four combinations of "no-ack" used in BAR and its BA response are valid.

The BA response to an N-Delayed BAR is transmitted after an unspecified delay, and when the recipient next has the opportunity to transmit. This response may be transmitted in a later TXOP owned by the recipient or in the current or a later TXOP owned by the initiator using the reverse direction feature.

6.8 TxOP continuation

A TXOP limit of zero is considered to allow an Aggregate exchange sequence containing the transfer of at most a single A-MPDU+SIFS+BA or MMPDU+SIFS+ACK.

6.9 PSDU Length Limit Rules

A STA shall declare the maximum PSDU size that it can receive using the Maximum Rx PSDU Factor capability field. The STA may limit the PSDU length at the association phase by indicating appropriate parameter in the HT information element. The STA shall receive PSDUs of length less than the indicated limit. When it receives a PSDU of length greater than the limit, it shall receive the first 2^(13 + Maximum Rx A-MPDU Factor) bytes and discard any remainder.

A STA shall form an aggregate for transmission such that all the MPDUs within the aggregate that are intended to be received by a particular STA shall be within the first 2^(13 + Maximum Rx A-MPDU Factor) bytes of the PSDU, using the limit declared by that STA.

6.10 MPDU density

A STA shall not allow transmission of more than one MPDU start within the time limit described in the MPDU maximum density field. The limitation shall be measured at the PHY_SAP; the number of bytes between the start of two consecutive MPDUs in A-MPDU shall be equal or greater than MPDU-density*PHY-bit-rate/8.

6.11 Scheduled PSMP

6.11.1 PSMP sequence

Once a STA has created a TSID using scheduled PSMP, the AP periodically initiates a PSMP sequence by transmitting a PSMP MPDU according to the service period (Service Start Time) within the TSPEC.

The start time of a PSMP sequence should be aligned with the start time of S-APSD. Within any arbitrary single PSMP sequence duration, multiple numbers of additional subsequent PSMPs (Sub-PSMPs) can be transmitted by AP in order to allow more precise resource allocation and error recovery. An initial PSMP followed by one or more Sub-PSMPs is termed Multi-phase PSMP.

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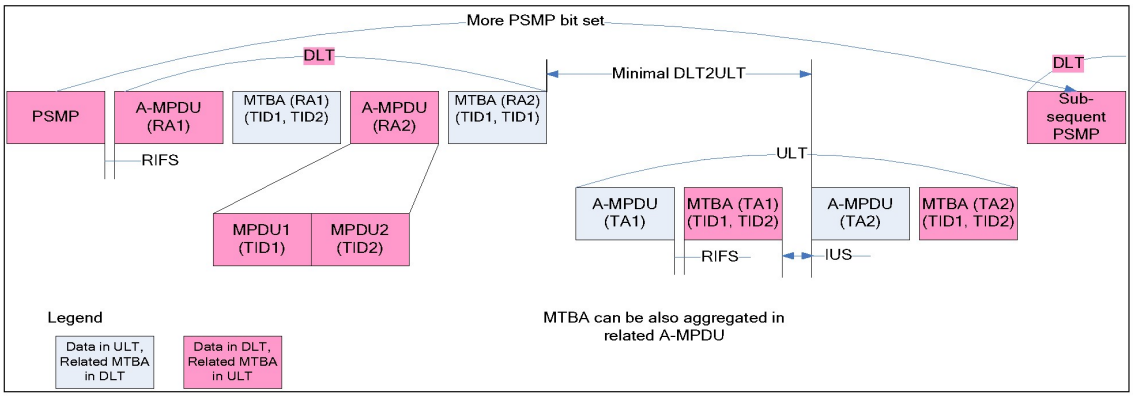


Figure 33 – PSMP sequence

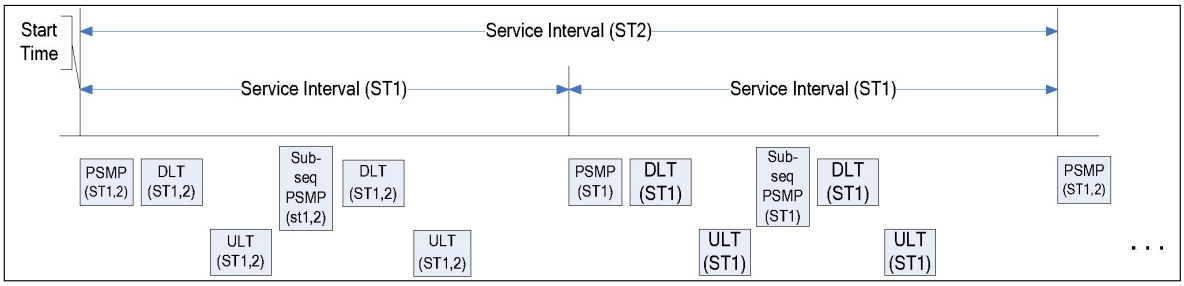


Figure 34 – Different Service intervals of different stations

An AP can gain access to the channel after a PIFS in order to start transmission of PSMP sequence. CTS-to-self may be sent before each PSMP. The PSMP may follow the CTS-to-self after a PIFS delay to allow sensing of the physical carrier. The PSMP frame shall be sent at a legacy basic rate.

The Minimal DLT2ULT delay is minimal time between DLT and ULT phases of the same station and shall be (TBD). This value indicates minimum time the Station is provided to react to MTBA and data received during DLT with related data and MTBA in ULT. If in a PSMP the number of STAs that are involved cannot ensure this required delay then, the AP shall delay the start of the entire ULT phase. This time can be protected using CTS to self sent one or more between DLT and ULT.

A PSMP sequence (scheduled or unscheduled) may be used to transmit Broadcast/Multicast frames along with unicast frames. Unicast frames shall be scheduled after Broadcast/Multicast frames. STAs that have unicast frames have their DLT and ULT Start Offsets preferably scheduled to minimize the number of on/off transitions or to maximize the delay between their DLT and ULT periods. STAs that have only DLT are scheduled closer to the start of DLT's, STAs that have only ULT are scheduled towards the end of ULTs, STAs that have both DLT and ULT are scheduled closer to the transition point from Downlink to Uplink transmissions. Frames of different TSID may be transmitted an DLT or ULT allocation of a (Scheduled or Unscheduled) PSMP sequence without regard to Access Category.

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6.11.1.1 Down Link Transmission

During a PSMP sequence, a STA is only required to be able to receive during its scheduled DLT.

The AP shall ensure that any transmissions within a PSMP sequence to a STA participating in the PSMP sequence occur wholly within its DLT.

The DLT transmission may contain one or several A-MPDUs and/or MPDUs containing payload and MTBA directed to STA according to the schedule transmitted in the PSMP.

PPDUs may be separated using RIFS or SIFS. RIFS may only be used when the AP's Additional Information Elements RIFS mode field contains the value 1.

Multiple RA are supported by separate PPDUs separated by RIFS or SIFS as described above. This is shown in Figure 35 below.

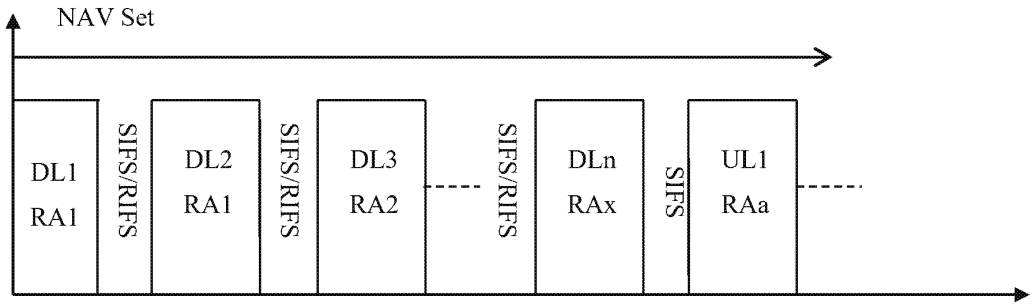


Figure 35 – Multiple RA packet transmission with RIFS or SIFS

6.11.1.2 Up Link Transmission

A STA starts transmitting without performing CCA at the start of its ULT Offset.

Even, if a STA has more data queued than the allocated time for its ULT, the STA shall release the medium at the end of the allocated duration.

ULT reserves time for each scheduled PSMP station to send one or several A-MPDUs and/or MPDUs containing payload and MTBA directed to AP as required. The "TSID set" field in the PSMP helps the STA decide which MPDUs to select for transmission. The STA decides which TSIDs to use and is not limited to the set indicated in the PSMP frame. An all Zero TSID set field means that the AP is not providing information about recommended TSIDs.

The TSIDs set field may therefore be used to simplify the Station decision in case there are frames of several TSIDs ready to be delivered. The AP may set the TSID field to all zeroes, indicating that there is no related information. The STA is free to ignore the value of this field.

PPDUs may be separated over RIFS or SIFS. RIFS may only be used when the STA's AP transmits an Additional Information Element RIFS mode field contains the value 1.

The AP may reuse any unused ULT in scheduled or unscheduled PSMP.

6.11.1.2.1 Scheduling of Up Link Transmissions

The uplink schedule in a transmitted PSMP shall allow a interval between ULT periods of different stations of Inter ULT Space (IUS).

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IUS may be 8us (>RIFS + Propagation time) or SIFS.

The 8us value may only be used when the AP's Additional Information Elements RIFS mode field contains the value 1.

6.11.1.3 Multi-phase PSMP

The ULT Duration delivered in a PSMP frame can be determined by the AP, based on TSPEC associated with each STA. For effective resource allocation, AP should precisely estimate ULT duration for each STA using the information indicated in TSPEC, such as Minimum Data Rate, Mean Data Rate, Peak Data Rate, Burst Size, and Delay Bound fields. However, in the case where the traffic characteristic is quite bursty (*e.g.* a real-time video application), precise estimation of ULT Duration is difficult without timely and frequent feedback of the current traffic statistics.

In order to avoid wasting the available bandwidth by overestimating the ULT Duration, the AP allocates the minimal amount of resource to each STA using ULT Duration field in PSMP, based on Minimum Data Rate in TSPEC, or other local knowledge. When the STA receives a PSMP frame, it decides if the allocated resource indicated by ULT 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.

If the allocated ULT Duration is not long enough for the queued data, the STA transmits only the part of queued data that can be fit within the allocated ULT Duration, with an additional Resource Request (RR) to AP. The RR is communicated by setting either the Queue Size field or the TXOP Duration Request field of the QoS Control Field which is carried in a QoS Data frame (Figure 36 – Multi-phase PSMP showing additional resource allocation). By transmitting an additional Sub-PSMP frame, the AP may subsequently allocate the exact amount of ULT Duration based on the RR from the STA for whatever the remaining queued data that has not been transmitted during the initially allocated ULT duration for that particular STA.

Multi-phase PSMP can also be used for retransmission as well as additional resource allocation (Figure 37 – Multi-Phase PSMP showing retransmission as well as additional resource allocation). The frames transmitted in DLT are acknowledged by MTBA in ULT phase within the current PSMP sequence. The frames transmitted in ULT can be acknowledged by MTBA in DLT phase within the following Sub-PSMP. Any failed transmissions during DLT and ULT can be respectively retransmitted in DLT and ULT period of the following Sub-PSMP sequence.

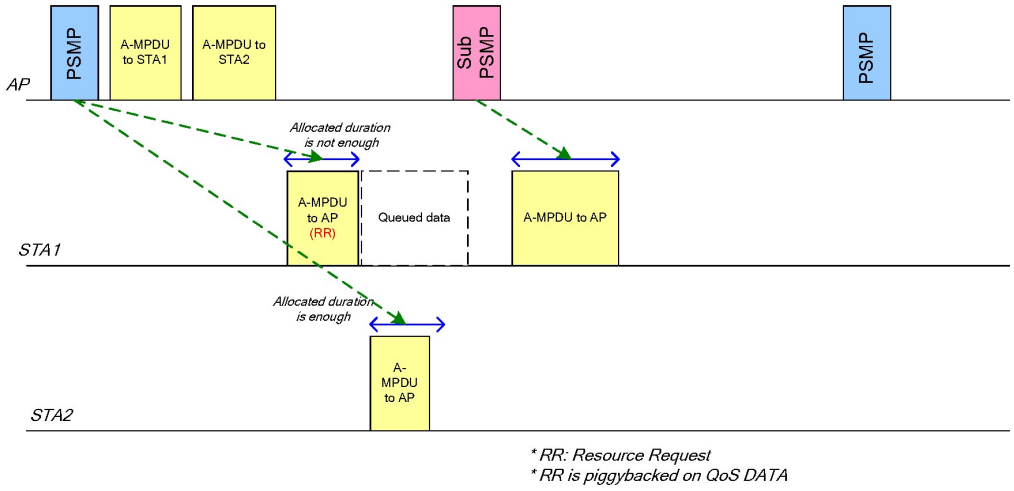


Figure 36 – Multi-phase PSMP showing additional resource allocation

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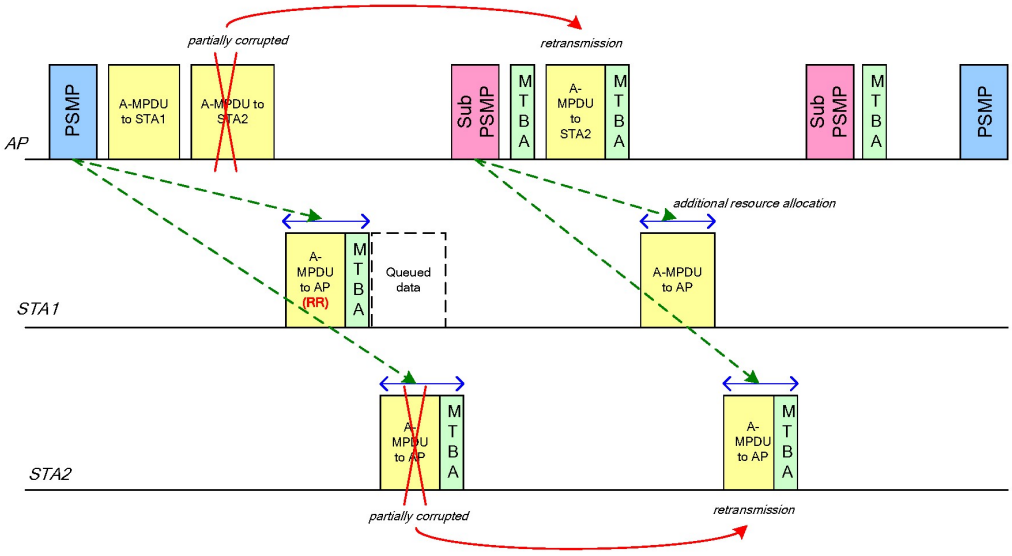


Figure 37 – Multi-Phase PSMP showing retransmission as well as additional resource allocation

6.11.2 PSMP Power management

Power is managed per Service Interval. A Station with an established SP will be awake at beginning of its SP. Once activated at the beginning of SP, the Station will stay active at least until a PSMP is received or the agreed upon maximum SP interval has elapsed, whichever comes first.

The AP shall signal the end of the Service Period for all STA by de-asserting of the More PSMP bit or by sending CF-END instead of the next PSMP.

In order to indicate EOSP on an individual STA basis, the AP shall signal the end of a service period using the EOSP bit set in the QoS Control field. This bit shall remain set for any retransmissions of the same MPDU and no more new MPDUs shall be sent to this particular Station in the current Service Interval.

The Station shall wake up at start of the next PSMP if the More PSMP bit is set to 1 in the current PSMP, unless the STA has been permitted to return to sleep or the maximum SP interval has elapsed.

6.12 MTBA rules in scheduled PSMP sequence

Data transmitted within a PSMP sequence DLT and ULT shall be acknowledged using MTBA.

Data sent and received by STA may be aggregated in an A-MPDU that contains MPDUs of different TSIDs. Frames of differing TSID may be transmitted in the same DLT or ULT and are not subject of Access Category prioritization.

Acknowledgement may be requested implicitly using the “normal ACK” setting of the ACK policy bits in Data MPDUs or explicitly with MTBAR. In both cases the response is a single MTBA.

A non-AP STA shall use ULT of the current PSMP sequence to transmit an MTBA relating to data received in DLT. The AP shall use the DLT of next PSMP sequence to transmit an MTBA response to data received in the ULT. The next PSMP may be concatenated in the same Service Interval (Sub-PSMP). The number of PSMPs in PSMP sequence is locally limited by the AP.

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The AP delivers the data as well the MTBA of related TSPEC in DLT and reserves the ULT only in the Service Intervals scheduled for this RA/TSPEC.

The AP receives any MTBA in ULT of the current PSMP sequence. If the MTBA indicates lost frames the AP schedules and retransmits these frames in the Sub-PSMP of the same Service Interval or in the next Service Interval. If the AP does not receive an expected MTBA it may schedule and retransmit all unacknowledged frames. Retry (and possibly lifetime) limits are independent per TSID.

6.12.1 ULT payload retransmission

A non-AP STA receives an MTBA in DLT of the next PSMP after its data transmission. In the Sub-PSMP of the same Service Interval the AP may reserve UL to allow STA retransmission of failed frames. The STA may retransmit lost frames in the subsequent PSMP of the same Service Interval if UL reservation is present or in the first PSMP in the next Service interval.

If the STA cannot complete its retransmissions in the last Sub-PSMP of the current Service Interval due to not enough time being allocated in its ULT, it can transmit the data outside any PSMP sequence. Frames transmitted outside the scheduled SP under EDCA are subject to the Access Category prioritization.

Note: in this case the related MTBA is delivered in the DLT of the related PSMP.

Retry (and possibly lifetime) limits are independent per TSID.

6.13 Unscheduled PSMP

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 station has configured to be trigger-enabled. A PS-Poll can be used as well.

The AP may also start at any time an unscheduled PSMP including STA that are PSMP capable. Note: this places no new requiremens on STA regarding their power-saving operation. The AP can only use this to address STA that it expects to be awake.

An unscheduled SP ends after the AP has attempted to transmit at least one 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 non-zero value.

The SP of U-PSMP may contain a PSMP frame, Downlink phase and Uplink phase. The Downlink phase of this SP can contain Data related to different AC of different stations. The data directed to the same station and associated with delivery-enabled ACs may be aggregated using A-MPDU aggregation. The AP transmits PPDUs to different stations separated by a RIFS or SIFS interval. The RIFS interval is subject to the same limitation as in DLT of scheduled PSMP.

If a BA agreement is in force for frames transmitted within the DLT then the MTBA method shall be used for acknowledgements transmitted in the ULT. In this case the ULT is scheduled by AP to allow stations to respond with an MTBA transmission.

Acknowledgement of data transmitted during ULT is requested implicitly by normal ACK setting of the ACK policy bits in Data MPDUs or explicitly with MTBAR and responded with MTBA. The AP shall transmit any response to these requests as an MTBA frame in the DLT of a subsequent PSMP sequence.

The subsequent PSMP may be used for retransmission.

Under the U-PSMP the station may transmit data to its AP outside Service Period using one of the following methods: regular ACK, immediate BA and delayed BA. Under the regular Ack and immediate BA. Note: In this case the AP responds immediately as defined by the response rules for these methods outside a PSMP sequence.

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A AP may transmit a BA of a delayed BA agreement in the Downlink phase of a SP using MTBA format.

6.14 Security

An HT STA shall not use WEP or TKIP based encryption when sending A-MPDU aggregated data to an HT peer.

6.15 Secondary Beacon Transmission

The AP may transmit a secondary beacon and MC/BC traffic using a Basic STBC MCS. The secondary beacon bit shall be set in this beacon, so that stations know that the TBTT for this beacon has an offset of half a beacon period. The TSF timestamp of the secondary beacon shall be the actual timestamp.

Any other fields inside the beacon shall be identical to the primary beacon. MC/BC traffic transmitted after the secondary beacon shall be identical to the MC/BC traffic transmitted after the primary beacon.

6.16 Dual CTS Protection

If the Dual CTS Protection bit is set in the beacons transmitted by its AP, a non-AP STA shall start a TXOP with an RTS directed at the AP. The AP shall respond with a dual CTS (CTS1 followed by CTS2) separated by PIFS. The following cases exist:

- Non-STBC RTS:
  - CTS1: Same rate or MCS as the RTS (non-STBC)
  - CTS2: Lowest Basic STBC MCS (STBC)
  - PIFS shall be used as the interval between CTS1 and CTS2 – if the medium becomes busy within a PIFS time following CTS1, then CTS2 shall not be transmitted as part of this frame exchange.
- STBC RTS
  - CTS1: Lowest Basic STBC MCS (STBC)
  - CTS2: Lowest Basic Rate (non-STBC)

The station resumes transmission a PIFS+CTS2+SIFS after receiving CTS1, instead of after SIFS. The time it takes to transmit CTS2 is known in advance according to the above rules.

The dual CTS response only applies to the AP, stations shall always respond to an RTS request with a single CTS.

If dual CTS Protection is enabled, the AP should protect STBC TXOPs with a non-STBC CTS-to-self and non-STBC TXOPs with an STBC CTS-to-self. The AP should continue PIFS after the CTS, to allow for a collision detect.

The protection frames shall set a NAV for the whole duration of the STBC sequence.

STBC control frames shall be transmitted in response to received STBC frames if the Dual CTS Protection bit is set. Non-STBC control frames shall be used otherwise.

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6.17 Link Adaptation

6.17.1 Introduction (informative)

To fully exploit MIMO channel variations and transmit beamforming on a MIMO link, a STA may request another STA to provide full MIMO channel sounding and MCS feedback.

The Link Adaptation can be done by two approaches:

- An immediate response when the responder's MFB is sent in the TxOP obtained by the Initiator. This approach allows the sender to obtain the benefit of link adaptation within the same TXOP.
- The MRQ is transmitted in a TXOP obtained by the sender and the response (MFB) is transmitted in a subsequent TXOP obtained by the responder.

6.17.2 Link Adaptation using HT Control Field

The sender may set the MRQ bits in the HT Control field to request the responder to provide MCS feedback. The sender may set the MRS field to any value in the range '000-110' every time it transmits +HTC frame with the MRQ bit set. How the sender chooses the MRS value is implementation dependent. The sender may use the field as a sequence number of the MRQ or it may implement any other encoding of the field. If the HT Control field is included in more than one MPDU (i.e., more than one +HTC frame) within the same PPDU, the MRQ bit and the MRS field in each +HTC frame shall be set to the same value.

When sender sets the MRQ bit, sounding PPDU should be used and sounding bits in HT-SIG shall indicate this if the user wants to get information from more dimensions than the number of spatial streams actually used for PPDU submission.

On receipt of a +HTC frame with the MRQ bit set the responder initiates MCS estimate computation and associates result of this computation with the MRS value. Hardware and buffer capability may limit the number of MCS estimate computations that a responder is capable of running simultaneously. When a new MRQ is received either from a different sender or from the same sender with a different MRS value, and the responder's number of simultaneous computations is exceeded, the responder may either discard the new request or may abandon an existing request and initiate an MCS estimate computation for the new MRQ.

If the responder discards or abandons computation for an MRQ, it should indicate this to the sender by setting the MFB to "all-ones" in the next transmission of a frame addressed to the sender that includes the HT Control field. The value of the MFS is set to the MRS value to indicate to the sender the correspondence to the MRQ that was discarded.

After the MCS estimate computation is completed, the responder should include the MCS feedback in the MFB field in the next transmission of a frame addressed to the sender that includes an HT Control field. The value of the MFS is set to the MRS value to indicate to the sender the correspondence between the MRQ and the MFB.

If the responder sends an unsolicited MFB, it sets the MFS to the value '111'.

If the HT Control field is included in more than one MPDU within the same PPDU, the responder may provide MFB corresponding to different MFS values in different MPDUs.

At the end of the TXOP, the final data frame from the initiator, shall not have the MRQ set to '1'if there not enough time left in the TxOP to get the responses.

Note: Bidirectional request/responses are permitted. In this case, a STA acts as the sender for one direction of a duplex link transmitting MRQ, and a responder for the other direction, transmitting MFB and including both within the same HT Data frame.

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6.17.3 Immediate Response Frame Exchange for HT Control

Certain frame exchanges are defined as immediate response exchanges. These include RTS/CTS, Data/ACK, Implicit BAR(BAR)/BA with immediate Block Ack. If an HT STA includes the HT Control field in the initial frame of an immediate response exchange and the responder 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.

If the sender sets MRQ = 1 in the HT Control Field, and the responder completes the MCS estimate in time, it can provide MFB in the HT Control field in the immediate response. If the MCS estimate is not available in time and if the HT Control field is included in the immediate response frame[4], the responder may set MFB to the default value "all-ones" following the MFS/MRS rules. Subsequently, when the MCS estimate corresponding to the MRQ becomes available at the responder, the responder should include the MCS feedback in the MFB field in the next transmission of a frame addressed to the sender that includes the HT Control field. The value of the MFS is set to the MRS value to indicate to the sender the correspondence between the MRQ and the MFB.

6.17.4 Fast Link Adaptation using explicit feedback

Explicit feedback mechanism can be used for Link Adaptation. The CSI matrices feedback may be used for this purpose.

6.18 Zero Length Frame as sounding frame

If an HT-STA has indicated receive capability for zero-length sounding frames in the HT capabilities IE during association, that STA shall process a zero-length MAC frame (ZLF) as a sounding frame if the destination of the sounding frame is determined to match itself as described in this subclause, and if the source of the sounding frame can be ascertained as described in this subclause.

The indicated MAC length of zero within a ZLF shall be an implicit indication that the frame is a sounding frame.

Only the current TXOP owner or RDG grantee shall be permitted to send a ZLF frame.

A transmitter that sends a ZLF shall send the ZLF within SIFS of sending a non-ZLF frame with the ZLF Announcement bit set to 1 which does not require an immediate response or within SIFS of successfully receiving a correctly formed and addressed immediate response to a non-ZLF frame with the ZLF Announcement bit set to 1 which required an immediate response. This rule insures that the ZLF receiver knows that it will receive a ZLF, and that it can ascertain the source and destination of the ZLF.

Feedback from the reception of the ZLF shall be transmitted using unsolicited feedback rules and signaling.

If the reception immediately preceding (within SIFS of the start of the ZLF) the ZLF has an FCS error, then the ZLF shall be dropped by the receiver.

A transmitter may transmit a ZLF within SIFS of a previously transmitted ZLF.

6.18.1 Determination of ZLF destination

The destination of a ZLF is determined at the ZLF receiver by examining the immediately previous (within SIFS) frame (with respect to the ZLF and with the ZLF Announcement bit set to 1) of a frame exchange as follows:

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[4] The HT Control field may be included in the immediate response frame for other reasons, since HT Control field supports other features, including MRQ in the opposite direction.

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If the immediately previous frame at the ZLF receiver was a transmission by the TXOP owner or the current RDG grantee, then the destination of the ZLF is equal to the RA of that immediately previous frame.

If the immediately previous frame at the ZLF receiver was a transmission by a STA which is not the TXOP owner or RDG grantee (i.e. a responder to the TXOP owner or RDG grantee), then the destination of the ZLF is equal to the TA of that immediately previous frame.

6.18.2 Determination of ZLF source

The source of a ZLF is determined at the ZLF receiver by examining the immediately previous (within SIFS) frame (with respect to the ZLF and with the ZLF Announcement bit set to 1) of a frame exchange as follows:

If the immediately previous frame at the ZLF receiver was a transmission by the TXOP owner or the current RDG grantee, then the source of the ZLF is equal to the TA of that immediately previous frame.

If the immediately previous frame at the ZLF receiver was a transmission by a STA which is not the TXOP owner or RDG grantee (i.e. a responder to the TXOP owner or RDG grantee), then the source of the ZLF is equal to the RA of that immediately previous frame.

6.19 Transmit Beamforming

6.19.1 Introduction (Informative)

In order for a transmitting STA to calculate an appropriate steering matrix for transmit spatial processing when transmitting to a specific receiving STA, the transmitting STA needs to have an accurate estimate of the channel that it is transmitting over. There are generally two ways of doing this:

- Implicit feedback
- Explicit feedback

With implicit feedback, the Initiator STA receives training symbols (HT-LTFs) from the Responder STA.

If the channel is reciprocal, then the initiator can use the training symbols that it receives from the responder to make a channel estimate suitable for computing transmit steering matrix. Generally, reciprocity requires calibrated RFs in MIMO systems. This will be discussed below.

With explicit feedback, the responder makes a direct estimate of the channel that the initiator is preparing to transmit over, from training symbols sent to the responder from the initiator. The responder may prepare Channel State Information or Steering Matrices. The responder quantizes the result and sends it back to the initiator, which then uses it as is or computes the steering matrix using the data returned by the responder.

6.19.2 Transmit Beamforming with Implicit Feedback

The following section explains AP behavior as a beamformer sending data frames to a station. The same rules apply to non AP stations as well. The AP should be calibrated for best performance, while the receiving client STA does not need to be calibrated for best performance, as long as it does not do transmit beamforming.

To fully support transmit beamforming exchanges that only involve receiving beamformed PPDUs from another STA (receive-only transmit beamforming), the receive-only beamforming STA must:

Fully support transmission of sounding PPDUs.

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A station that transmits beamformed PPDUs must be capable of:

Receiving sounding PPDUs

Computing steering matrices from channel estimates obtained from HT-LTFs received responder STA

The responder that supports calibration exchange shall:

Receive and transmit sounding PPDUs

Respond with MIMO channel measurement obtained from receiving of the sounding PPDU

The Initiator that supports calibration exchange shall:

Receive and transmit sounding PPDUs

At the end of the TXOP, the final data frame from the initiator, shall not have the TRQ set to '1'if there not enough time left in the TxOP to get the responses.

The frame exchange used in implicit transmit beamforming is shown in Figure 38

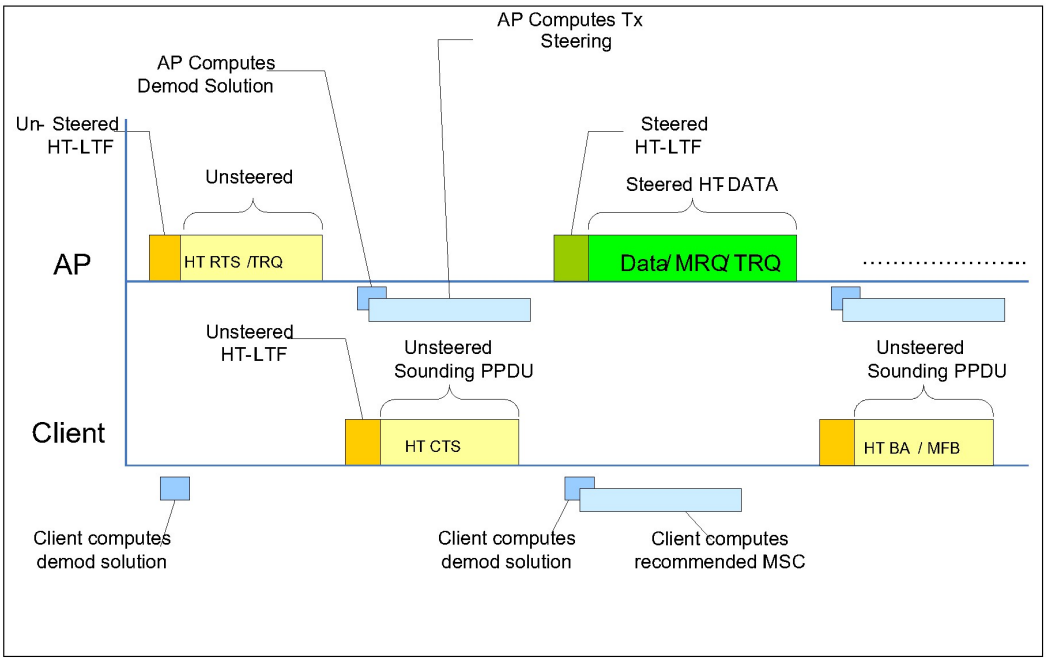


Figure 38 – Frame Exchange Sequence for Transmit Beaforming with Implicit Feedback

The frame exchange can be summarized as follows:

1. The initiating AP sends an un-steered sounding PPDU to the client. The PPDU includes a training request; the sounding PPDU is required.
2. The responding STA returns a sounding PPDU

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3. On receiving the sounding PPDU, the initiating AP uses the resulting channel estimate to compute steering matrices, using SVD or other techniques, and uses the resulting steering matrices for sending a beamformed PPDU back to the responder.
4. Repeat steps 2 and 3. If the channel estimate resulting from step becomes stale because of delay, then the sequence can be restarted by returning to step 1.

6.20 Explicit feedback beamforming

6.20.1 Introduction (informative)

When using explicit beamforming the initiator is using feedback it receives from the responder to calculate the steering matrices for beamforming. The feedback may have 1 of those 3 formats:

- Channel State Information – The responder sends to the initiator the MIMO channel coefficients.
- Uncompressed steering matrices – the responder sends to the initiator the calculated steering matrices, the transmitter may use those for transmission as the steering matrices.
- Compressed steering matrices – the responder sends to the initiator the compressed steering matrices, the transmitter may use those for transmission as the steering matrices after the de-compression of the data.

6.20.2 Feedback requesting and responding rules

Feedback rules:

Immediate – the receiver shall return the feedback SIFS after end of the PPDU that contains the related request. The feedback can be a single frame or aggregated with another response. The transmitter shall issue next PPDU not earlier than PIFS after the PPDU with request while not getting the expected feedback.

Aggregated – the receiver may return the feedback in aggregation with another response. The transmitter shall not request the aggregated feedback if there is not enough time left in TxOP. The transmitter shall not expect getting the feedback of each request.

Unsolicited – the receiver shall return the feedback by its own link access. Unsolicited request may be submitted once per association to inform the responder what is the expected type of feedback.

The Responder shall use QoS Null +_HTC frame with the MA field of the HTC set to 1 for immediate and aggregated feedback of CSI Matrices, Uncompressed Steering Matrices, and Compressed Steering Matrices frames. The Ack policy shall be set to No Ack in the QoS control field.

6.20.3 Transmit Beamforming with explicit Feedback

In this example the AP requests and uses the explicit feedbacks of CSI for computing the steering matrices for transmit beamforming (Figure 39). A similar frame exchange can also accommodate computation of the steering matrices at the responder. In this case, instead of sending back CSI, the responding STA will return quantized steering matrices to the initiating AP, and the AP may use it for transmission. The feedback of steering matrices can be compressed or uncompressed. The type of information returned to Initiator is subject of advertised capabilities. The same rules apply to non AP stations as well.

The sequence is as follows:

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1. The sequence is initiated by an AP which sends an un-steered sounding PPDU containing a CSI Feedback Request.
2. The responding client STA uses the sounding packet to make a channel estimate, and collects the CSI of the channel
3. The CSI are quantized and returned to the AP in a PPDU containing a CFB (CSI FeedBack) message.
4. The AP uses the result to transmit a steered PPDU to the client STA. If the AP has subsequent PPDUs to send in steered mode, this PPDU may also be a sounding PPDU.
5. Steps 2, 3, and 4 may be repeated for an ongoing beamforming exchange. If latencies cause the channel estimates or steering matrices to get stale, then step one need to be repeated.

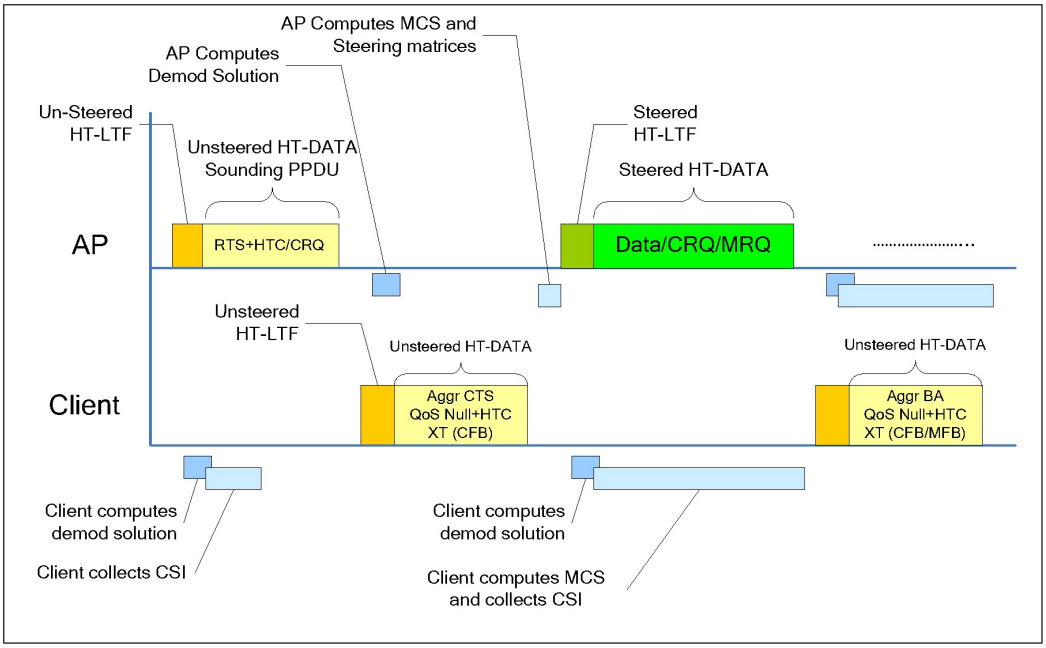


Figure 39 – Frame exchange for transmit beamforming with explicit feedback

6.21 Calibration

6.21.1 Introduction (Informative)

Transmit beamforming can operate with or without calibration assistance from the receiver. Support for calibration is optional.

Differences in transmit and receive chains in a STA or AP destroy the inherent reciprocity of the over-the-air Time Division Duplex channel. Calibration is helpful in order to remove differences in transmit and receive chains and enforce reciprocity in the observed baseband-to-baseband channels. A simple over-the-air calibration procedure effectively corrects for these differences. The calibration procedure ensures that the observed channel matrices in the two directions of the link are transposes of each other and thus renders the resultant channel reciprocal. Thus, if they are able to do so, STAs calibrate upon association. Calibration is applicable to any square or non-square dimensionality, i.e., N_{Tx} and N_{Rx} greater than one and less than five.

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6.21.2 Procedure

A STA shall only initiate a calibration training frame exchange sequence with another device that supports calibration.

The calibration procedure begins with a Calibration Sounding frame exchange sequence, illustrated as Step 1 in Figure 40:

- STA A transmits a Calibration Start frame (Position field = '01') and TRQ = '1'. This frame initiates a calibration procedure. An immediate response with a sounding PPDU is required.
- In response, STA B transmits a Calibration Sounding Response (Position field = '10') and TRQ=1 after a SIFS interval, which includes sounding (HT-LTFs) that allow STA A to estimate the MIMO channel from STA B to STA A.
- In response, STA A transmits a Calibration Sounding Complete (Position field = '11') after a SIFS interval, which includes sounding (HT-LTFs) that allow STA B to estimate the MIMO channel from STA A to STA B.

To ensure that the reciprocal channel changes as little as possible during the Calibration Sounding frame exchange sequence, STAs should use short non-aggregate frames in the Sounding Response and Sounding Complete PPDUs.

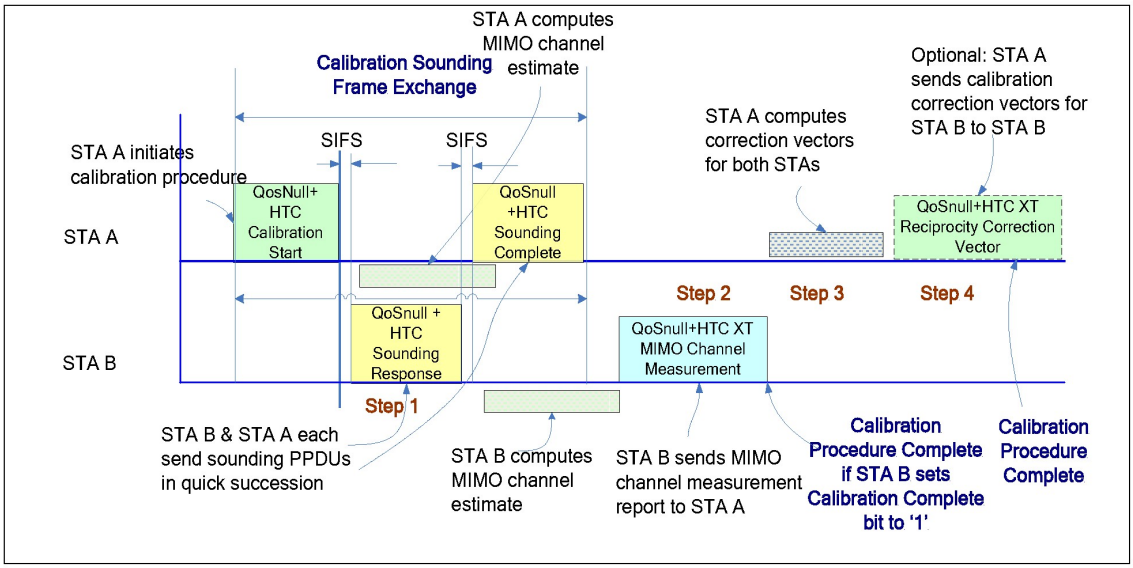


Figure 40 – Calibration Procedure

The remaining message exchange in the calibration procedure is not time critical.

When the MIMO channel measurements become available at STA B, STA B sends one or more MIMO Channel Measurement frames that contain the MIMO Channel Measurement Report (Step 2 in Figure 40). STA B sets the Calibration Complete bit to '1' in this packet in case the STA B is not capable of transmit beamforming or does not desire to obtain its Reciprocity Correction matrices from STA A. In this case STA A will not send Reciprocity Correction frame and the calibration procedure is complete.

In case that both STAs are capable of transmit beamforming, once STA A has the MIMO Channel Measurement Report from STA B, along with its local channel measurement measured from the Calibration Sounding Response transmitted by STA B, STA A can compute the correction matrices required for both itself and STA B (Step 3 in Figure 40). If STA B did not set the Calibration Complete

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bit to in the MIMO Channel Measurement frame to '1', STA A transmits the Reciprocity Correction frame to complete the calibration procedure (Step 4 in Figure 40). The message includes the Reciprocity Correction Vector for STA B which provides reciprocity correction on the receive channel estimates at STA B. STA B applies the supplied reciprocity correction to its transmit chain. The Calibration Complete bit in the Reciprocity Correction frame is set to '1'.

6.22 Antenna Selection

6.22.1 Introduction (Informative)

Antenna selection is a possibly 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 channel state information. Antenna selection 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 one TXOP. To avoid channel distortions, these PPDUs shall be transmitted consecutively. The training information is exchanged by the HT control field, transparent in PHY. When both transmitter and receiver have antenna selection capabilities, training of TX and RX antennas can be done one after another. It is constrained that the number of antenna elements in any STA is no more than 8, while the number of RF chains is no more than 4.

6.22.2 Procedure

An STA shall only initiate an AS training frame exchange sequence with another device that supports AS.

When transmitter conducts antenna selection, the frame exchange sequence for transmit antenna selection is shown in Figure 41.

1. (Optional) Receiver may initiate the transmit antenna selection training by sending a TX AS sounding request.
2. The transmitter sends out consecutive sounding PPDUs or ZLFs separated by SIFS in a TXOP using burst transmission with no ACK over different antenna sets, with setting TX AS sounding indication, and sounding frame format. A single sounding PPDU or ZLF is transmitted over one antenna set.
3. (Informative) For example, in case of sounding over all disjointed antenna sets, the number of consecutive sounding PPDUs or ZLFs 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.
4. The receiver estimates the subchannel corresponding to each sounding PPDU or ZLF.
5. After receiving all the consecutive sounding PPDUs or ZLFs, the receiver may either explicitly feedback the full size channel state information, or conduct antenna selection computation and feedback the selected antenna indices in a subsequent TXOP. The feedback format follows Table 5
   - When feeding back the full size channel information, the QoS Null +HTC with MA field of the HTC set to 1 is used for MIMO CSI Matrices frame feedback defined in subclause 5.4.6. Multiple CSI Matrices frames may be required to feedback the full size channel, and all these frames of one feedback should set identical explicit feedback sequence number.
   - When feeding back the antenna indices, QoS Null + HTC frame with MA field of the HTC set to 1 is used for antenna selection indices feedback defined in subclause 5.4.9. One octet in antenna selection indices field is used to feedback the selected antenna indices.

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- In the case that the receiver does not correctly receive the sounding PPDUs or ZLFs, or the current feedback is outdated, the receiver sends one frame + HTC setting MRQ='0', ASI='111', the command part in ASC='110' to indicate the failure of antenna selection training process.

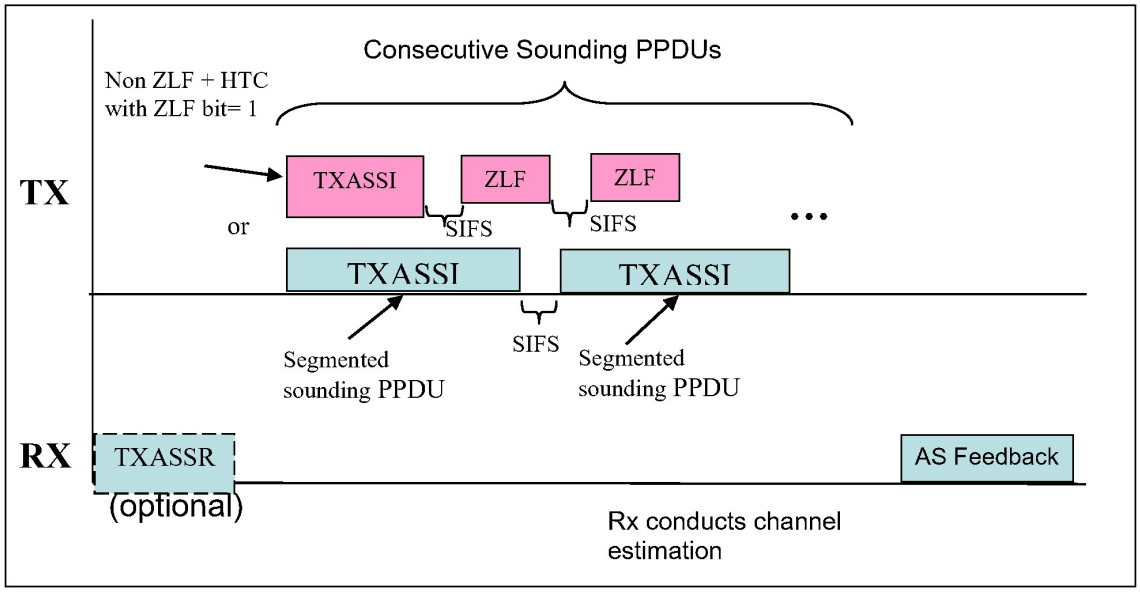


Figure 41 – Frame Exchange Sequence of Transmit Antenna Selection

When receiver conducts antenna selection, the frame exchange sequence is shown Figure 42 – Frame Exchange Sequence of Receive Antenna Selection.

1. The receiver sends out a frame + HTC setting RX AS sounding request in the command part of ASC subfield in HTC field, and the data part in ASC to indicate the number of total sounding PPDUs required.
2. (Informative) For example, in case of sounding over all disjointed antenna sets, the number of total consecutive sounding PPDUs or ZLFs equals the smallest integer that is greater than or equal to the number of antennas divided by the number of RF chains.
3. The transmitter responds with the corresponding number of sounding PPDUs or ZLFs in its subsequent TXOP, using burst transmission with no ACK, with setting RX AS sounding indication, and sounding frame format.
4. The receiver uses different antenna sets to receive these sounding PPDUs or ZLFs, estimates channel state information after receiving all these sounding PPDUs or ZLFs, and conducts the antenna selection.

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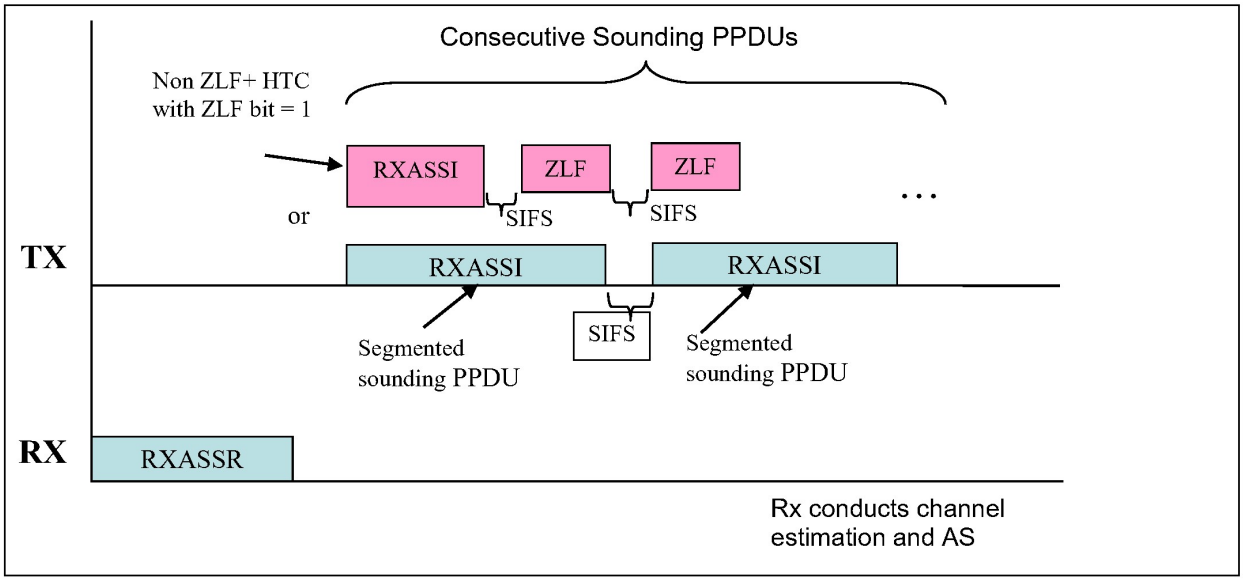


Figure 42 – Frame Exchange Sequence of Receive Antenna Selection

7 MAC sublayer management

7.1 Probe responses (informative)

The Probe request contains the HT Capabilities element. This enables a STA transmitting a probe response to ensure that it selects an MCS supported by the intended receiver.

The AP transmits a probe response using an MCS from the supported MCS set received in the HT capabilities element of the corresponding Probe request.

7.2 Coexistence management

7.2.1 Operating Modes (Informative)

The operating modes of an HT BSS are defined in the following table. These modes the kind of protection used for HT transmissions. Both AP and non-AP STA use the same protection mechanism (RTS/CTS and CF-end). No AP managed protection mechanisms are defined. Support of the AP centric PCO mechanism is optional.

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Table 45 – Operating Modes according to Band and BSS Capability

Band	BSS capability	Definition of Mode
5.2 GHz	40/20MHz	Main operational HT mode. The BSS occupies two adjacent 20MHz channels. 40MHz, 20MHz HT and legacy devices can be associated in the same BSS. 20MHz devices can be associated only on the control channel. Other (overlapping) BSSs may sit in the extension channel. Beacon are sent in legacy mode in the control channel only. RTS/CTS, MPDU/Ack, OR self CTS may be used to establish Long NAV protection of TxOP.
	20MHz	BSS occupies a 20MHz channel. 40/20MHz operating as 20MHz, 20MHz HT and legacy devices can be associated in the same BSS. Beacon will be sent in legacy mode. RTS/CTS, MPDU/Ack, OR self CTS may be used to establish Long NAV protection of TxOP.
	PCO	Phased Coexistence Operation (PCO) is an optional BSS mode with alternating 20 MHz phase and 40 MHz phase controlled by PCO AP. PCO capable AP shall advertise its BSS as 40/20 MHz capable and PCO capable. PCO capable AP also advertises its PCO operation status. PCO capable STA shall associate with BSS as PCO STA when PCO active bit in Additional HT information element is set to 1 and when its transition time meets the time indicated by PCO AP. If the previous condition is not met, then PCO capable STA regards the BSS as 40/20 MHz BSS and may associate with the BSS as 40/20 MHz STA. Non PCO capable STA regards the BSS as 40/20 MHz BSS and may associate with the BSS as in normal.
2.4 GHz	40/20MHz	Main operational HT mode. Occupies two adjacent 20MHz channels. 40MHz, 20MHz HT and legacy devices can be associated in the same BSS. 20MHz devices can be associated only on the control channel. Other (overlapping) BSSs may sit in the extension channel. Beacon is sent in legacy mode in the control channel only. RTS/CTS, MPDU/Ack, OR self CTS may be used to establish Long NAV protection of TxOP. This protection may be required, depending on the setting of the operating mode bits of the HT additional information element. When used, this protection shall be done either in OFDM duplicate legacy format or DSSS/CCK legacy format
	20MHz	Support of CCK, OFDM and HT frames on per frame basis

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	PCO	Phased Coexistence Operation (PCO) is an optional BSS mode with alternating 20 MHz phase and 40 MHz phase controlled by PCO AP. PCO capable AP shall advertise its BSS as 40/20 MHz capable and PCO capable. PCO capable AP also advertises its PCO operation status. PCO capable STA shall associate with BSS as PCO STA when PCO active bit in Additional HT information element is set to 1 and when its transition time meets the time indicated by PCO AP. If the previous condition is not met, then PCO capable STA regards the BSS as 40/20 MHz BSS and may associate with the BSS as 40/20 MHz STA. Non PCO capable STA regards the BSS as 40/20 MHz BSS and may associate with the BSS as in normal.

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7.2.2 STA Capabilities (Informative)

This section summarizes the operation of a STA operating according to this specification based on the combination of BSS and STA width capabilities.

Table 46 – STA operation according to BSS Capability and STA width capability

BSS capability	STA capability	Rx 40MHz	Rx 20Mhz HT control	Rx Legacy in control	Rx legacy dupl.	Tx 40 MHz	Tx 20 MHz HT	Tx legacy in control	Tx legacy dupl	Comments
40/20 MHz	40/20 MHz	Yes	Yes	Yes	Cntrl chan only	Yes	Yes	Yes	Yes	STA may transmit/receive in 40MHz as well in 20MHz control channel.
40/20 MHz	20 MHz	No	Yes	Yes	Cntrl chan only	No	Yes	Yes	No	STA is 20Mhz capable and shall be able to transmit/receive 20MHz HT and legacy frames.
20 MHz	20 MHz	NA	Yes	Yes	NA	NA	Yes	Yes	NA	20Mhz HT Tx Mode, all AP modes supported
PCO	PCO	Yes	Yes	Yes	Cntrl chan only	Yes (40 MHz Phase only)	Yes (20 MHz Phase only)	Yes (20 MHz Phase only)	Yes (40 MHz Phase only. Except CF-end)	Transition by PCO STA shall obey 40 MHz phase and 20 MHz phase indicated by PCO AP. PCO STA shall use 40 MHz native MCS to send CF-end.
PCO	40/20 MHz	Yes	Yes	Yes	Cntrl chan only	Yes	Yes	Yes	Yes	STA may transmit/receive in 40 MHz as well as in 20 MHz control channel.
PCO	20 MHz	No	Yes	Yes	Cntrl chan only	No	Yes	Yes	No	STA is 20 MHz capable and shall be able to transmit/receive 20 MHz HT and legacy frames.

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7.3 Channel management

7.3.1 Rules for operation in 40/20Mhz BSS

A 40/20 Capable STA operating in 20MHz mode follows the rules for a 20MHz capable STA.

A 40/20 Capable STA operating under PCO operates the rules defined in section 7.4.

A 40/20 Capable STA operating under L-SIG TXOP protection operates the rules defined in section 6.1.3.2.

Otherwise, it shall operate as defined in this section.

7.3.1.1 Basic functionality in BSS 40/20Mhz mode

An HT AP declares its capabilities in the HT capability element contained in each beacon. Protection requirements for HT frames are part of the HT additional information element transmitted by the AP..

Long NAV protection may be used to protect TxOP of several frames.

40/20MHz capable stations, 20MHz capable stations and legacy stations may be associated in the 40/20Mhz capable BSS.

An HT non-AP STA declares its own capabilities by the Supported Channel Width Set in the HT capability element issued with association request.

The STA may switch between 40/20MHz capable and 20MHz capable operation by disassociation and (re-)association.

The 40/20MHz capable STA will transmit/receive its own HT frames in 40MHz channel or in the 20MHz control channel.

The Set recommended transmission channel width action frame may be used by a STA station to choose an actual channel width. Transmission of this frame by a non-AP STA requests that the AP send frames in indicated width. This frame shall be sent in the control channel using legacy mode

It may use BSSBasicRateSet OFDM legacy frames for protections of 20 MHz HT transmit/receive in control channel unless the Use Protection field of the ERP information element as defined in 9.10 of IEEE 802.11g-2003 is set. If set, DSSS/CCK frames shall be used for protection.

A 20MHz capable station shall transmit/receive HT frames in the 20MHz control channel and may use BSSBasicRateSet OFDM legacy frames for protection unless the Use Protection field of the ERP information element as defined in 9.10 of IEEE 802.11g-2003 is set. If set, DSSS/CCK frames shall be used for protection.

The 40/20MHz capable BSS use protection to avoid collision between 20MHz capable stations and other 40/20 capable stations working in 40MHz channel as described in section 7.3.1. Note: These stations can collide because the 20MHz capable stations cannot respect virtual carrier of the 40MHz capable stations.

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Table 47 – AP Mode Definitions

AP Mode	Beacon Transmission	Indicated STA operation	Protection (per Indicated STA operation)
5.2GHz band BSS 40/20Mhz	Legacy OFDM	40MHz	Duplicated legacy OFDM
5.2GHz band BSS 40/20Mhz	Legacy OFDM	20MHz HT	Legacy OFDM
5.2GHz band BSS 20Mhz	Legacy OFDM	20MHz HT	Legacy OFDM
2.4GHz band BSS 40/20Mhz	Legacy DSSS/CCK or OFDM*	40MHz	Duplicated legacy OFDM
2.4MHz band BSS 40/20Mhz	Legacy DSSS/CCK or OFDM*	20MHz HT	Legacy DSSS/CCK or OFDM**
2.4GHz band BSS 20Mhz	Legacy DSSS/CCK or OFDM*	20MHz HT	Legacy DSSS/CCK or OFDM**

* As determined by the BSSBasicRateSet.

** If the Use_Protection field of the ERP information element as defined in 9.10 is set, DSSS/CCK frames are used for protection; otherwise, OFDM frames are used in the BSSBasicRateSet.

7.3.1.2 STA CCA sensing 40/20MHz BSS

A STA transmitting a 40MHz PPDU (either a 40MHz HT PPDU or a legacy duplicate PPDU) shall sense CCA on the 20 MHz control channel and may sense CCA on the 20 MHz extension channel and combine the result with that from the control channel. Note: This allows far-away overlapping BSSs on the extension channel to be ignored or to inhibit 40 MHz transmissions as a matter of policy.

A STA transmitting a 20MHz PPDU shall sense CCA of the control channel only. Back-off and AIFS are derived from the corresponding CCA used for transmission.

Note: In addition a STA may obtain a CCA indication from extension channel or be able to receive and compare from both control and extension channels.

7.3.1.3 AP CCA sensing in 40/20Mhz BSS

The AP CCA sensing rule in 40/20MHz BSS is the same as STA CCA sensing rule.

7.3.1.4 NAV assertion in 40/20Mhz BSS

STA will assert NAV in accordance to duration of any frame received in control or 40MHz channel.

A STA does not have to set its NAV in response to 20MHz frames received on the extension channel, even if it is capable of receiving those frames.

7.3.1.5 Frame transmission in 40/20Mhz BSS

A station that has to transmit a response control frame it responds using same channel as the related frame has been received as described in this section.

In 40MHz mode, A 40/20 STA that receives a legacy duplicate control frame shall respond with a legacy duplicate PPDU.

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In 40MHz mode, A 40/20 STA that cannot distinguish between the reception of legacy PPDU and a legacy duplicate PPDU that receives a legacy control frame shall respond a legacy duplicate PPDU.

A 40/20 capable STA in 20MHz mode shall transmit HT or legacy control frames in the control channel.

7.3.1.6 Protection in 40/20MHz BSS

A STA transmitting a 40MHz PPDU shall ensure this transmission is protected if its AP indicates there are 20Mhz capable HT Stations and/or Legacy Stations associated in the same BSS. Operating mode = 11 or 10 in the Additional HT information element indicates this case.

If such protection is needed, it shall be implemented in the following way: legacy control frames RTS/CTS, MPDU/Ack or AMPDU/BA, or CTS-to-self may be used for protection. MPDU/Ack may only be used for protection of the transmission in a 20MHz wide channel. CF-end may be used to return the reserved but unused time of the TXOP.

A STA actually transmitting in 40MHz mode shall transmit an RTS or CTS-to-self in legacy duplicate mode, as well using the legacy duplicate mode when transmitting a CTS response.

A 40 MHz capable station shall be able to receive duplicated frames at least on the control channel.

If the control frame does not contain any feedback request or response the following rule shall work relative to the actual channel width: 20 MHz packet uses 20 MHz legacy ACK/BA; 40 MHz packet uses duplicate legacy ACK/BA. See more details of the legacy duplicated in the section 7.3.1.8.

The HT PPDU shall be used if the response contains link adaptation and explicit channel state feedback; the request channel width shall be the same as the intended data transmission width and the response channel width shall be the same as the request width.

7.3.1.7 CF-end in duplicated mode

A STA that uses a legacy duplicate mode to establish protection of its TXOP shall send any terminal CF-end in legacy duplicate mode.

7.3.1.8 ACK and BA in legacy duplicated mode

A STA shall behave in the following way if it uses legacy duplicated mode for protection.

Non-aggregated 40MHz frames shall be acknowledged by ACK in legacy duplicate mode.

A non-aggregated BAR shall be transmitted in legacy duplicate mode if the STA is operating in a 40MHz mode.

A non-aggregated BA shall be sent in legacy duplicated mode if it is a response to a PPDU that is a 40MHz type.

7.3.1.9 STA switching from 40MHz to 20MHz in 40/20MHz BSS

Once associated a non-AP STA shall support the same channel width capabilities it declared in its association request. This capability is asserted in Supported Channel Width Set in the HT capabilities element.

When a STA is associated with an AP that declares a Supported Channel Width of 20/40 MHz, the STA may transmit frames in the 20Mhz wide control channel as well as the 40Mhz wide channel.

The AP may communicate its Recommended transmission Width Set either by transmitting the Additional HT Information Element (in beacons and probe response frames) or by transmitting the Set Recommended transmission Channel Width management action frame.

A 20/40 MHz capable non-AP STA in a 20/40MHz capable BSS may request its peer to send frames of 20 or 40 MHz width. The STA uses the Set Recommended transmission Channel Width management action frame for this purpose.

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The reaction of both STA and AP to switch the channel width may be not immediate after receiving these frames. The STA that has transmitted one of these frames shall decide that the related request has been adopted when getting first HT frame of requested Recommended Transmission Width.

Note: STA should be aware that recommending a transmission width of 20MHz has no effect on the BSS behavior regarding protection of 40MHz sequence. If it is necessary to obtain this protection, the STA should re-associate with 20MHz-only capability.

7.3.2 STA asking for MIMO Power Save support

A MIMO device consumes power on all active Rx chains, even though they are not necessarily required for the actual frame exchange.

The MIMO Power Save feature allows a STA to spend most of its time with only one active Rx chain. In the case of dynamic MIMO power save mode, it enabled its multiple Rx chains when it receives the start of a sequence directed to it. Such a sequence shall start with a single-spatial stream unicast MPDU addressed to it. Legacy RTS/CTS sequence may be used for this purpose. The receiver switches to the multiple Rx chain mode when it gets the RTS directed to it and switches back immediately when the TxOP ends.

The Receiver cannot distinguish between RTS/CTS sequence that precedes true MIMO transmission and any other RTS/CTS and therefore always enables its multiple Rx chains when it sees an RTS directed to it.

A STA may use the MIMO Power save management action frame to inform its peers of its MIMO Power Save state. A non-AP STA may also use MIMO 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 Rx chain immediately after association.

There may be a delay at a STA receiving the action frame to respond to any change. A STA that transmits this frame should wait to receive the related RTS for transitions into dynamic MIMO power save mode before locally operating its MIMO power save mode.

7.3.3 STA reducing MIMO capability

The Station uses the HT capabilities IE to signal whether it is MIMO capable when gets associated.

The STA enables its MIMO capabilities accordingly the Max number of Rx spatial channels of the HT capability element it sends in its Association Request when it associates.

The station may dynamically disable/enable its MIMO capabilities and inform its peers using the Reduce MIMO Capability management action frame.

A STA shall not send any MIMO PPDUs to a peer that is in static MIMO power save mode, as determined by receiving this management action frame.

There may be a delay at a STA receiving the action frame to respond to any change. A STA that transmits this frame should wait a beacon period for transitions into static MIMO power save mode before locally operating its MIMO power save mode.

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7.3.4 Channel Management at the AP

An HT AP shall receive the beacons of other HT BSSs on its channel when it first powers up.

It may receive these beacons later as part of background scanning.

HT BSSs shall only overlap HT BSSs with the same control channel and extension channel location. [5]

AP may switch the BSS capability between 40/20MHz and 20MHz by changing the value of the Supported Channel Width Set field of the HT capability information element in the Beacon. The Station shall de-associate/associate or re-associates to accommodate the new capability. Doing that movement the AP should take in consideration the Stations that actually are in sleeping mode.

7.4 Phased Coexistence Operation

Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a BSS operates in alternating 20 MHz and 40 MHz phases under the control of PCO AP. PCO AP reserves the 20 MHz control channel and the 20 MHz extension 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. The process is illustrated in Figure 43. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

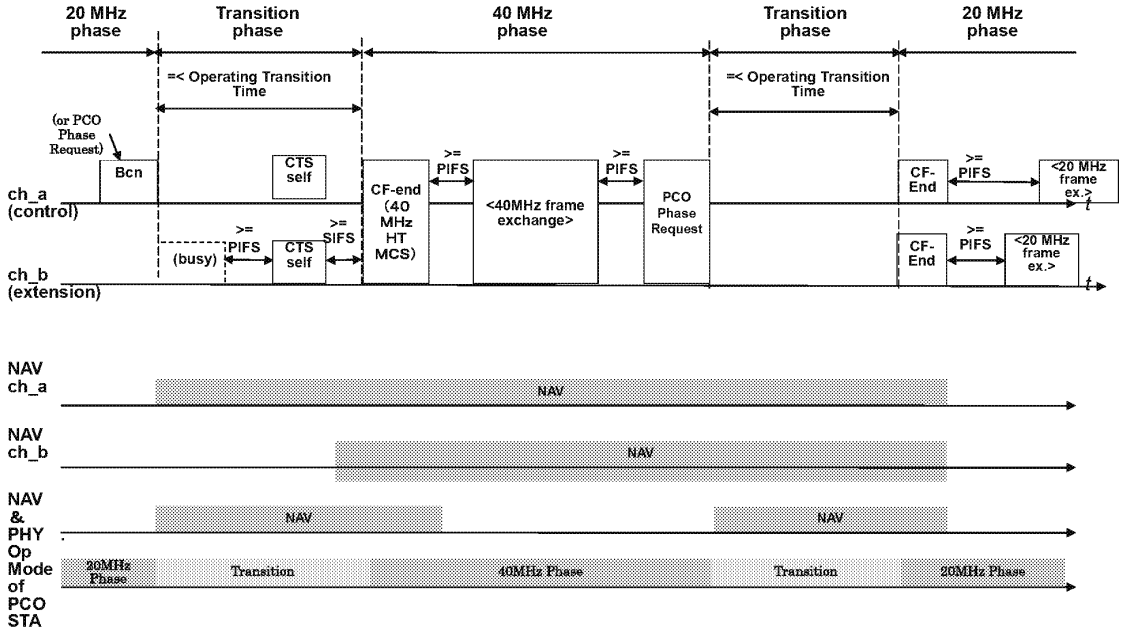


Figure 43 – Phased Coexistence Operations

A PCO capable AP activates PCO if it considers PCO is more appropriate than 40/20 MHz mode and 20 MHz mode in the current circumstances.[6] The PCO capable AP advertises its BSS as both 40/20 MHz

[5] This, together with the requirement for the same basic width set ensures that any pure-mode control frames sent in one BSS can be received in any overlapping HT BSS.

[6] PCO capable AP may consider the capabilities of associated STAs as well as the interferences between the BSS and OBSSs to determine the BSS operation mode.

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capable and PCO capable. It also advertises its PCO operation status. A Non PCO capable STA regards the BSS as 40/20 MHz BSS and may associate with the BSS as in normal.

During the 40 MHz phase of PCO, PCO AP and PCO STA shall send CF-end in 40 MHz HT mode.

7.4.1 Rules for Operation at PCO AP

A PCO capable AP declares its capabilities by HT capability element and the PCO operation status by Additional HT information element included in each beacon. The PCO capable AP shall advertise the BSS as PCO capable and 40/20 MHz capable. A PCO capable AP becomes a PCO AP when PCO is activated in BSS and the PCO active bit in Additional HT information element is set to 1.

When a PCO AP detects that the PCO is not gaining performance, the PCO AP may deactivate PCO and go to either 40/20 MHz mode or 20 MHz mode. A PCO capable AP shall set PCO mode bit in Additional HT information element to 0 when PCO is deactivated. Since the AP advertises the current mode in its beacons, its associated STAs can detect the mode change and may take appropriate action.

If an AP chooses to maintain PCO mode and a 40/20 MHz capable non PCO capable STA is associated, the PCO AP shall choose the operation mode using 40 MHz channel width, in which PCO AP can receive and transmit 40 MHz frame during 20 MHz PCO phase.

The PCO AP may extend the transition time if PCO capable STA associates whose transition time is larger than the one currently used by PCO AP. The method of notification by PCO capable STA is described in the following clause.

After a PCO AP sends a PCO phase request indicating switch to 40 MHz phase in beacon or in the action frame, it shall wait for at least the transition time before sending a CF-end in the 40 MHz channel to start the 40 MHz operating phase. Likewise, after it sends a PCO phase request to switch to the 20 MHz phase, it shall wait for at least a transition time before sending out a CF-end in duplicated legacy mode to start the 20 MHz operating phase (see Figure 43).

The NAV in a CFP, a CTS-to-Self, a beacon or a PCO phase request that are sent by PCO AP in order to reserve the medium for the 40 MHz phase shall include the transition time between 20 MHz **channel width** and 40 MHz **channel width** operation. If a PCO AP intends to continue the CFP after the 40 MHz phase, it may do so by setting a longer duration for the CFP.

A CTS-to-self shall be sent in duplicated legacy mode. In order to issue this frame, the PCO AP shall sense the extension channel clear at least PIFS period. The PCO AP need not sense the control channel at that moment since it is already reserved by CFP. *(Notes: The carrier sense mechanism for the extension channel is TBD.)*

To avoid an unexpectedly long delay for the extension channel access before 40 MHz phase, the PCO AP starts a timer with a timeout value equal to transition time after transmitting the beacon or a PCO phase request action frame. If the timer expires while attempting to reserve the extension channel, the AP abandons switching to the 40 MHz phase by transmitting a PCO phase request action frame indicating switch-back to 20 MHz phase and a CF-end frame both on the control channel. If the timer expires when the extension channel is already reserved but 40 MHz phase is not started yet, the AP abandons switching to the 40 MHz phase by transmitting a PCO phase request action frame indicating switch-back to 20 MHz phase and a CF-end frame in duplicated legacy mode.

Although PCO improves throughput in some circumstances, PCO can also introduce jitter. To minimize the jitter, the maximum duration of 40 MHz phase and 20 MHz phase is TBD msec and TBD msec, respectively. Also in order for PCO AP to give chances for every STA to send frames, the minimum duration of 40 MHz phase and 20 MHz phase is TBD msec and TBD msec, respectively.

The PCO AP exchanges frames with PCO STAs using 40 MHz HT MCS and duplicated legacy in a 40 MHz phase. However in this phase, PCO AP shall not send a legacy or duplicate legacy CF-end frame but may send CF-end in 40 MHz HT MCS.

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7.4.2 Rules for Operation at PCO STAs

A PCO capable STA declares its own capabilities by the Extended HT Capabilities Info field in the HT capability element of association request. If in the association request to a PCO AP, the PCO bit is set to 1, transition time meets the transition time indicated by PCO AP, and the association succeeds, then the STA shall work in PCO mode. The PCO STA may also try to associate with transition time that is larger than one currently advertised by PCO AP. In this case the PCO AP may decide to extend its transition time and to respond with this new transition time value. Also in this case the STA shall work in PCO mode. If the association succeeds but the related PCO parameters does not meet the PCO STA values, it shall regard the BSS as 40/20 MHz BSS and shall work as 40/20 MHz STA. Non PCO capable STA shall see this BSS as regular 40/20 MHz capable.

A PCO STA associated with PCO AP may switch its operating phase from 20 MHz channel width to 40 MHz channel width when it receives a beacon frame that contains the PCO phase request bit set to 1 or a PCO phase request action frame with the PCO phase set to 1. The related CFP or duration value shall be interpreted as the duration of the PCO 40 MHz phase.

A PCO STA associated with a PCO AP may switch its operating phase from 40 MHz channel width to 20 MHz channel width when it receives a beacon frame that contains the PCO phase request bit set to 0 or a PCO phase request action frame with the PCO phase set to 0. It also may switch from 40 MHz channel width to 20 MHz channel width when the expected 40 MHz phase duration ends.

During the 40 MHz phase a PCO STA shall transmit data frames using 40 MHz HT MCS and control frames in duplicated legacy mode but the CF-end frame shall be sent in 40 MHz HT MCS only. In the 40 MHz phase PCO STA will set NAV in accordance to duration of any frame received in control or 40 MHz channels.

During the 20 MHz phase the PCO STA shall only transmit frames using a 20 MHz (HT or legacy) MCS.

A PCO capable STA shall follow the BSS operation mode by examining the beacons. In particular, A PCO STA shall change the operation mode from PCO if PCO mode is deactivated by AP. A STA may disassociate and re-associate with AP to change its operation mode.

7.5 Management of Scheduled PSMP

7.5.1 Introduction (Informative)

Scheduled PSMP is created by AP in response to first TSPEC request. The main purpose of the TSPEC is to reserve resources within the AP and modify the AP's scheduling behavior. The TSPEC contains two groups of parameters: PSMP scheduling and PSMP reservation. The scheduling parameters are used by AP to schedule a suitable Service Interval. The reservation parameters are used by the AP to reserve time in the ULT and DLT.

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PSMP scheduling parameters
Minimum Service Interval
Maximum Service Interval
Inactivity Interval
Suspension Interval
Service Start time
Schedule subfield

PSMP reservation parameters
Nominal MSDU size
Maximum MSDU size
Minimum data rate
Mean Data rate
Peak Data rate
Burst Size
Delay Bound
Minimum PHY rate
Surplus Bandwidth Allowance
Medium Time
TS Info subfields: Traffic Type TSID Direction Access Policy Aggregation APSD User priority Ack Policy

Table 48 – TSPEC contained PSMP parameters

The Service Start time and Service Interval specifies the PSMP schedule in the response's Scheduling Element. All other parameters result in a reservation for the ULT and DLT within the scheduled PSMP sequence.

It is always the responsibility of the non-AP STA to initiate the creation of PSMP regardless of the TSPEC direction.

The lifecycle rules of PSMP are the rules of last TSPEC associated with this particular PSMP.

Once created, the PSMP can be extended by another TSPEC. The same or other stations can issue more TSPEC requests to the already existent PSMP. Parameters of TSPEC already associated with PSMP can be changed. However the Service Interval cannot be changed and establishing Start Time of the new STA cannot change the Start Time of existing STAs

7.5.2 Join PSMP

Under PSMP, the TSPEC Aggregation subfield shall be 0 and the APSD subfield shall be 1.

Unidirectional as well bidirectional TSPECs may be used for PSMP resources reservation. The bidirectional TSPEC may be used if the reservation parameters of the both directions are equal (voice or videoconferencing for example). If a STA reserves a separate TSPEC for each direction the TSID for both should be the same.

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A station joins PSMP outside the PSMP mechanism using any appropriate channel access mechanism. The non-AP STA SME decides that a PSMP needs to be joined. How it does this, and how it selects the related TSPEC parameters, is beyond the scope of this specification. The SME generates an MLMEADDTS.request containing a TSPEC. A TSPEC may also be generated autonomously by the MAC without any initiation by the SME. The non-AP STA MAC transmits the TSPEC in an ADDTS request frame to the AP and waits for response.

The AP decides whether to admit the TSPEC as specified, or refuse the TSPEC, or not admit but suggest an alternative TSPEC and transmits an ADDTS response frame containing this TSPEC and status. The encoding of additional ResultCode values for the Status Code field are defined in Table 26.6. If the ResultCode is "SUCCESS", the TS enters into an active state. Otherwise, the whole process may be repeated using the same TSID and Direction and a modified TSPEC until the non-AP STA decides that the granted TXOP is adequate or inadequate and cannot be improved. The AP may attache the requesting Station to the Start Service Interval of an already established service period, or it may create a new service period for this Station. The Service Interval it selects shall be in multiples of the Service Interval Granularity.

Table 49 – Encoding of Result Code to Status Code Field Value

Result Code	Status Code
Success	0
Invalid Parameters	38
Rejected with Suggested Changes	39
Rejected for Delay Period	47

The Station may resubmit a TSPEC request with suggested changes if the ResultCode is "Rejected_with_suggested_changes". The suggested changes are included in the response's Schedule element. The suggestion may be related to scheduling as well to reservation parameters. The suggested scheduling parameters may not be negotiated – i.e. the AP is unlikely to accept any request that does not use the specific suggestions for these parameters.

The station may add another TSPEC under TBD conditions. In this case the AP shall use the Start Service Interval of already established service The requested Service Intervals of different TSPECs shall be multiples of the Service Interval Granularity (Figure 34 – Different Service intervals of different stations).

7.6 Management of Unscheduled PSMP

Under U-PSMP operation, a station does not need to use TSPEC for resources reservation. Each of the two U-APSD methods may be used to make a particular AC trigger-enabled and/or delivery-enabled. All delivery enabled ACs may be transmitted to the station in the same SP. The ULT shall only used by the stations for acknowledgement. This ACK/MTBA shall be transmitted at a basic rate/MSC (thus allowing AP precise reservation of the ULT per station).

7.6.1 Multiple TID Block Ack management under scheduled PSMP

A Block Ack agreement shall be set up after the related TSPEC has been established. The Multiple TID Block Ack scheme and frame formats are used under a TSPEC with PSMP access policy. A AP as an Originator of DLT and Station as an Originator of ULT shall establish a BA agreement for each such TSID. The related ADDBA exchange is performed outside the PSMP mechanism using any applicable channel access mechanism.. No synchronization is required between Originators to order these ADDBA

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transmissions. The BA setup procedure is the same as defined in the .11e. During the BA setup procedure, the originator uses the TSID already established.

7.6.2 Multiple TID Block Ack management under unscheduled PSMP

An AP may choose to transmit data under 802.11e unscheduled APSD operation during the DLT of a PSMP sequence. A BA agreement shall be established before sending any data under MTBA/PSMP ack policy during unscheduled PSMP.

7.7 Channel Selection Methods

7.7.1 Introduction (Informative)

The best coexistence is achieved when all BSSs occupy separate channels and when legacy and HT devices do not overlap.

On detecting the arrival of a co-channel legacy BSS on the extension channel, the AP may need to either adjust its recommended transmission channel widths to avoid the legacy BSS, or select a new set of channels.

7.7.2 Rules

The HT AP should either be configured manually or configure itself automatically as described in this section.

The HT AP should scan its environment before selecting channel parameters. AP should use mixed or legacy mode PPDU types for any active scanning.

If the selected channel parameters overlap an existing HT BSS, then they should use the same control channel and extension channel offset. The AP should reselect new channel parameters if an HT BSS that does not have the same control channel, extension channel offset starts operating on an overlapped channel.

Given a choice of 40MHz channel selections recommended transmission by the previous rules, the AP should prefer a channel selection that aligns its 40MHz channel with the starting (i.e. lowest frequency) pair of adjacent 20MHz channels within any band or sub-band plus zero or more times 40MHz.

Note: The purpose of this recommendation is to avoid introducing 20MHz "holes" between adjacent operating 40MHz BSS, thus making them unavailable for 40MHz operation.

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