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

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

Amendment 3: Enhancements for Very High Throughput in the 60 GHz Band

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
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(Amendment to
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as amended by IEEE Std 802.11ae™-2012
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Approved 19 October 2012

IEEE-SA Standards Board

Abstract: This amendment defines modifications to both the IEEE 802.11 physical layers (PHYs) and the IEEE 802.11 medium access control layer (MAC) to enable operation in frequencies around 60 GHz and capable of very high throughput.
Keywords: 60 GHz, A-BFT, announcement transmission interval, association beamforming training time, ATI, beacon transmission interval, beamforming, BTI, CBAP, clustering, contention-based access period, directional multi-gigabit, DMG, dynamic allocation of service period, dynamic extension of service period, dynamic truncation of service period, fast session transfer, FST, GCMP, IEEE 802.11ad, millimeter-wave, multi-band operation, PBSS, PBSS control point, PCP, personal basic service set, relay operation, service period, SP, spatial sharing

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Introduction

This introduction is not part of IEEE Std 802.11ad-2012, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications—Amendment 3: Enhancements for Very High Throughput in the 60 GHz Band.

This amendment defines standardized modifications to both the IEEE 802.11 physical layers (PHYs) and the IEEE 802.11 medium access control layer (MAC) to enable operation in frequencies around 60 GHz and capable of very high throughput.

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(This amendment is based on IEEE Std 802.11™-2012, as amended by IEEE Std 802.11ae™-2012 and IEEE Std 802.11aa™-2012.)

NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard. The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. **Change** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). **Delete** removes existing material. **Insert** adds new material without disturbing the existing material. Deletions and insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. **Replace** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.[1]

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

1. Overview

1.3 Supplementary information on purpose

Change the first list item of the dashed list in 1.3 as follows:

— Describes the functions and services required by an IEEE 802.11™-compliant device to operate within independent, personal, and infrastructure networks as well as the aspects of STA mobility (transition) within those networks.

Insert the following list item at the end of the dashed list in 1.3:

— Defines the PHY signaling, MAC, and beamforming procedures required for operation with directional antenna patterns.

2. Normative references

Insert the following references into Clause 2 in alphanumeric order:

ITU-T Recommendation O.150, General requirements for instrumentation for performance measurements on digital transmission equipment.[2]

NIST Special Publication 800-38D, Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC, Morris Dworkin, November 2007.[3]

3. Definitions, acronyms, and abbreviations

3.1 Definitions

Delete the following definitions from 3.1 (note that both definitions are reinserted with changes into 3.2):

downlink

uplink

Change the following definitions in 3.1 as follows:

coordination function: The logical function that determines when a station (STA) operating within a basic service set (BSS) is permitted to transmit protocol data units (PDUs) via the wireless medium (WM). The coordination function within a BSS might have one hybrid coordination function (HCF), or it might have one HCF and one point coordination function (PCF) and has one distributed coordination function (DCF). A quality-of-service (QoS) BSS has one DCF and one HCF. In addition, a directional multi-gigabit (DMG) STA has a DMG channel access function that includes the beacon transmission interval (BTI), the association beamforming training (A-BFT), the announcement transmission interval (ATI), and the service period channel access (SPCA).

[2]ITU publications are available from the International Telecommunications Union (http://www.itu.int/).
[3]NIST publications are available from the National Institute of Standards and Technology (http://csrc.nist.gov/).

scheduled service period (SP): The SP that is scheduled by the quality-of-service (QoS) access point (AP) or the personal basic service set (PBSS) control point (PCP). Scheduled SPs start at fixed intervals of time.

Insert the following definitions into 3.1 in alphabetic order:

access period: A time period during a beacon interval established in a directional multi-gigabit (DMG) basic service set (BSS) that has associated channel access rules.

antenna weight vector (AWV): A vector of weights describing the excitation (amplitude and phase) for each element of an antenna array.

average noise plus interference power indicator (ANIPI): A medium access control (MAC) indication of the average noise plus interference power measured on a channel that meets the two simultaneous conditions: 1) the station (STA) is not transmitting a frame, and 2) the station (STA) is not receiving a frame addressed to itself.

contention-based access period (CBAP): The time period within the data transfer interval (DTI) of a directional multi-gigabit (DMG) basic service set (BSS) where enhanced distributed channel access (EDCA) is used.

directional multi-gigabit (DMG): Pertaining to operation in a frequency band containing a channel with the Channel starting frequency above 45 GHz.

NOTE—The Channel starting frequency for 802.11 stations (STAs) is defined in Annex E.

fast session transfer (FST): The transfer of a session from a channel to another channel, in the same or different frequency bands. The term “session” refers to non-physical layer state information kept by a pair of stations (STAs) that communicate directly (i.e., excludes forwarding).

multiple medium access control (MAC) station management entity (SME) (MM-SME): Component of station management that manages multiple cooperating stations (STAs).

non-personal basic service set control point (non-PCP) station (STA): A STA that is not a PCP.

non-personal basic service set control point (non-PCP)/non-access point (non-AP) station (STA): A STA that is not a PCP and that is not an AP.

personal basic service set (PBSS): A directional multi-gigabit (DMG) basic service set (BSS) that includes one PBSS control point (PCP), and in which access to a distribution system (DS) is not present but an intra-PBSS forwarding service is optionally present.

personal basic service set (PBSS) control point (PCP): An entity that contains one station (STA) and coordinates access to the wireless medium (WM) by STAs that are members of a PBSS.

personal basic service set (PBSS) control point (PCP)/access point (AP): A station (STA) that is at least one of a PCP or an AP.

peer-to-peer traffic specification (PTP TSPEC): The quality-of-service (QoS) characteristics of a data flow between non-access point (non-AP) QoS stations (STAs).

sector: A transmit or receive antenna pattern corresponding to a Sector ID.

spatial sharing (SPSH): Use of a frequency channel by multiple stations (STAs) located in the same vicinity, and whose directional transmissions may overlap in time.

3.2 Definitions specific to IEEE 802.11

Change the following definition in 3.2:

bufferable unit (BU): An MSDU, A-MSDU (HT STAs and DMG STAs only) or bufferable MMPDU that is buffered to operate the power saving protocol.

Insert the following definitions into 3.2 in alphabetic order:

beacon header interval (BHI): The contiguous period of time that starts at the target beacon transmission time (TBTT) of a beacon interval of a directional multi-gigabit (DMG) basic service set (BSS) and that ends no later than the beginning of the data transfer interval (DTI) of the beacon interval.

beacon transmission interval (BTI): The time interval between the start of the first Directional Multi-gigabit (DMG) Beacon frame transmission by a DMG station (STA) in a beacon interval to the end of the last DMG Beacon frame transmission by the DMG STA in the same beacon interval.

centralized coordination service root (CCSR): An entity that provides synchronization and configuration services to synchronization access points (S-APs).

centralized coordination service set (CCSS): The collection of one centralized coordination service root (CCSR) and a set of one or more synchronization access points (S-APs) that are stationary with respect to their local environment while operating and are connected to the CCSR.

destination directional multi-gigabit (DMG) station (STA): A DMG STA identified by the destination association identifier (AID) field contained in a Grant frame or Extended Schedule element that caused the allocation of a service period (SP) or a contention-based access period (CBAP).

directional multi-gigabit (DMG) access point (AP): An AP whose radio transmitter is capable of transmitting and receiving DMG physical layer convergence procedure (PLCP) protocol data units (PPDUs).

directional multi-gigabit (DMG) antenna: A DMG antenna is a phased array, a single element antenna, or a set of switched beam antennas covered by a quasi-omni antenna pattern.

directional multi-gigabit (DMG) basic service set (BSS): A BSS in which DMG Beacon frames are transmitted by DMG stations (STAs).

directional multi-gigabit (DMG) frame: A frame transmitted or received within a DMG physical layer convergence procedure (PLCP) protocol data unit (PPDU).

directional multi-gigabit (DMG) physical layer convergence procedure (PLCP) protocol data unit (PPDU): A Clause 21 PPDU transmitted or received using the Clause 21 physical layer (PHY).

directional multi-gigabit (DMG) station (STA): A STA whose radio transmitter is capable of transmitting and receiving DMG physical layer convergence procedure (PLCP) protocol data units (PPDUs).

directional transmission: A transmission that does not use an omnidirectional antenna pattern or quasi-omni antenna pattern.

downlink: A unidirectional link from an access point (AP) to one or more non-AP stations (STAs) or a unidirectional link from a non-AP destination directional multi-gigabit (DMG) STA to a non-AP source DMG STA.

extended centralized personal basic service set (PBSS) control point (PCP)/access point (AP) cluster (ECPAC): The collection of 1) a single centralized coordination service set (CCSS), 2) the set of centralized PCP/AP clusters such that each synchronization AP (S-AP) of a centralized PCP/AP cluster is within the CCSS, and 3) all stations (STAs) within the basic service sets (BSSs) of the S-APs and member PCPs/APs of the centralized PCP/AP clusters.

multiple medium access control (MAC) sublayers link (MMSL): A link between two stations (STAs), wherein one of the STAs is coordinated by a multiple MAC station management entity (MM-SME) that delivered a Multiple MAC Sublayers (MMS) element to the peer STA.

multiple medium access control (MAC) sublayers link cluster: All multiple MAC sublayers links between a pair of stations (STAs).

personal basic service set (PBSS) control point (PCP)/access point (AP) cluster: One directional multi-gigabit (DMG) synchronization PCP or DMG synchronization AP, plus zero or more neighboring DMG PCPs, DMG APs (or a mixture of both) that join as member PCPs/APs to the synchronization PCP or synchronization AP.

quasi-omni antenna pattern: A directional multi-gigabit (DMG) antenna operating mode with the widest beamwidth attainable.

receive sector sweep (RXSS): Reception of Sector Sweep (SSW) frames via different sectors, in which a sweep is performed between consecutive receptions.

source directional multi-gigabit (DMG) station (STA): A DMG STA identified by the source association identifier (AID) field contained in a Grant frame or Extended Schedule element that caused the allocation of a service period (SP) or contention-based access period (CBAP).

sweep: A sequence of transmissions, separated by a short beamforming interframe space (SBIFS) interval, in which the antenna configuration at the transmitter or receiver is changed between transmissions.

synchronization access point (AP) (S-AP): An AP that provides synchronization and other services to a personal basic service set (PBSS) control point (PCP)/AP Cluster.

synchronization personal basic service set (PBSS) control point (PCP) (S-PCP): A PCP that provides synchronization and other services to a PCP/access point (AP) Cluster.

synchronization personal basic service set (PBSS) control point (PCP) (S-PCP)/synchronization access point (AP) (S-AP): A station (STA) that is at least one of an S-PCP or an S-AP.

transmit sector sweep (TXSS): Transmission of multiple Sector Sweep (SSW) or Directional Multi-gigabit (DMG) Beacon frames via different sectors, in which a sweep is performed between consecutive transmissions.

transmit sector sweep contention-based access period (TXSS CBAP): A CBAP that is available to all stations (STAs) in an extended centralized personal basic service set (PBSS) control point (PCP)/access point (AP) cluster outside which TXSSs in the data transfer interval (DTI) can be prohibited.

uplink: A unidirectional link from a non-access point (non-AP) station (STA) to an access point (AP) or a unidirectional link from a non-AP source directional multi-gigabit (DMG) STA to a non-AP destination DMG STA.

3.3 Abbreviations and acronyms

Insert the following abbreviations into 3.3 in alphabetic order:

A-BFT	association beamforming training
ANIPI	average noise plus interference power indicator
ATI	announcement transmission interval
AWV	antenna weight vector
BC	beam combining
BF	beamforming
BHI	beacon header interval
BRP	beam refinement protocol
BRPIFS	beam refinement protocol interframe space
BTI	beacon transmission interval
CBAP	contention-based access period
CCSR	centralized coordination service root
CCSS	centralized coordination service set
CPHY	control physical layer
DMG	directional multi-gigabit
DTP	dynamic tone pairing
DTI	data transfer interval
ECPAC	extended centralized PCP/AP cluster
FD-AF	full-duplex amplify-and-forward
FST	fast session transfer
FSTS	fast session transfer session
GCM	Galois/Counter Mode
GCMP	Galois/Counter Mode with GMAC Protocol
GMAC	Galois Message Authentication Code
GP	grant period
HD-DF	half-duplex decode-and-forward
ISS	initiator sector sweep
LBIFS	long beamforming interframe space
LP	low power
MBIFS	medium beamforming interframe space
MID	multiple sector identifier
MIDC	multiple sector identifier capture
MM-SME	multiple MAC station management entity
MMS	multiple MAC sublayers
MMSL	multiple MAC sublayers link
OCT	on-channel tunneling
PBSS	personal basic service set
PCP	PBSS control point
PCPS	PBSS control point service
PP	polling period
PTP TSPEC	peer-to-peer traffic specification
QAB	quieting adjacent BSS
RLS	relay link setup

ROC	relay operation type change
RSS	responder sector sweep
RDS	relay DMG STA
REDS	relay endpoint DMG STA
RXSS	receive sector sweep
S-AP	synchronization access point
SBIFS	short beamforming interframe space
SC	single carrier
SEMM	SPCA-EDCA mixed mode
SLS	sector-level sweep
SPCA	service period channel access
S-PCP	synchronization PBSS control point
SPR	service period request
SPSH	spatial sharing
SSW	sector sweep
TDDTI	time division data transfer interval
TPA	transmission time-point adjustment
TRN-R	receive training
TRN-T	transmit training
TXSS	transmit sector sweep

4. General description

4.3 Components of the IEEE 802.11 architecture

4.3.1 General

Change the third paragraph of 4.3.1 as follows:

It is useful to think of the ovals used to depict a BSS as the coverage area within which the member STAs of the BSS may remain in communication. In the case of transmissions such as in a directional multi-gigabit (DMG) BSS, the individual coverage area of a transmission from one member STA to another can be thought of as a cone and hence is referred to as a directional transmission. The collection of all possible directional transmissions by a member STA defines the coverage area. (The concept of area, while not precise, is often good enough.) This area is called the Basic Service Area (BSA). If a STA moves out of its BSA, it can no longer directly communicate with other STAs present in the BSA.

Insert the following subclause, 4.3.2a, after 4.3.2:

4.3.2a The personal BSS (PBSS) as an ad hoc network

Similar to the IBSS, the PBSS is a type of IEEE 802.11 LAN in which STAs communicate directly with each other.

In contrast to the IBSS, in the PBSS one STA assumes the role of the PBSS control point (PCP). The PCP provides the basic timing for the PBSS through DMG Beacon and Announce frames as well as allocation of service periods and contention-based access periods.

A PBSS can be established only by DMG STAs. Not every DMG BSS is a PBSS. A DMG BSS can be a PBSS, an infrastructure BSS, or an IBSS.

4.3.4 Distribution system (DS) concepts

4.3.4.3 Robust security network association (RSNA)

Change the third and fourth paragraphs of 4.3.4.3 as follows:

The first component is an IEEE 802.1X port access entity (PAE). PAEs are present on all STAs in an RSNA and control the forwarding of data to and from the medium access control (MAC). An AP always implements the Authenticator PAE and Extensible Authentication Protocol (EAP) Authenticator roles, and a non-AP STA always implements the Supplicant PAE and EAP peer roles. In an IBSS or PBSS, each STA implements both the Authenticator PAE and Supplicant PAE roles and both EAP Authenticator and EAP peer roles.

A second component is the Authentication Server (AS). The AS may authenticate the elements of the RSNA itself, i.e., the STAs may provide material that the RSNA elements can use to authenticate each other. The AS communicates through the IEEE 802.1X Authenticator with the IEEE 802.1X Supplicant on each STA, enabling the STA to be authenticated to the AS and vice versa. An RSNA depends upon the use of an EAP method that supports mutual authentication of the AS and the STA, such as those that meet the requirements in IETF RFC 4017. In certain applications, the AS may be integrated into the same physical device as the AP, or into a STA in an IBSS or PBSS.

Insert the following subclause, 4.3.4.4, after 4.3.4.3:

4.3.4.4 Centralized Coordination Service Set (CCSS) and Extended Centralized PCP/AP Cluster (ECPAC) within the DMG

PCP/AP clustering is a protocol between a DMG Synchronization PCP/AP (S-PCP/S-AP) and other DMG PCP/APs within the cluster, known as member PCP/APs, and the protocol is used to improve spatial sharing and interference mitigation among the DMG BSSs of the S-PCP/S-AP and member PCP/APs. PCP/AP clustering allows a PCP/AP within a cluster to schedule transmissions in nonoverlapping time periods with respect to other PCP/APs within the same cluster. There are two types of clustering:

- Decentralized PCP/AP clustering involves a single S-PCP/S-AP in the BSA of the S- PCP/S-AP.
- Centralized PCP/AP clustering is where there can be multiple S-APs in the BSA of any one S-AP and all S-APs are coordinated via a single centralized coordination service set (CCSS).

New architectural entities are introduced to support centralized PCP/AP clustering as follows. A CCSS comprises a centralized coordination service root (CCSR) and a set of one or more synchronization APs that are stationary with respect to their local environment while operating and are connected to the CCSR via, for instance, one of the following:

- The wireless medium to an associated STA that contains the CCSR
- The DS to an AP (or beyond, to a STA associated to the AP)
- A combination of distribution service, portal, and external network

The CCSR is the entity that provides coordination services for the CCSS, such as selecting the target Beacon transmission time of S-APs within the CCSS to minimize interference (see Annex Y for a more detailed description of the functions of the CCSR). The CCSR might logically reside within an S-AP or in another entity as long as it has a globally administered MAC address as defined in 9.2 of IEEE Std 802-2001. A CCSS is suited to an area and a frequency band having propagation characteristics so that the BSAs of the S-APs within a CCSS cover the area, yet transmissions within the area are isolated to a high degree.

An extended centralized PCP/AP cluster (ECPAC) comprises a single CCSS and the set of centralized PCP/AP clusters so that each S-AP of a centralized PCP/AP cluster is within the CCSS. The ECPAC also includes all STAs within the BSSs of the S-APs and member PCPs/APs of the centralized PCP/AP clusters. This is shown by example in Figure 4-3a, wherein

- STA3a and STA3b are two STAs coordinated by a one MM-SME component
- STA4a and STA4b are two STAs coordinated by a second MM-SME component
- The CCSR happens to be located in an external network

There are no S-PCPs in an ECPAC since a PCP has no mechanism to communicate with the CCSR.

The CCSS is unrelated to an ESS in the sense that a CCSS might contain whole ESSs, subsets of ESSs, or some combination thereof.

Decentralized PCP/AP clustering does not involve the use of the CCSS, CCSR, and ECPAC entities.

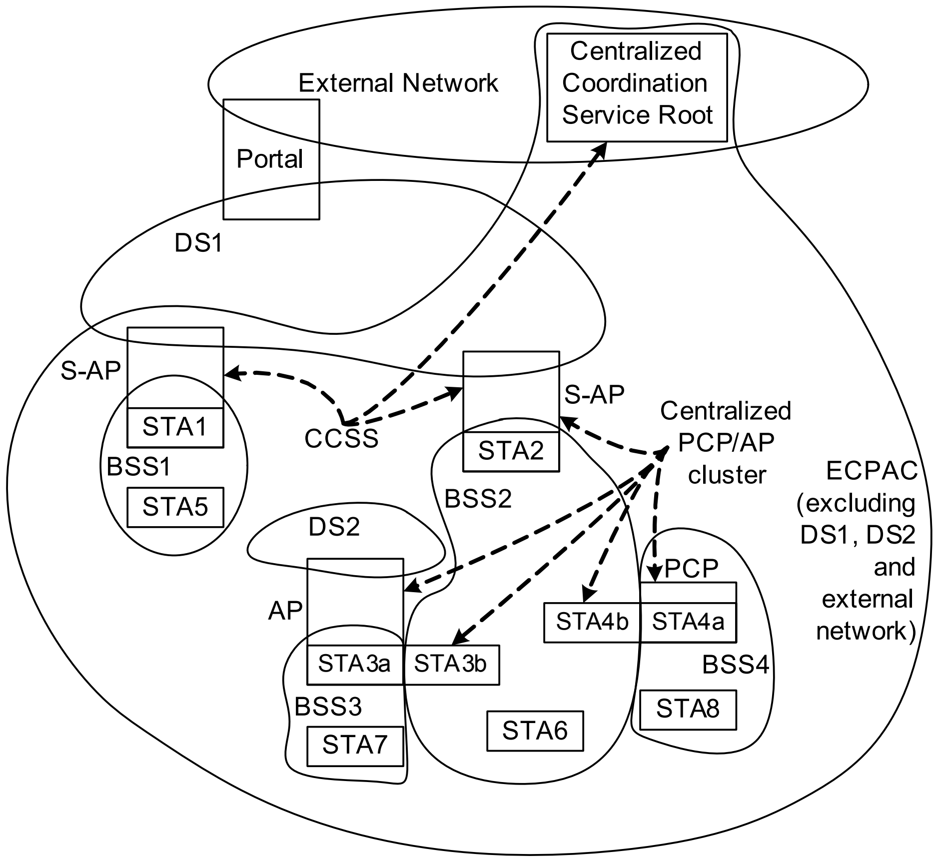


Figure 4-3a—CCSS and ECPAC

4.3.7 QoS BSS: The QoS network

Change 4.3.7 as follows:

The IEEE 802.11 QoS facility provides MAC enhancements to support LAN applications with QoS requirements. The QoS enhancements are available to QoS STAs associated with a QoS access point or PCP in a QoS BSS. A subset of the QoS enhancements is available for use between STAs that are members of the same QoS IBSS. Similarly, a subset of the QoS enhancements is available for use between neighbor peer mesh STAs. A mesh BSS is one type of QoS BSS, and it is described in 4.3.15. For a QoS STA that is a non-DMG STA, ~~B~~because ~~a~~ the nonmesh QoS STA implements a superset of STA functionality, as defined in this standard, the STA might associate with a non-QoS access point in a non-QoS BSS, to provide non-QoS MAC data service when there is no QoS BSS with which to associate. As a mesh STA does not implement the necessary service, the mesh STA does not associate with any access point.

A STA within a DMG BSS is a QoS STA; hence a DMG BSS is a QoS BSS.

The enhancements that distinguish QoS STAs from non-QoS STAs and QoS APs from non-QoS APs are collectively termed the *QoS facility*. Which of the QoS-specific mechanisms a QoS STA supports might vary among QoS implementations, as well as between QoS STAs and QoS APs, over ranges specified in subsequent clauses. All service primitives, frame formats, coordination function and frame exchange rules, and management interface functions except for the Block Acknowledgment (Block Ack) function, direct-link setup (DLS), and automatic power-save delivery (APSD) are part of the core QoS facilities. A QoS STA or QoS AP implements those core QoS facilities necessary for its QoS functions to interoperate with other QoS STAs. Functions such as the Block Ack, DLS, and APSD are separate from the core QoS facilities; and the presence of these functions is indicated by STAs separately from the core QoS facilities.

For infrastructure BSS, and IBSS, this standard provides four ~~two~~ mechanisms for the support of applications with QoS requirements.

The first mechanism, designated the *enhanced distributed channel access* (EDCA), delivers traffic based on differentiating user priorities (UPs). This differentiation is achieved by varying the following for different UP values:

— Amount of time a STA senses the channel to be idle before backoff or transmission, or
— The length of the contention window to be used for the backoff, or
— The duration a STA may transmit after it acquires the channel.

These transmissions may also be subject to certain channel access restrictions in the form of admission control. A DMG STA uses EDCA only within a contention-based access period (CBAP). Details of this mechanism are provided in 9.19.2 and, for DMG STAs, additional details are provided in 9.33.4, 9.33.5, and 9.33.6.3.

The second mechanism, designated the *hybrid coordination function* (HCF) *controlled channel access* (HCCA), is not applicable to DMG STAs and allows for the reservation of transmission opportunities (TXOPs) with the hybrid coordinator (HC). A STA based on its requirements requests the HC for TXOPs, both for its own transmissions as well as for transmissions from the AP to itself.[13] The request is initiated by the station management entity (SME) of the STA. The HC, which is collocated at the AP, either accepts or rejects the request based on an admission control policy. If the request is accepted, the HC schedules TXOPs for both STAs (both the AP and the non-AP STA). For transmissions from the non-AP STA, the HC polls the STA based on the parameters supplied by the STA at the time of its request. For transmissions to the STA, the AP directly obtains TXOPs from the collocated HC and delivers the queued frames to the STA, again based on the parameters supplied by the STA. Details of the mechanism are provided in 9.19.3 and 10.4. This mechanism may be used for applications such as voice and video, which may need periodic service from the HC. If the application constraints dictate the use of this mechanism, the application initiates this mechanism by using the management service primitives.

The third mechanism, designated the *service period* (SP) *access* or *service period channel access* (SPCA), is applicable only to the DMG STAs and allows for the reservation of channel time by the PCP/AP. A non-PCP/non-AP STA requests the PCP/AP for SPs, which can be used for transmission to any other STA in the BSS. The request is initiated by the SME of the non-PCP/non-AP STA. The PCP/AP either accepts or rejects the request based on an admission control policy. If the request is accepted, the PCP/AP uses the Extended Schedule element to schedule SPs for communication between the source and destination DMG STAs indicated within the request. Details of this mechanism are provided in 9.33.6.2, 9.33.6.4, 9.33.6.6, and 10.4.

The fourth mechanism, designated as *dynamic allocation*, is applicable only to the DMG STAs and allows for near-real-time reservation of channel time with the PCP/AP. This type of access is used in addition to the service period and contention-based access period mechanisms. A PCP/AP can poll a STA and receive requests for channel time allocation. Based on the received requests, the PCP/AP can accept a request and immediately allocate (within the same beacon interval) channel time for the STA to communicate with another STA by using a Grant frame. Details of this mechanism are provided in 9.33.7, 9.33.8, and 9.33.9.

Non-QoS STAs may associate in a QoS BSS, if allowed to associate by the AP. All individually addressed frames that are sent to non-QoS STAs by an AP do not use the frame formats associated with the QoS facility.

A QoS STA associated in a non-QoS BSS acts as a non-QoS STA.

Insert the following subclauses, 4.3.17 and 4.3.18 (including Figure 4-10a), after 4.3.15.5.13:

4.3.17 DMG STA

The IEEE 802.11 DMG STA provides PHY and MAC features that can support a throughput of 1 Gb/s and greater, as measured at the MAC data service access point (SAP). A DMG STA supports DMG features as identified in Clause 9, Clause 10, and Clause 21. A DMG STA operates in a DMG BSS and supports transmission and reception of frames that are compliant with PHY specifications as defined in Clause 21. A DMG STA is also a QoS STA. The basic channel access of a DMG STA (see 9.33) allows it to operate in an Infrastructure BSS, in an IBSS, and in a PBSS. Certain DMG features such as service period allocation are available only to DMG STAs that are associated with an AP or with a PCP, while other DMG features such as EDCA operation in a PBSS do not require association. A DMG STA supports beamforming (BF) as described in 9.35 and 21.10 and GCM encryption as described in 11.4.5.

A DMG STA supports the PHY signaling as described in 21.4, 21.5, 21.6, and 21.7. At a minimum, a DMG STA supports the mandatory modulation and coding scheme (MCS) and PLCP protocol data unit (PPDU) formats described in 21.4 and 21.6. A DMG STA has PHY features that include a low-density parity check (LDPC) encoding, a preamble making use of Golay sequences, and beamforming. The PPDUs are always transmitted with the same channel spacing as described in Annex E.

A DMG STA supports MAC features that provide channel access in an environment in which transmissions use a directional antenna pattern. A DMG STA has MAC features that include frame aggregation, Block Ack features, service periods, contention-based access periods, DMG protected period, PCP/AP clustering, dynamic channel time management, reverse direction, spatial sharing, beamforming, and operation (fast session transfer) in a multi-band device. A DMG STA is not a mesh STA. A DMG STA follows the same channel access rules irrespective of the type of BSS in which it operates.

4.3.18 DMG relay

The 802.11 DMG relay function allows a source relay endpoint DMG STA (REDS) to transmit frames to a destination REDS with the assistance of another DMG STA, the relay DMG STA (RDS), as shown in Figure 4-10a. Relaying can improve the reliability of communication in a DMG BSS in the case the direct link between the source REDS and the destination REDS has poor quality or is disrupted. Following the DMG relay setup procedures, a source REDS can discover and select an appropriate RDS to act as the relay for a particular destination REDS, prior to data frame transmission using the relay. A relay operating as a link switching type of relay uses the RDS to forward frames between the source and destination REDS if the direct link between the REDS is disrupted. In a link cooperating type of relay operation, the RDS simultaneously repeats the transmission of frames between the source and destination REDS, which can possibly increase the signal quality received at the destination REDS.

4.4 Logical service interfaces

4.4.1 General

Change the second paragraph of 4.4.1 as follows:

IEEE Std 802.11 explicitly does not specify the details of DS implementations. Instead, IEEE Std 802.11 specifies *services*. The services are associated with different components of the architecture. There are three ~~two~~ categories of IEEE 802.11 service: the station service (SS), the PCP service (PCPS), and the distribution system service (DSS). These ~~Both~~ categories of service are used by the IEEE 802.11 MAC sublayer.

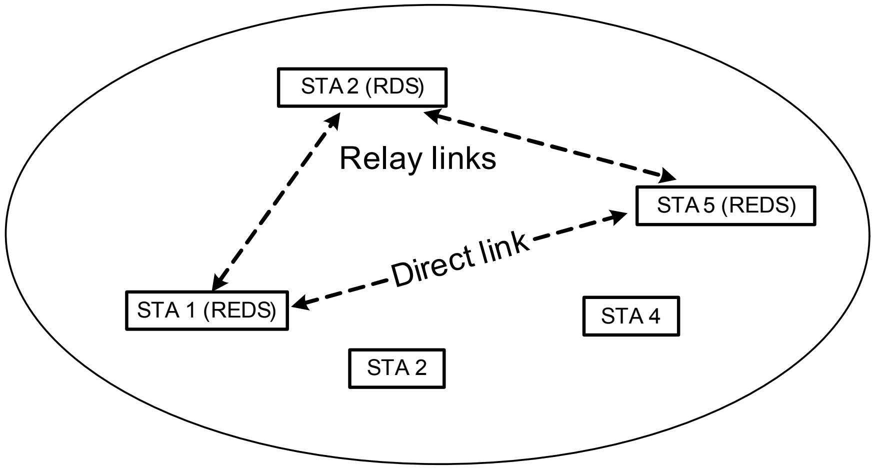


Figure 4-10a—DMG relay in a DMG BSS

Change the last paragraph of 4.4.1 as follows:

This set of services is divided into three ~~two~~ groups: the SS, the PCPS, and the DSS. The SS is part of every STA. The PCPS is provided by the PCP of a PBSS. The DSS are provided by the DS.

Insert the following subclause, 4.4.2a, after 4.4.2:

4.4.2a PBSS control point service (PCPS)

The service provided by the PCP of a PBSS is known as the PCPS. Since all STAs within a PBSS can operate as a PCP, every STA within the PBSS is capable of providing PCPS should it become the PCP of the PBSS. Non-PCP STAs do not provide PCPS.

The services that comprise the PCPSs are the following:

a) Association
b) Disassociation
c) Reassociation
d) QoS traffic scheduling

PCPSs are specified for use by MAC sublayer entities.

4.4.3 DSS

Change the last paragraph of 4.4.3 as follows:

Figure 4-11 combines the components from previous figures with ~~both~~ the three types of services to show the complete IEEE 802.11 architecture.

Replace Figure 4-11 with the following figure:

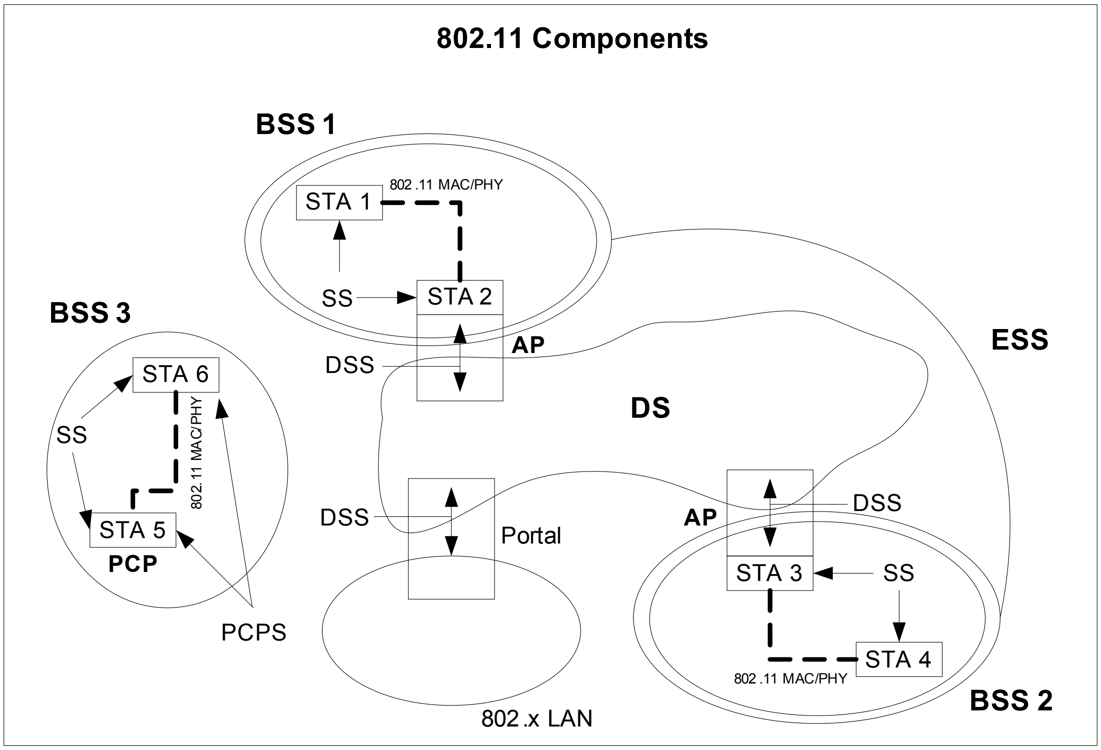


Figure 4-11—Complete IEEE 802.11 architecture

4.5 Overview of the services

4.5.1 General

Change the second paragraph of 4.5.1 as follows:

This subclause presents the services, an overview of how each service is used, and a description of how each service relates to other services and the IEEE 802.11 architecture. The services are presented in an order designed to help build an understanding of the operation of an IEEE 802.11 ~~ESS~~ network. As a result, the services that comprise the SS and DSS are intermixed in order (rather than being grouped by category). The services that comprise the PCPS are a subset of the services provided by the SS and DSS.

Change the fourth and fifth paragraphs of 4.5.1 as follows:

The IEEE 802.11 MAC sublayer uses ~~three~~ four types of messages—*data*, *management*, *extension*, and *control* (see Clause 8). The data messages are handled via the MAC data service path.

MAC management messages and MAC extension messages (see 8.3.4) are used to support the IEEE 802.11 services and are handled via the MAC management service path.

Change the last paragraph of 4.5.1 as follows:

The examples here assume an ESS network environment. The differences ~~between~~ among the ESS, the PBSS, and the IBSS network environments are discussed separately in 4.7.

Change the title of 4.5.3 as follows:

4.5.3 Services that support the distribution service and the PCP service

4.5.4 Access control and data confidentiality services

4.5.4.2 Authentication

Change the sixth paragraph of 4.5.4.2 as follows:

SAE authentication or Open System 802.11 authentication is used by non-DMG STAs in an RSN for infrastructure BSS. SAE authentication, Open System 802.11 authentication, or no 802.11 authentication is used in an RSN for IBSS. SAE authentication is used in an MBSS. An RSNA disallows the use of Shared Key 802.11 authentication. In an RSN for DMG BSS, Open System 802.11 authentication is not used (11.1.4).

4.5.4.4 Data confidentiality

Change the third and fourth paragraphs of 4.5.4.4 as follows (note that footnote 19 remains unchanged):

IEEE Std 802.11 provides several cryptographic algorithms to protect data traffic, including WEP, TKIP, GCMP, and CCMP. WEP and TKIP are based on the ARC4[19] algorithm, and CCMP and GCMP are ~~is~~ based on the advanced encryption standard (AES). A means is provided for STAs to select the algorithm(s) to be used for a given association.

IEEE Std 802.11 provides the following ~~one~~ security protocols~~, CCMP,~~ for protection of individually addressed robust management frames: CCMP and GCMP. This standard does not provide data confidentiality for group addressed robust management frames.

Change 4.7 and insert Figure 4.13a as follows:

4.7 Differences ~~between~~ among ESS, PBSS, and IBSS LANs

In 4.3.2 the concept of the IBSS LAN was introduced, and in 4.3.2a the concept of the PBSS LAN was introduced. In an IBSS and a PBSS network, a STA communicates directly with one or more other STAs.

Consider the full IEEE 802.11 architecture as shown in Figure 4-12.

Replace Figure 4-12 with the following figure:

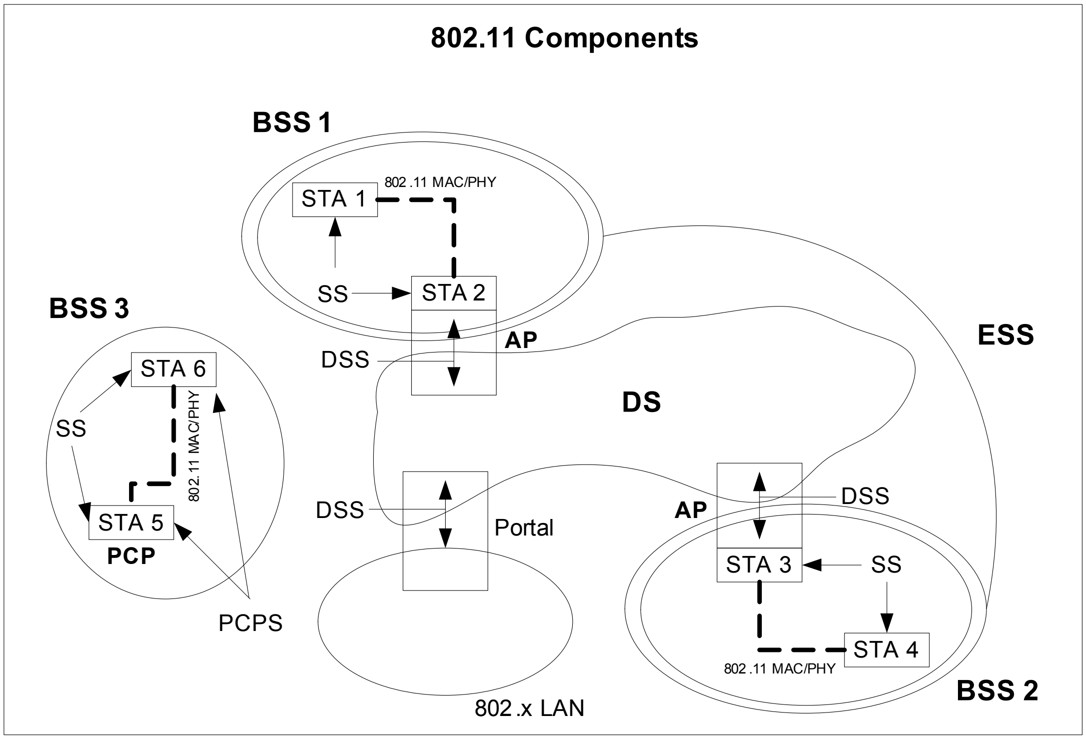


Figure 4-12—IEEE 802.11 architecture (again)

An IBSS consists of STAs that are directly connected. Thus there is (by definition) only one BSS. Further, because there is no physical DS, there is no portal, integrated wired LAN, or DSS. The logical picture reduces to Figure 4-13.

Figure 4-13 remains unchanged.

An important difference between the IBSS and the PBSS is that, within the PBSS, Beacons are not transmitted by every STA and instead only a single STA, namely the PCP, is responsible for DMG Beacon frame transmission. Within the IBSS, all STAs are responsible for beacon frame transmission. When compared to the infrastructure BSS, the PBSS does not provide certain DSSs as described in 4.4.2a.

There can be more than one PBSS in the same BSA. One of the STAs within each PBSS assumes the role of the PCP. The logical picture of the PBSS reduces to Figure 4-13a.

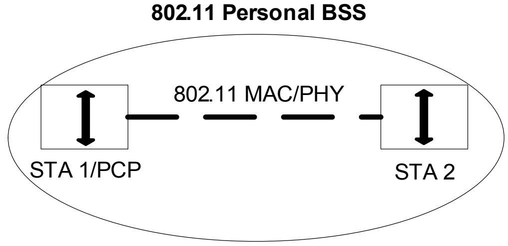


Figure 4-13a—Logical architecture of a PBSS

Only the minimum two STAs are shown in Figure 4-13. An IBSS might have an arbitrary number of members. In an IBSS, only Class 1 and Class 2 frames are allowed because there is no DS in an IBSS. There can be no more than 254 STAs associated with a PCP and with a DMG AP.

The services that apply to an IBSS are the SSs. A QoS IBSS supports operation under the HCF using TXOPs gained through the EDCA mechanism. The parameters that control differentiation of the delivery of MSDUs with different priority using EDCA are fixed. A QoS IBSS has no HC and does not support polled TXOP operation and setting up of TSPEC.

The services that apply to the PBSS are the SSs and the PCPSs as described in 4.4.2a. A PBSS supports operation under the HCF using TXOPs gained through the EDCA mechanism. In a PBSS, the EDCA mechanism is used only within CBAPs. The parameters that control differentiation of traffic classes using EDCA can be configured by the PCP in a PBSS. The PCP of a PBSS has no HC, but can support TSPEC setup, DMG TSPEC setup, and service periods.

In an IBSS, each STA enforces its own security policy. In an ESS and a PBSS, an AP and a PCP can, respectively, enforce a uniform security policy across all STAs.

4.9 Reference model

Insert the following subclauses, 4.9.3 and 4.9.4 (including Figure 4-16a through Figure 4-16c), after 4.9.2:

4.9.3 Reference model for supporting multiple MAC sublayers

An MM-SME function interfaces with the SMEs of the coordinating STAs. STAs managed under the MM-SME share the same antennas and PHY and optionally unify power management. The reference model for supporting multiple MAC sublayers is shown in Figure 4-16a.

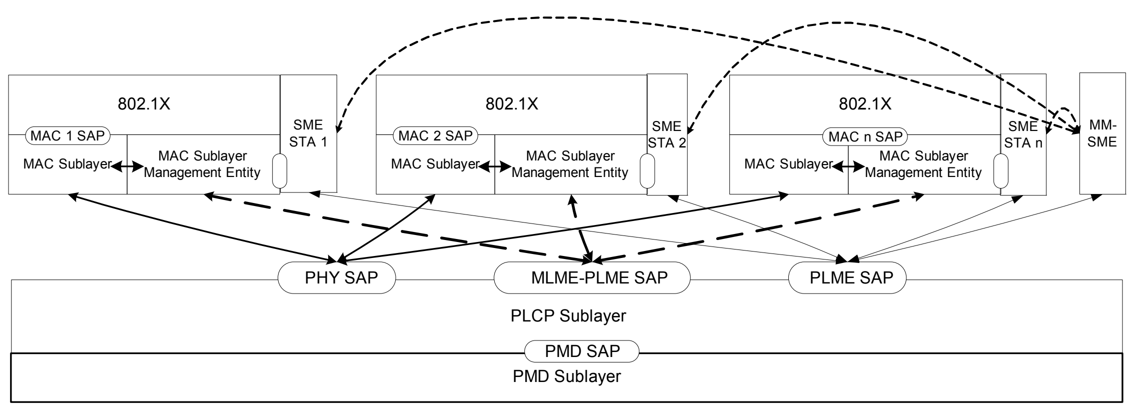


Figure 4-16a—Reference model for supporting multiple MAC sublayers

An MM-SME coordinates the management of multiple MAC sublayers. Each MAC sublayer has a separate MAC SAP and MLME SAP. A MAC SAP together with its corresponding MLME SAP is identified by a MAC address.

Even when coordinated by an MM-SME, each MAC retains its single MAC address, and each STA contains a single MAC; therefore, the MM-SME coordinates multiple STAs as well as multiple MACs.

Multiple STAs coordinated by an MM-SME have a single PLCP and PMD sublayer that is shared by the multiple MAC sublayers. Transmission attempts of different MAC sublayers can collide internally if the STAs share a single PHY, and a backoff procedure is invoked in this case. Since multiple STAs coordinated by the same MM-SME share the PHY, the STAs do not directly exchange frames with each other.

NOTE—The multiple MAC reference model shown in Figure 4-16a defines how multiple STAs can share the same physical layer entity. If this model is used in conjunction with the reference model for multi-band operation (see 4.9.4), the multiple MAC reference model applies within each physical layer entity contained in the multi-band device whereas the multi-band operation reference model applies to different physical layers.

The MM-SME accesses each of the MLME SAPs of the coordinated STAs separately to deliver MLME SAP primitives. STAs that are coordinated by the same MM-SME can establish a multiple MAC sublayers link (MMSL) with a peer STA. The set of all MMSLs between a pair of STAs creates an MMSL cluster.

An MM-SME controls the power management mode, DMG antenna configuration, and other parameters and states of the coordinated STAs to eliminate unnecessary duplication of functions. A change in the power management mode of the STAs coordinated by an MM-SME is signaled to a peer STA via any one of the STAs' MAC sublayer. Also, a beamforming link established between STAs can be used by all the MAC sublayers of any of the STAs coordinated by the same MM-SME. For these purposes, a Multiple MAC Sublayers (MMS) element is used.

The MMS element contains multiple MAC addresses of the MACs coordinated by the same MM-SME. The element can be included in any frame that advertises the MM-SME capabilities, such as Probe frames and Information Request and Response frames, and the frames that establish communication agreements, such as association, ADDTS, and BA request and responses.

4.9.4 Reference model for multi-band operation

The reference model of a device that is multi-band capable (see 10.32) and that supports transparent fast session transfer (FST) is shown in Figure 4-16b. The reference model of a device that is multi-band capable and that supports nontransparent FST is shown in Figure 4-16c.

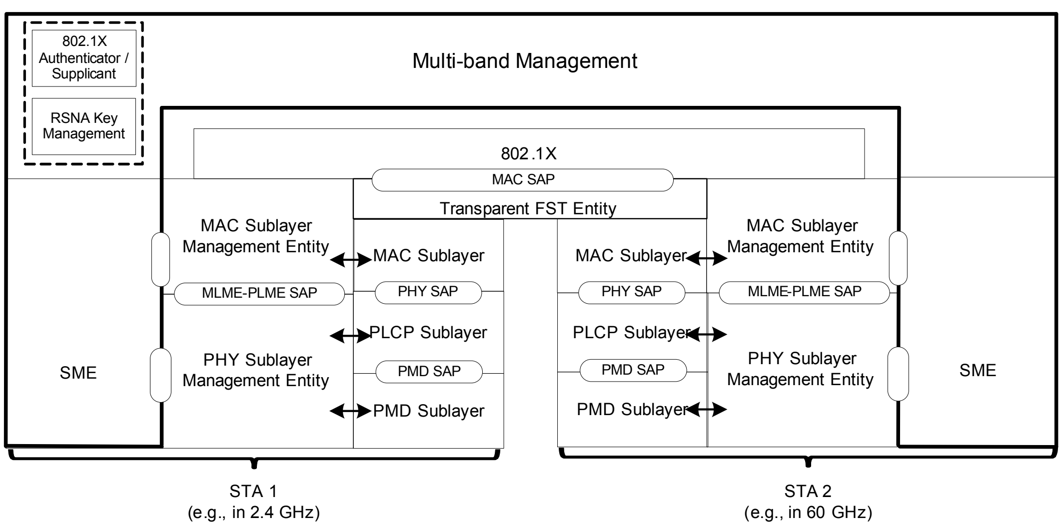


Figure 4-16b—Reference model for a multi-band capable device (transparent FST)

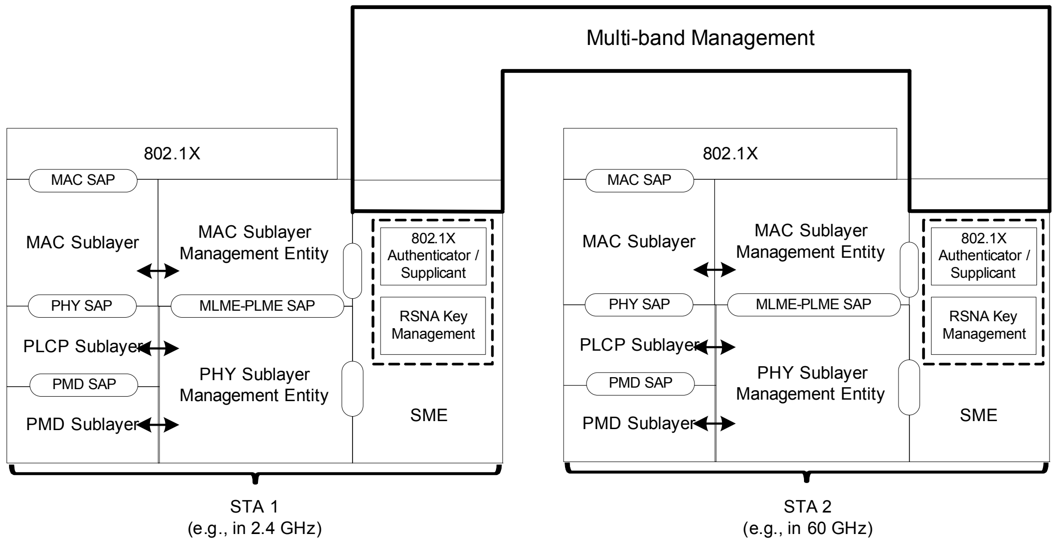


Figure 4-16c—Reference model for a multi-band capable device (nontransparent FST)

A multi-band capable device can manage operation over more than one frequency band/channel. The operation across the different frequency bands/channels can be simultaneous or nonsimultaneous.

A multi-band capable device can also support multiple MAC sublayers; in this case, it is coordinated by an MM-SME.

NOTE—For simplicity, Figure 4-16b and Figure 4-16c depict the reference model when there is a one-to-one mapping between PHYs and MACs. However, the reference model for a multi-band capable device can be applied in conjunction with the reference model for STAs that support multiple MAC sublayers (see 4.9.3).

The SME of a multi-band capable device contains a multi-band management entity that is responsible for coordinating the setup, configuration, teardown, and transfer of FST sessions from a band/channel to another band/channel supported by the multi-band capable device. If using nontransparent FST, the multi-band management entity can employ a combination of the source and destination MAC addresses in both the old and new band/channel to configure the routing of MSDUs and MLME primitives within the STA. If using transparent FST, in addition to the MAC addresses, the multi-band management entity can employ the TID of an FST session for this routing.

The multi-band procedures (see 10.32) allow a pair of multi-band capable devices to discover, synchronize, (de)authenticate, (re)associate, disassociate, and manage resources with each other on any common band/channel that is supported by both STAs.

When used in the context of FST, the term “session” refers to non-PHY state information that is kept in a pair of STAs that communicate directly (i.e., excludes forwarding) and that is available prior to and following a session transfer. This state information is different depending if transparent or nontransparent is used. For transparent FST, a shared multi-band management entity has access to the local information within each SME; and in this case the state information includes BA agreements, TSs, association state, RSNA, security keys, sequence counter, and PN counter. For nontransparent FST, the function of the multi-band management entity is restricted to coordinating the setup and teardown of a session transfer with no access to other local information within each SME. Therefore, with nontransparent FST, any information local to an SME needs to be reestablished for the new band/channel, and this can be done either prior to or following the session transfer (see 10.32).

By using the on-channel tunneling (OCT) multi-band procedure described in 10.32.4, the SME of a multi-band capable device can instruct one of its MLMEs to use the OCT services provided by another MLME of the same multi-band capable device to communicate with a peer MLME of a peer multi-band capable device. This enables the SMEs of a pair of multi-band capable devices to provide a seamless FST, including performing (de)authentication and (re)association across bands/channels. The MLMEs that use the OCT services provided by another MLME within the same multi-band capable device to communicate are referred to as being on-the-air disabled with respect to each other. Following an FST, two peer on-the-air disabled MLMEs can become on-the-air enabled with respect to each other.

As described in 5.1.5, a MAC address is not unique within the multi-band capable device when transparent FST is intended to be used. When transparent FST is used, a single MAC SAP at each peer is presented to the higher layers of that peer for all the frequency bands/channels that are identified by the same MAC address at that peer. When nontransparent FST is used, different MAC SAPs are presented to higher layers since different MAC addresses are used prior to and following an FST session transfer. Therefore, when nontransparent FST is used, higher layers are responsible for managing the session transition between different frequency bands/channels.

Each MAC SAP is controlled by a separate and independent RSNA key management entity and 802.1X Authenticator/Supplicant, unless if transparent FST is used in which case the multi-band management entity is responsible for coordinating with each of the SMEs to ensure that a single RSNA key management entity and 802.1X Authenticator/Supplicant are shared among the MACs and that a single 802.1X entity is controlled.

4.10 IEEE Std 802.11 and IEEE Std 802.1X-2004

Insert the following subclause, 4.10.4a (including Figure 4-23a), after 4.10.4.4:

4.10.4a PBSS functional model description

This subclause summarizes the system setup and operation of an RSNA in a PBSS.

If a non-PCP STA chooses to associate with the PCP of the PBSS, the non-PCP STA establishes an RSNA with the PCP following the infrastructure functional model as specified in 4.10.3.

If a non-PCP STA wants to establish an RSNA with the PCP without association or if the non-PCP STA wants to establish an RSNA with another non-PCP STA, it can directly initiate an RSNA authentication with the peer STA, followed by a 4-Way Handshake. One difference between this model and the IBSS functional model is that only one RSNA authentication and one 4-Way Handshake are performed between two STAs. If both STAs initiate an RSNA setup at the same time, the RSNA setup initiated by the STA with the lower MAC address is carried through, while the RSNA setup initiated by the STA with the higher MAC address is terminated.

Figure 4-23a shows an example of the RSNA setup in a PBSS. An initiator STA discovers a peer STA's RSNA policies through the DMG Beacons from the peer STA if the peer STA is the PCP or through the Probe Response or Information Response frames from the peer STA. In this example, the initiator STA does not associate with the peer STA. The initiator STA may optionally perform RSNA authentication with the peer STA to derive a PMK. A 4-Way Handshake is then started to complete the RSNA setup.

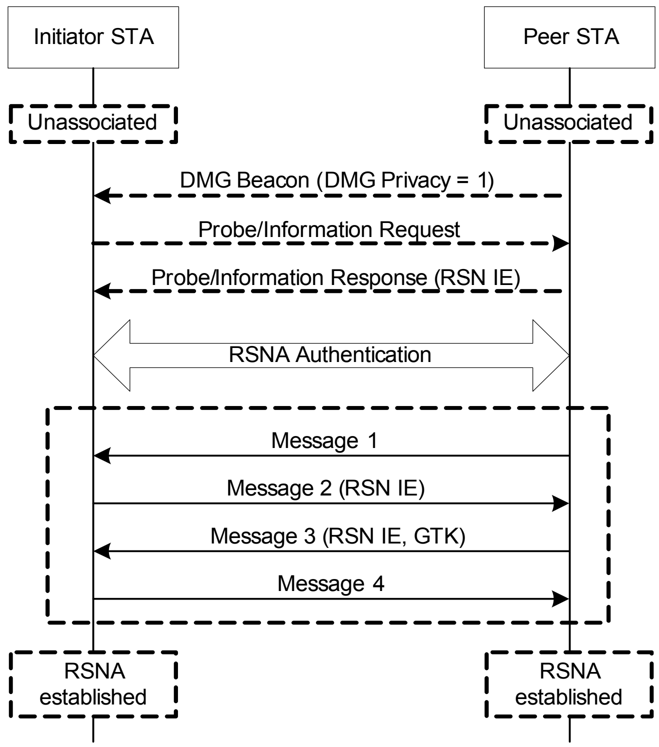


Figure 4-23a—Example of RSNA setup in a PBSS

4.11 Generic advertisement service (GAS)

Change the third and fourth paragraphs of 4.11 as follows:

In an IBSS/PBSS, GAS functionality enables a STA to access the availability and information related to desired services provided by other STAs in the IBSS/PBSS. Exchange of information using GAS may be performed either prior to joining an IBSS/PBSS or after joining the IBSS/PBSS.

There are a number of reasons why providing information to a STA in a preassociated state is beneficial:

— It supports more informed decision making about an IEEE 802.11 infrastructure or PBSS with which to associate. This is generally more efficient than requiring a non-PCP/non-AP STA to associate with ~~an~~ PCP/AP before discovering the information and then deciding whether to stay associated.

— It is possible for the non-PCP/non-AP STA to query multiple networks in parallel.

— The non-AP STA can discover information about APs that are not part of the same administrative group as the AP with which it is associated, supporting the selection of an AP belonging to a different IEEE 802.11 infrastructure that has an appropriate SSP roaming agreement in place.

5. MAC service definition

5.1 Overview of MAC services

5.1.5 MAC data service architecture

Change the first and second paragraphs, and insert a new third paragraph in 5.1.5 as follows:

The MAC data plane architecture (i.e., processes that involve transport of all or part of an MSDU) is shown in Figure 5-2 for when transparent FST is used and shown in Figure 5-1 otherwise. During transmission, an MSDU goes through some or all of the following processes: MSDU rate limiting, aggregate MSDU (A-MSDU) aggregation, frame delivery deferral during power save mode, sequence number assignment, fragmentation, encryption, integrity protection, frame formatting, and aggregate MAC protocol data unit (A-MPDU) aggregation. When transparent FST is used, an MSDU goes through an additional transparent FST entity that contains a demultiplexing process that forwards the MSDU down to the selected TX MSDU Rate Limiting process and thence further MAC data plane processing. IEEE Std 802.1X-2004 may block the MSDU at the Controlled Port. At some point, the data frames that contain all or part of the MSDU are queued per AC/TS.

During reception, a received data frame goes through processes of possible A-MPDU deaggregation, MPDU header and cyclic redundancy code (CRC) validation, duplicate removal, possible reordering if the Block Ack mechanism is used, decryption, defragmentation, integrity checking, and replay detection. After replay detection (or defragmentation if security is not used), possible A-MSDU deaggregation, and possible MSDU rate limiting, one or more MSDUs are delivered to the MAC_SAP or to the DS. When transparent FST is used, MSDUs originating from different PHY-SAPs go through an additional transparent FST entity that contains a multiplexing process before forwarding the MSDU to the MSDU rate limiting process. The IEEE 802.1X Controlled/Uncontrolled Ports discard any received MSDU if the Controlled Port is not enabled and if the MSDU does not represent an IEEE 802.1X frame. Frame order enforcement provided by the enhanced data cryptographic encapsulation mechanisms occurs after decryption, but prior to MSDU defragmentation; therefore, defragmentation fails if MPDUs arrive out of order.

When transparent FST is used, the same security keys, sequence counter, and PN counter are used by the MAC data plane to encrypt the MPDU prior to and following an FST session transfer, and the same security keys are used to check the integrity and perform the protection of MSDUs. When nontransparent FST is used, independent RSNAs, security keys, sequence counters, and PN counters have to be established for each MAC data plane to be used prior to and following an FST session transfer. When transparent FST is used, a single MAC SAP at each peer is presented to the higher layers of that peer for all the frequency bands/channels that are identified by the same MAC address at that peer. When nontransparent FST is used, different MAC SAPs are presented to higher layers since different MAC addresses are used prior to and following an FST session transfer.

Insert the following figure, Figure 5-2, after Figure 5-1:

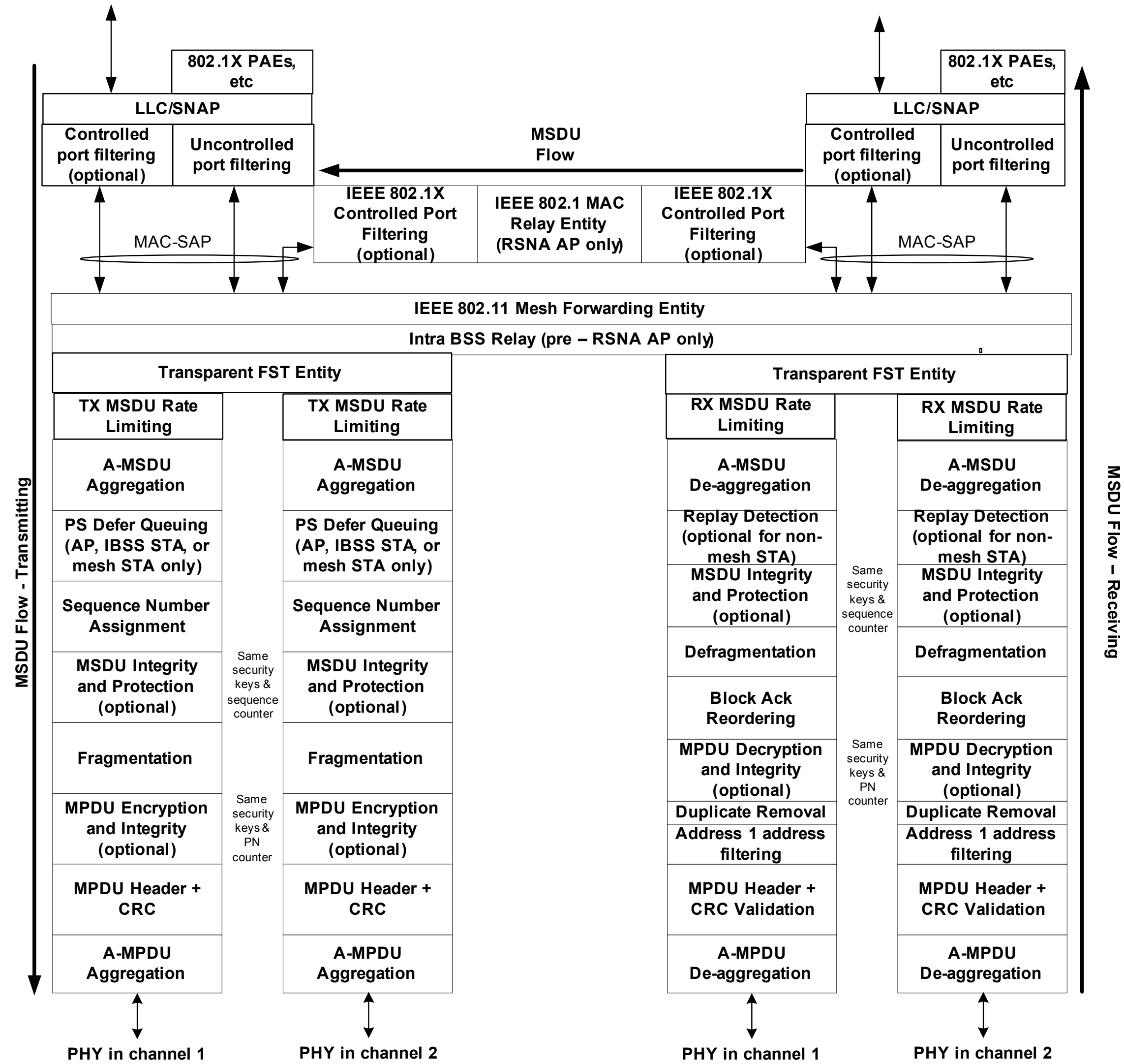


Figure 5-2—MAC data plane architecture (transparent FST)

5.2 MAC data service specification

5.2.2 MA-UNITDATA.request

5.2.2.2 Semantics of the service primitive

Change the fifth paragraph of 5.2.2.2 as follows:

The data parameter specifies the MSDU to be transmitted by the MAC sublayer entity. For IEEE Std 802.11, the length of the MSDU shall be less than or equal to <u>the value shown in Table 8-0a</u>~~2304 octets~~.

6. Layer management

6.3 MLME SAP interface

6.3.3 Scan

6.3.3.2 MLME-SCAN.request

6.3.3.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.3.2.2 as follows:

MLME-SCAN.request(
BSSType,
BSSID,
SSID,
ScanType,
ProbeDelay,
ChannelList,
MinChannelTime,
MaxChannelTime,
RequestInformation,
SSID List,
ChannelUsage,
AccessNetworkType,
HESSID,
MeshID,
<u>DiscoveryMode,</u>
VendorSpecificInfo
)

Change the following row in the untitled table in 6.3.3.2.2:

Name	Type	Valid range	Description
BSSType	Enumeration	INFRASTRUCTURE, <u>PERSONAL,</u> INDEPENDENT, MESH, ANY_BSS	Determines whether infrastructure BSS, <u>PBSS,</u> IBSS, MBSS, or all are included in the scan.

Insert the following row before the VendorSpecificInfo row in the untitled table in 6.3.3.2.2:

Name	Type	Valid range	Description
DiscoveryMode	Integer	0–1	Indicates, if equal to 1, that a DMG Beacon frame is transmitted during active scanning with the Discovery Mode field set to 1 and, if equal to 0, that a DMG Beacon frame is not transmitted during active scanning. Present only when dot11DMGOptionImplemented is true.

6.3.3.3 MLME-SCAN.confirm

6.3.3.3.2 Semantics of the service primitive

Change the following row of the untitled table describing BSSDescriptions in 6.3.3.3.2:

Name	Type	Valid range	Description	IBSS adoption
BSSType	Enumeration	INFRASTRUCTURE, PERSONAL, INDEPENDENT, MESH	The type of the found BSS	Adopt

Insert the following rows at the end of the untitled table describing BSSDescriptions in 6.3.3.3.2:

Name	Type	Valid range	Description	IBSS adoption
Sector Sweep	As defined in frame format	As defined in 8.3.4.1	The values from the Sector Sweep field from the DMG Beacon frame, else null. The parameter is present only if dot11DMGOptionImplemented is true.	Adopt
Beacon Interval Control	As defined in frame format	As defined in 8.3.4.1	The values from the Beacon Interval Control field from the DMG Beacon frame, else null. The parameter is present only if dot11DMGOptionImplemented is true.	Adopt
DMG Parameters	As defined in frame format	As defined in 8.3.4.1	The values from the DMG Parameters field from the DMG Beacon frame, else null. The parameter is present only if dot11DMGOptionImplemented is true.	Adopt
Clustering Control	As defined in frame format	As defined in 8.3.4.1	The values from the Clustering Control field from the DMG Beacon frame, else null. The parameter is present only if dot11DMGOptionImplemented is true.	Do not adopt
DMG Capabilities	As defined in frame format	As defined in 8.4.2.130	The values from the DMG Capabilities element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11DMGOptionImplemented is true.	Do not adopt

Name	Type	Valid range	Description	IBSS adoption
DMG Operation	As defined in frame format	As defined in 8.4.2.131	The values from the DMG Operation element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11DMGOptionImplemented is true.	Adopt
Extended Schedule	As defined in frame format	As defined in 8.4.2.134	The values from the Extended Schedule element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11DMGOptionImplemented is true.	Adopt
Next DMG ATI	As defined in frame format	As defined in 8.4.2.137	The values from the Next DMG ATI element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11DMGOptionImplemented is true.	Adopt
DMG BSS Parameter Change	As defined in frame format	As defined in 8.4.2.129	The values from the DMG BSS Parameter Change element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11DMGOptionImplemented is true.	Adopt
Multi-band	As defined in frame format	As defined in 8.4.2.140	The values from the Multi-band element if such an element was present in the Probe Response or DMG Beacon frame, else null. The Multi-band element is optionally present if dot11MultibandImplemented is true.	Adopt
Wakeup Schedule	As defined in frame format	As defined in 8.4.2.133	The values from the Wakeup Schedule element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11DMGOptionImplemented is true.	Adopt

Name	Type	Valid range	Description	IBSS adoption
Antenna Sector ID Pattern	As defined in frame format	As defined in 8.4.2.159	The values from the Antenna Sector ID Pattern element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11DMGOptionImplemented is true.	Adopt
Relay Capabilities	As defined in frame format	As defined in 8.4.2.150	The values from the Relay Capabilities element if such an element was present in the Probe Response or DMG Beacon frame, else null. The parameter is optionally present only if dot11RelayActivated is true.	Do not adopt

6.3.4 Synchronization

6.3.4.2 MLME-JOIN.request

6.3.4.2.2 Semantics of the service primitive

Change the following row in the untitled table in 6.3.4.2.2 as follows:

Name	Type	Valid range	Description
OperationalRateSet	Set of integers	1–127 inclusive (for each integer in the set)	Non-DMG: The set of data rates that the STA desires to use for communication within the BSS. The STA shall be able to receive at each of the data rates listed in the set. This set is a superset of the rates contained in the BSSBasicRateSet parameter. DMG: The set of MCS indexes that the STA desires to use for communication within the BSS.

6.3.4.2.4 Effect of receipt

Change the second paragraph of 6.3.4.2.4 as follows:

If the ~~an~~ MLME of a non-DMG STA receives an MLME-JOIN.request primitive with the SelectedBSS parameter containing a BSSBasicRateSet element that contains any unsupported rates, the MLME response in the resulting MLME-JOIN.confirm primitive shall contain a ResultCode parameter that is not set to the value SUCCESS.

6.3.5 Authenticate

6.3.5.2 MLME-AUTHENTICATE.request

6.3.5.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.5.2.2 as follows:

MLME-AUTHENTICATE.request(
PeerSTAAddress,
AuthenticationType,
AuthenticateFailureTimeout,
Content of FT Authentication elements,
Content of SAE Authentication Frame,
Multi-band local,
Multi-band peer,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.5.2.2:

Name	Type	Valid range	Description
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the local MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.

6.3.5.3 MLME-AUTHENTICATE.confirm

6.3.5.3.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.5.3.2 as follows:

MLME-AUTHENTICATE.confirm(
PeerSTAAddress,
AuthenticationType,
ResultCode,
Content of FT Authentication elements,
Content of SAE Authentication Frame,
Multi-band local,
Multi-band peer,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.5.3.2:

Name	Type	Valid range	Description
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the local MAC entity. This parameter is present if OCT is being used and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.

6.3.5.4 MLME-AUTHENTICATE.indication

6.3.5.4.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.5.4.2 as follows:

MLME-AUTHENTICATE.indication(
PeerSTAAddress,
AuthenticationType,
Content of FT Authentication elements,
Content of SAE Authentication Frame,
<u>Multi-band local,</u>
<u>Multi-band peer,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.5.4.2:

Name	Type	Valid range	Description
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the local MAC entity. This parameter is present if OCT is being used and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.

6.3.5.5 MLME-AUTHENTICATE.response

6.3.5.5.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.5.5.2 as follows:

MLME-AUTHENTICATE.response(
PeerSTAAddress,
ResultCode,
Content of FT Authentication elements,
Content of SAE Authentication Frame,
<u>Multi-band local,</u>
<u>Multi-band peer,</u>

VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.5.5.2:

Name	Type	Valid range	Description
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the local MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.

6.3.7 Associate

6.3.7.1 Introduction

Change the first paragraph of 6.3.7.1 as follows:

The following primitives describe how a STA becomes associated with a~~n~~ PCP/AP.

6.3.7.2 MLME-ASSOCIATE.request

6.3.7.2.1 Function

Change 6.3.7.2.1 as follows:

This primitive requests association with a specified peer MAC entity that is within a~~n~~ PCP/AP.

6.3.7.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.7.2.2 as follows:

MLME-ASSOCIATE.request(
PeerSTAAddress,
AssociateFailureTimeout,
CapabilityInformation,
ListenInterval,
Supported Channels,
RSN,
QoSCapability,
Content of FT Authentication elements,
SupportedOperatingClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
QoSTrafficCapability,
TIMBroadcastRequest,
EmergencyServices,
DMG Capabilities,
Multi-band local,
Multi-band peer,

MMS,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.2.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the local MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the remote (peer) MAC entity. The parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.7.2.3 When generated

Change 6.3.7.2.3 as follows:

This primitive is generated by the SME when a STA wishes to establish association with ~~an~~ PCP/AP.

6.3.7.3 MLME-ASSOCIATE.confirm

6.3.7.3.1 Function

Change 6.3.7.3.1 as follows:

This primitive reports the results of an association attempt with a specified peer MAC entity that is within ~~an~~ PCP/AP.

6.3.7.3.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.7.3.2 as follows:

MLME-ASSOCIATE.confirm(
ResultCode,
CapabilityInformation,
AssociationID,
SupportedRates,
EDCAParameterSet,
RCPI.request,
RSNI.request,
RCPI.response,
RSNI.response,

RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
QosMapSet,
QMFPolicy,
DMG Capabilities,
Multi-band local,
Multi-band peer,
MMS,
VendorSpecificInfo
)

Delete "AP" and insert in its place "PCP/AP" in the following rows in the untitled table in 6.3.7.3.2: CapabilityInformation, AssociationID, SupportedRates, RMEnabledCapabilities, and BSSMaxIdlePeriod.

Delete "non-AP" and insert in its place "non-PCP/non-AP" in the following row in the untitled table in 6.3.7.3.2: QoSMapSet.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.3.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the local MAC entity. The parameter is present if OCT is being used and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.7.3.3 When generated

Change 6.3.7.3.3 as follows:

This primitive is generated by the MLME as a result of an MLME-ASSOCIATE.request primitive or receipt of an association response frame from the peer MAC entity to associate with a specified peer MAC entity that is within ~~an~~ PCP/AP.

6.3.7.4 MLME-ASSOCIATE.indication

6.3.7.4.1 Function

Change 6.3.7.4.1 as follows:

This primitive indicates that a specific peer MAC entity is requesting association with the local MAC entity, which is within a~~n~~ PCP/AP.

6.3.7.4.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.7.4.2 as follows:

MLME-ASSOCIATE.indication(
PeerSTAAddress,
CapabilityInformation,
ListenInterval,
SSID,
SupportedRates,
RSN,
QoSCapability,
RCPI,
RSNI,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
DSERegisteredLocation,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
QoSTrafficCapability,
TIMBroadcastRequest,
EmergencyServices,
DMG Capabilities,
Multi-band local,
Multi-band peer,
MMS,
VendorSpecificInfo
)

Delete "AP" and insert in its place "PCP/AP" in the following rows in the untitled table in 6.3.7.4.2: RMEnabledCapabilities and SupportedOperatingClasses.

Delete "non-AP" and insert in its place "non-PCP/non-AP" in the following rows in the untitled table in 6.3.7.4.2: QoSTrafficCapability and EmergencyServices.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.4.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the local MAC entity. The parameter is present if OCT is being used and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.7.5 MLME-ASSOCIATE.response

6.3.7.5.1 Function

Change 6.3.7.5.1 as follows:

This primitive is used to send a response to a specific peer MAC entity that requested an association with the STA that issued this primitive, which is within a~~n~~ PCP/AP.

6.3.7.5.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.7.5.2 as follows:

MLME-ASSOCIATE.response(
PeerSTAAddress,
ResultCode,
CapabilityInformation,
AssociationID,
EDCAParameterSet,
RCPI,
RSNI,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
DSERegisteredLocation,
HTCapabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
QoSMapSet,
QMFPolicy
DMG Capabilities,
Multi-band local,

Multi-band peer,
MMS,
VendorSpecificInfo
)

Delete "AP" and insert in its place "PCP/AP" in the following rows in the untitled table in 6.3.7.5.2: CapabilityInformation, AssociationID, RMEnabledCapabilities, SupportedOperatingClasses, BSSMaxIdlePeriod, and QMFPolicy.

Delete "non-AP" and insert in its place "non-PCP/non-AP" in the following row in the untitled table in 6.3.7.5.2: QoSMapSet.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.5.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the local MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the remote (peer) MAC entity. The parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.7.5.3 When generated

Change 6.3.7.5.3 as follows:

This primitive is generated by the SME of a STA that is within ~~an~~ PCP/AP as a response to an MLME-ASSOCIATE.indication primitive.

6.3.8 Reassociate

6.3.8.1 Introduction

Change 6.3.8.1 as follows:

The following primitives describe how a STA becomes associated with another PCP/AP.

6.3.8.2 MLME-REASSOCIATE.request

6.3.8.2.1 Function

Change 6.3.8.2.1 as follows:

This primitive requests a change in association to a specified new peer MAC entity that is within a~~n~~ PCP/AP.

6.3.8.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.8.2.2 as follows:

MLME-REASSOCIATE.request(
NewPCPorAPAddress,
ReassociateFailureTimeout,
CapabilityInformation,
ListenInterval,
Supported Channels
RSN,
QoSCapability,
Content of FT Authentication elements,
SupportedOperatingClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
QoSTrafficCapability,
TIMBroadcastRequest,
FMSRequest,
DMSRequest,
EmergencyServices,
DMG Capabilities,
Multi-band local,
Multi-band peer,
MMS,
VendorSpecificInfo
)

Delete "AP" and insert in its place "PCP/AP" in the following row in the untitled table in 6.3.8.2.2: CapabilityInformation.

Delete "non-AP" and insert in its place "non-PCP/non-AP" in the following rows in the untitled table in 6.3.8.2.2: QoSTrafficCapability and EmergencyServices.

Change the following row in the untitled table in 6.3.8.2.2:

Name	Type	Valid range	Description
NewPCPorAPAddress	MACAddress	Any valid individual MAC address	Specifies the address of the peer MAC entity with which to perform the reassociation process.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.2.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the local MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the remote (peer) MAC entity. The parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.8.2.3 When generated

Change 6.3.8.2.3 as follows:

This primitive is generated by the SME for a STA to change association to a specified new peer MAC entity that is within a~~n~~ PCP/AP.

6.3.8.3 MLME-REASSOCIATE.confirm

6.3.8.3.1 Function

Change 6.3.8.3.1 as follows:

This primitive reports the results of a reassociation attempt with a specified peer MAC entity that is within a~~n~~ PCP/AP.

6.3.8.3.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.8.3.2 as follows:

MLME-REASSOCIATE.confirm(
ResultCode,
CapabilityInformation,
AssociationID,
SupportedRates,
EDCAParameterSet,
RCPI.request,
RSNI.request,
RCPI.response,
RSNI.response,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,

HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
FMSRespone,
DMSResponse,
QoSMapSet,
QMFPolicy,
DMG Capabilities,
Multi-band local,
Multi-band peer,
MMS,
VendorSpecificInfo
)

Delete "AP" and insert in its place "PCP/AP" in the following rows in the untitled table in 6.3.8.3.2: CapabilityInformation, AssociationID, SupportedRates, RMEnabledCapabilities, and BSSMaxIdlePeriod.

Delete "non-AP" and insert in its place "non-PCP/non-AP" in the following row in the untitled table in 6.3.8.3.2: QosMapSet.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.3.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the local MAC entity. The parameter is present if OCT is being used and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.8.3.3 When generated

Change 6.3.8.3.3 as follows:

This primitive is generated by the MLME as a result of an MLME-REASSOCIATE.request primitive to reassociate with a specified peer MAC entity that is within ~~an~~ PCP/AP.

6.3.8.4 MLME-REASSOCIATE.indication

6.3.8.4.1 Function

Change 6.3.8.4.1 as follows:

This primitive indicates that a specific peer MAC entity is requesting reassociation with the local MAC entity, which is within ~~an~~ PCP/AP.

6.3.8.4.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.8.4.2 as follows:

```
MLME-REASSOCIATE.indication(
        PeerSTAAddress,
        CurrentAPAddress,
        CapabilityInformation,
        ListenInterval,
        SSID,
        SupportedRates,
        RSN,
        QoSCapability,
        RCPI,
        RSNI,
        RMEnabledCapabilities,
        Content of FT Authentication elements,
        SupportedOperatingClasses,
        DSERegisteredLocation,
        HT Capabilities,
        Extended Capabilities,
        20/40 BSS Coexistence,
        QoSTrafficCapability,
        TIMBroadcastRequest,
        FMSRequest,
        DMSRequest,
        EmergencyServices,
        DMG Capabilities,
        Multi-band local,
        Multi-band peer,
        MMS,
        VendorSpecificInfo
        )
```

Delete "AP" and insert in its place "PCP/AP" in the following rows in the untitled table in 6.3.8.4.2: CurrentAPAddress and RMEnabledCapabilities.

Delete "non-AP" and insert in its place "non-PCP/non-AP" in the following rows in the untitled table in 6.3.8.4.2: QoSTrafficCapability and EmergencyServices.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.4.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the local MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the remote (peer) MAC entity. This parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.8.5 MLME-REASSOCIATE.response

6.3.8.5.1 Function

Change 6.3.8.5.1 as follows:

This primitive is used to send a response to a specific peer MAC entity that requested a reassociation with the STA that issued this primitive, which is within ~~an~~ PCP/AP.

6.3.8.5.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.8.5.2 as follows:

MLME-REASSOCIATE.response(
PeerSTAAddress,
ResultCode,
CapabilityInformation,
AssociationID,
EDCAParameterSet,
RCPI,
RSNI,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
DSERegisteredLocation,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
FMSResponse,

DMSResponse,
QoSMapSet,
QMFPolicy,
DMG Capabilities,
Multi-band local,
Multi-band peer,
MMS,
VendorSpecificInfo
)

Delete "AP" and insert in its place "PCP/AP" in the following rows in the untitled table in 6.3.8.5.2: CapabilityInformation, AssociationID, RMEnabledCapabilities, BSSMaxIdlePeriod, and QMFPolicy.

Delete "non-AP" and insert in its place "non-PCP/non-AP" in the following row in the untitled table in 6.3.8.5.2: QoSMapSet.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.5.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band local	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the local MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
Multi-band peer	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that identify the remote (peer) MAC entity. The parameter is present if OCT is being used and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.

6.3.8.5.3 When generated

Change 6.3.8.5.3 as follows:

This primitive is generated by the SME of a STA that is within ~~an~~ PCP/AP as a response to an MLME-REASSOCIATE.indication primitive.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.11.2.2 as follows:

MLME-START.request(
SSID,
SSIDEncoding,
BSSType,
BeaconPeriod,
DTIMPeriod,
CF parameter set,
PHY parameter set,
IBSS parameter set,
ProbeDelay,
CapabilityInformation,
BSSBasicRateSet,
OperationalRateSet,
Country,
IBSS DFS Recovery Interval,
EDCAParameterSet,
DSERegisteredLocation,
HT Capabilities,
HT Operation,
BSSMembershipSelectorSet,
BSSBasicMCSSet,
HTOperationalMCSSet,
Extended Capabilities,
20/40 BSS Coexistence,
Overlapping BSS Scan Parameters,
MultipleBSSID,
InterworkingInfo,
AdvertisementProtocolInfo,
RoamingConsortiumInfo,
Mesh ID,
Mesh Configuration,
QMFPolicy,
DMG Capabilities,
Multi-band,
MMS,
DMG Operation,
Clustering Control,
CBAP Only,
PCP Association Ready,
VendorSpecificInfo
)

Change the following rows in the untitled table in 6.3.11.2.2:

Name	Type	Valid range	Description
BSSType	Enumeration	INFRASTRUCTURE, INDEPENDENT, MESH, PERSONAL	The type of the BSS.
OperationalRateSet	Set of integers	1–127 inclusive (for each integer in the set)	Non-DMG: The set of data rates that the STA desires to use for communication within the BSS. The STA shall be able to receive at each of the data rates listed in the set. This set is a superset of the rates contained in the BSSBasicRateSet parameter. DMG: The set of MCS indexes that the STA desires to use for communication within the BSS.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.11.2.2:

Name	Type	Valid range	Description
DMG Capabilities	DMG Capabilities element	As defined in 8.4.2.130	Specifies the parameters within the DMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the parameters within the Multi-band element that are supported by the MAC entity. The parameter is present if dot11MultibandImplemented is true and is absent otherwise.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	Specifies the parameters within the Multiple MAC Sublayers element that are supported by the MAC entity. The parameter is present if dot11MultipleMACActivated is true and is absent otherwise.
DMG Operation	DMG Operation element	As defined in 8.4.2.131	Specifies the parameters within the DMG Operation element that are supported by the MAC entity. The parameter is present if dot11DMGOptionImplemented is true and is absent otherwise.
Clustering Control	Clustering Control field	As defined in 8.3.4.1	Specifies the parameters within the Clustering Control field that are supported by the MAC entity. The parameter is present if dot11ClusteringActivated is true and is absent otherwise.
CBAP Only	Integer	0 or 1	Specifies the setting of the CBAP Only field as defined in 8.3.4.1
PCP Association Ready	Integer	0 or 1	Specifies the setting of the PCP Association Ready field as defined in 8.3.4.1

6.3.11.2.3 When generated

Change the first and second paragraphs of 6.3.11.2.3 as follows:

This primitive is generated by the SME to start an infrastructure BSS (with the MAC entity within an AP), an IBSS (with the MAC entity acting as the first STA in the IBSS), or an MBSS (with the MAC entity acting as the first mesh STA in the MBSS) or to become a member of an existing MBSS or a PBSS (with the MAC entity within a PCP). In an MBSS, this primitive starts the process of mesh beaconing.

An MLME-START.request primitive may be generated in an infrastructure BSS or IBSS or PBSS only after an MLME-RESET.request primitive has been used to reset the MAC entity and before an MLME-JOIN.request primitive has been used to successfully join an existing infrastructure BSS or IBSS or PBSS.

6.3.11.2.4 Effect of receipt

Change the second paragraph of 6.3.11.2.4 as follows:

If the ~~an~~ MLME of a non-DMG STA receives an MLME-START.request primitive with a BSSBasicRateSet parameter containing any unsupported rates, the MLME response in the resulting MLME-START.confirm primitive shall contain a ResultCode parameter that is not set to the value SUCCESS.

6.3.12 Stop

6.3.12.2 MLME-STOP.request

6.3.12.2.3 When generated

Change the first paragraph of 6.3.12.2.3 as follows:

This primitive is generated by the SME to terminate an infrastructure BSS (with the MAC entity within an AP) or a PBSS (with the PCP entity within the MAC). The MLME-STOP.request primitive shall be generated only after successful use of an MLME-START.confirm primitive.

6.3.12.2.4 Effect of receipt

Change the first paragraph of 6.3.12.2.4 as follows:

This primitive initiates the termination of the BSS. All services provided by the AP to an infrastructure BSS, including Beacons, Probe Responses, and access to the DS, are stopped by the termination. All STAs in an infrastructure BSS are deauthenticated by the termination. In a PBSS, all the services provided by the PCP, including DMG Beacons, are stopped by the termination. All the STAs in a PBSS have their RSNA unestablished by the termination.

6.3.26 TS management interface

6.3.26.1 General

Change Table 6-1 as indicated below:

Table 6-1—Supported TS management primitives

Primitive	Request	Confirm	Indication	Response
ADDTS	DMG STA Non-AP QoS STA	DMG STA Non-AP QoS STA	PCP DMG STA HC	PCP DMG STA HC
DELTS	DMG STA Non-AP QoS STA ~~and~~ PCP HC	DMG STA Non-AP QoS STA ~~and~~ PCP HC	DMG STA Non-AP QoS STA ~~and~~ PCP HC	—
ADDTSRESERVE	HC	HC	Non-AP QoS STA	Non-AP Qos STA

6.3.26.2 MLME-ADDTS.request

6.3.26.2.1 Function

Change 6.3.26.2.1 as follows:

This primitive requests addition (or modification) of a TS. It requests the PCP/HC to admit the new or changed TS.

6.3.26.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.2.2 as follows:

```
MLME-ADDTS.request (
        DialogToken,
        TSPEC,
        TCLAS,
        TCLASProcessing,
        ADDTSFailureTimeout,
        U-APSD Coexistence,
        EBR,
        IntraAccessCategoryPriority,
        HigherLayerStreamID,
        STAAddress,
        DMG TSPEC,
        Multi-band,
        U-PID,
        MMS,
        VendorSpecificInfo
        )
```

Insert the following rows before the VendorSpecficInfo row in the untitled table in 6.3.26.2.2:

Name	Type	Valid range	Description
STAAddress	MACAddress		Specifies the MAC address of the peer STA for the PTP TSPEC.
DMG TSPEC	DMG TSPEC element	As defined in 8.4.2.136	Specifies the characteristics and QoS (scheduling) requirements of the DMG allocation request.
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the TSID is to be established. The parameter is absent if the TSID is intended to be established on the same frequency band and channel where the ADDTS Request is transmitted.
U-PID	U-PID element	As defined in 8.4.2.156	This parameter is optionally present and specifies the parameters of the LLC for the purpose of (de)multiplexing of frames associated with the TSID.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	This parameter is optionally present and specifies the parameters of an MMSL cluster establishment.

6.3.26.3 MLME-ADDTS.confirm

6.3.26.3.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.3.2 as follows:

MLME-ADDTS.confirm(
ResultCode,
DialogToken,
TSDelay,
TSPEC,
Schedule,
TCLAS,
TCLASProcessing,
EBR,
HigherLayerStreamID,
STAAddress,
Extended Schedule,
DMG TSPEC,
Multi-band,
U-PID,
MMS,
VendorSpecificInfo
)

Change the following row in the untitled table in 6.3.26.3.2:

Name	Type	Valid range	Description
ResultCode	Enumeration	SUCCESS, INVALID_PARAMETERS, REJECTED_WITH_SUGGESTED_CHANGES, REJECTED_FOR_DELAY_PERIOD, REJECTED_WITH_SUGGESTED_BSS_TRANSITION, REQUESTED_TCLAS_NOT_SUPPORTED, TCLAS_RESOURCES_EXHAUSTED, REJECTED_HOME_WITH_SUGGEST_CHANGES, REJECTED_FOR_SSP_PERMISSIONS, SUCCESS_STA_IN_DOZE_MODE, REJECT_U-PID_SETTING	Indicates the results of the corresponding MLME-ADDTS.request primitive.

Insert the following rows before the VendorSpecficInfo row in the untitled table in 6.3.26.3.2:

Name	Type	Valid range	Description
STAAddress	MACAddress		Specifies the MAC address of the peer STA for the PTP TSPEC.
Extended Schedule	Extended Schedule element	As defined in 8.4.2.134	Specifies the schedule information of the TS. Present when dot11DMGOptionImplemented is true, otherwise absent.
DMG TSPEC	DMG TSPEC element	As defined in 8.4.2.136	Specifies the characteristics and QoS (scheduling) requirements of the DMG allocation request.
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the TSID is to be established. The parameter is absent if the TSID is intended to be established on the same frequency band and channel where the ADDTS Request is transmitted.
U-PID	U-PID element	As defined in 8.4.2.156	This parameter is optionally present and specifies the parameters of the LLC for the purpose of (de)multiplexing of frames associated with the TSID.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	This parameter is optionally present and specifies the parameters of an MMSL cluster establishment.

Change the text after the untitled table in 6.3.26.3.2 as indicated:

For the ResultCode value of SUCCESS received by a non-DMG STA, the TSPEC and the optional TCLAS parameters describe the characteristics of the TS that has been created (or modified); and the specified (nonzero) parameters [with the exception of Service Start Time, Medium Time, and any possibly unspecified minimum set of parameters (see 9.19.4.3) in the TSPEC in ADDTS Request frame] exactly match those of the matching MLME-ADDTS.request primitive.

For other values of ResultCode received by a non-DMG STA, no new TS has been created. In the case of REJECTED_WITH_SUGGESTED_CHANGES, the TSPEC represents an alternative proposal by the HC based on information about the current status of the MAC entity. In the case of REJECTED_HOME_WITH_SUGGESTED_CHANGES, the TSPEC represents an alternative proposal by the HC based on information received from the SSPN interface. A TS is not created with this definition. If the suggested changes are acceptable to the STA, it is the responsibility of the STA to set up the TS with the suggested changes.

In the case of REJECTED_WITH_SUGGESTED_BSS_TRANSITION, non-AP STA should retry TS setup process with the newly associated AP once the transition is done.

If this is the result of a modification of an existing TS, the status of that TS remains unchanged.

For the ResultCode value of SUCCESS or SUCCESS_STA_IN_DOZE_MODE received by a DMG STA, the DMG TSPEC and the optional TCLAS parameters describe the characteristics of the allocation or TS that has been created (or modified); and the specified (nonzero) parameters [with the exception of Maximum Allocation in the DMG TSPEC in the ADDTS Request frame] exactly match those of the matching MLME-ADDTS.request primitive.

For other values of ResultCode received by a DMG STA, no new allocation or TS has been created. In the case of REJECTED_WITH_SUGGESTED_CHANGES or REJECT_U-PID_SETTING, then the DMG TSPEC, Multi-band, and U-PID parameters represent an alternative proposal by the peer STA. In such cases, an allocation or TS has not been created. If the suggested changes are acceptable to the STA, it is the responsibility of the STA to set up the allocation or TS with the suggested changes.

If this failure is the result of a modification of an existing allocation or TS, the status of that allocation or TS remains unchanged.

6.3.26.3.3 When generated

Change the second paragraph of 6.3.26.3.3 as follows:

This primitive is generated when that MLME-ADDTS.request primitive is found to contain invalid parameters, when a timeout occurs, or when the STA receives a response in the form of an ADDTS Response frame in the corresponding QoS Action frame from the HC or DMG STA.

6.3.26.4 MLME-ADDTS.indication

6.3.26.4.1 Function

Change 6.3.26.4.1 as indicated:

This primitive reports to the DMG STA's or HC's SME the request for adding (or modifying) a TS.

6.3.26.4.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.4.2 as follows:

MLME-ADDTS.indication (
DialogToken,
STAAddress,
TSPEC,
TCLAS,
TCLASProcessing,
U-APSD Coexistence,
EBR,
IntraAccessCategoryPriority,
HigherLayerStreamID,
DMG TSPEC,
Multi-band,
U-PID,
MMS,

VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.26.4.2:

Name	Type	Valid range	Description
DMG TSPEC	DMG TSPEC element	As defined in 8.4.2.136	Specifies the characteristics (scheduling) and QoS requirements of the DMG allocation request.
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the TSID is to be established. The parameter is absent if the TSID is intended to be established on the same frequency band and channel where the ADDTS Request is transmitted.
U-PID	U-PID element	As defined in 8.4.2.156	This parameter is optionally present and specifies the parameters of the LLC for the purpose of (de)multiplexing of frames associated with the TSID.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	This parameter is optionally present and specifies the parameters of an MMSL cluster establishment.

6.3.26.4.4 Effect of receipt

Change the second paragraph of 6.3.26.4.4 as follows:

This primitive solicits an MLME-ADDTS.response primitive from the SME that reflects the results of admission control at the HC <u>or DMG STA </u>on the TS requested to be added (or modified).

6.3.26.5 MLME-ADDTS.response

6.3.26.5.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.5.2 as follows:

MLME-ADDTS.response (
ResultCode,
DialogToken,
STAAddress,
TSDelay,
TSPEC,
Schedule,
TCLAS,
TCLASProcessing,
EBR,
HigherLayerStreamID,
<u>Extended Schedule,</u>
<u>DMG TSPEC,</u>
<u>Multi-band,</u>
<u>U-PID,</u>
<u>MMS,</u>
VendorSpecificInfo
)

Change the following row in the untitled table in 6.3.26.5.2:

Name	Type	Valid range	Description
ResultCode	Enumeration	SUCCESS, INVALID_PARAMETERS, REJECTED_WITH_SUGGESTED_CHANGES, REJECTED_FOR_DELAY_PERIOD, REJECTED_WITH_SUGGESTED_ BSS_TRANSITION, REQUESTED_TCLAS_NOT_SUPPORTED, TCLAS_RESOURCES_EXHAUSTED, REJECTED_HOME_WITH_SUGGESTED_CHANGES, REJECTED_FOR_SSP_PERMISSIONS, SUCCESS_STA_IN_DOZE_MODE, REJECT_U-PID_SETTING	Indicates the results of the corresponding MLME-ADDTS.indication primitive.

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.26.5.2:

Name	Type	Valid range	Description
Extended Schedule	Extended Schedule element	As defined in 8.4.2.134	Specifies the schedule information of the TS.
DMG TSPEC	DMG TSPEC element	As defined in 8.4.2.136	Specifies the characteristics (scheduling) and QoS requirements of the DMG allocation request.
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the TSID is to be established. The parameter is absent if the TSID is intended to be established on the same frequency band and channel where the ADDTS Request is transmitted.
U-PID	U-PID element	As defined in 8.4.2.156	This parameter is optionally present and specifies the parameters of the LLC for the purpose of (de)multiplexing of frames associated with the TSID.
MMS	Multiple MAC Sublayers element	As defined in 8.4.2.155	This parameter is optionally present and specifies the parameters of an MMSL cluster establishment.

Change the text after the untitled table in 6.3.26.5.2 as follows:

The DialogToken and STAAddress parameters contain the values from the matching MLME-ADDTS.indication primitive.

If a non-DMG STA receives a ~~the~~ result code of ~~is~~ SUCCESS, the TSPEC and (optional) TCLAS parameters contain the values from the matching MLME-ADDTS.indication.

If a DMG STA receives a result code of SUCCESS or SUCCESS_STA_IN_DOZE_MODE, the DMG TSPEC and (optional) TCLAS parameters contain the values from the matching MLME-ADDTS.indication.

If a non-DMG STA receives a ~~the~~ result code of ~~is~~ REJECTED_WITH_SUGGESTED_CHANGES or REJECTED_HOME_WITH_SUGGESTED_CHANGES, the TSPEC and TCLAS parameters represent an alternative proposed TS either based on information local to the MAC entity or using additional information received across the SSPN interface. The TS, however, is not created. The TSID and direction values within the TSPEC are as in the matching MLME-ADDTS.indication primitive. The difference may lie in the QoS (e.g., minimum data rate, mean data rate, and delay bound) values, as a result of admission control performed at the SME of the HC on the TS requested to be added (or modified) by the STA. If sufficient bandwidth is not available, the QoS values may be reduced. In one extreme, the minimum data rate, mean data rate, and delay bound may be all set to 0, indicating that no QoS is to be provided to this TS.

If a DMG STA receives a result code of REJECTED_WITH_SUGGESTED_CHANGES or REJECT_U-PID_SETTING, then the DMG TSPEC, TCLAS, Multi-band, and U-PID parameters represent an alternative proposal for the allocation or TS. The allocation or TS, however, has not been created. The allocation ID value within the DMG TSPEC is as in the matching MLME-ADDTS.indication primitive. The difference might lie in the other parameter values, as a result of admission control performed at the SME of the peer STA on the allocation or TS requested to be added (or modified). If sufficient bandwidth is not available, the QoS values might be reduced.

If the result code is REJECTED_WITH_SUGGESTED_BSS_TRANSITION, the non-AP STA should initiate a transition query as defined in 10.23.6. Once the transition is completed, the STA should retry TS setup process, as defined in 10.4.4.

6.3.26.5.3 When generated

Change 6.3.26.5.3 as follows:

This primitive is generated by the SME at the HC or DMG STA as a result of an MLME-ADDTS.indication primitive to initiate addition (or modification) of a TS with a specified peer MAC entity or entities.

6.3.26.5.4 Effect of receipt

Change the second paragraph of 6.3.26.5.4 as follows:

This primitive causes the MAC entity at the HC or DMG STA to send an ADDTS Response frame in the corresponding QoS Action management frame to the requesting STA containing the specified parameters.

6.3.26.6 MLME-DELTS.request

6.3.26.6.1 Function

Change the second paragraph in 6.3.26.6.1 as indicated:

This primitive may be generated at one of the following: ~~either a~~

- DMG STA
- Non-AP STA
- PCP ~~or the~~
- HC

6.3.26.6.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.6.2 as follows:

```
MLME-DELTS.request(
        STAAddress,
        TSInfo,
        ReasonCode,
        STAAddress,
        DMG Allocation Info,
```


Multi-band,
VendorSpecificInfo
)

Change the untitled table in 6.3.26.6.2 as follows:

Name	Type	Valid range	Description
STAAddress	MACAddress		Specifies the MAC address of the STA that initiated this TS. Present only at the HC.
TSInfo	TS Info field	As defined in 8.4.2.32	Specifies the TS to be deleted. Not present when DMG Allocation Info is present.
ReasonCode	Enumeration	STA_LEAVING, END_TS, UNKNOWN_TS, TIMEOUT, SERVICE_CHANGE_PRECLUDES_TS	Indicates the reason why the TS is being deleted.
STAAddress	MACAddress		Specifies the MAC address of the peer STA for the PTP TSPEC.
DMG Allocation Info	DMG Allocation Info field	As defined in 8.4.2.136	Specifies the DMG allocation to be deleted. Not present when TSInfo is present.
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the TS is to be deleted. The parameter is absent if the TS is intended to be deleted on the same frequency band and channel where the DELTS is transmitted.
VendorSpecificInfo	A set of elements	As defined in 8.4.2.28	Zero or more elements.

6.3.26.6.4 Effect of receipt

Change the second paragraph of 6.3.26.6.4 as follows:

This primitive causes the local MAC entity to send out a DELTS frame containing the specified parameters. If this primitive was generated at the HC, the frame is sent to the specified STA's MAC address. If this primitive was generated at the non-AP STA that is a non-DMG STA, the frame is sent to its HC. A DMG STA sends the frame to the specified STA's MAC address. In ~~either~~ any of the cases, the DELTS frame does not solicit a response from the recipient frame other than an acknowledgment to receipt of the frame.

6.3.26.7 MLME-DELTS.indication

6.3.26.7.1 Function

Change 6.3.26.7.1 as follows:

This primitive reports the deletion of a TS by a specified peer MAC entity or deletion of the TS due to an inactivity timeout (PCP/HC only).

6.3.26.7.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.7.2 as follows:

MLME-DELTS.indication (
STAAddress,
TSInfo,
ReasonCode,
DMG Allocation Info,
Multi-band,
VendorSpecificInfo
)

Change the untitled table in 6.3.26.7.2 as follows:

Name	Type	Valid range	Description
STAAddress	MACAddress		Specifies the MAC address of the STA for which the TS is being deleted. Present only at the HC.
TSInfo	TS Info field	As defined in 8.4.2.32	Specifies the TS information of the TS of concern. Not present when DMG Allocation Info is present.
ReasonCode	Enumeration	STA_LEAVING, END_TS, UNKNOWN_TS, TIMEOUT, SERVICE_CHANGE_PRECLUDES_TS	Indicates the reason why the TS is being deleted.
DMG Allocation Info	DMG Allocation Info field	As defined in 8.4.2.136	Specifies the DMG allocation under consideration. Not present when TSInfo is present.
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number for the TS under consideration. The parameter is absent if the TS is intended to be deleted on the same frequency band and channel where the DELTS is transmitted.
VendorSpecificInfo	A set of elements	As defined in 8.4.2.28	Zero or more elements.

6.3.26.7.3 When generated

Change the second paragraph of 6.3.26.7.3 as follows:

This primitive may also be generated by the MLME at the DMG STA or HC as a result of inactivity of a particular TS. Inactivity results when a period equal to the inactivity interval in the TSPEC for the TS elapses

— Without arrival of an MSDU belonging to that TS at the MAC entity of the DMG STA or HC via an MA-UNITDATA.request primitive when the DMG STA or HC is the source STA of that TS or

— Without reception of an MSDU belonging to that TS by the MAC entity of the DMG STA or HC when the DMG STA or HC is not the source STA of that TS.

6.3.29 Block Ack

6.3.29.2 MLME-ADDBA.request

6.3.29.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.29.2.2 as follows:

MLME-ADDBA.request(
PeerSTAAddress,
DialogToken,
TID,
BlockAckPolicy,
BufferSize,
BlockAckTimeout,
ADDBAFailureTimeout,
BlockAckStartingSequenceControl,
GCRGroupAddress,
Multi-band,
TCLAS,
ADDBA Extension,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.29.2.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the Block Ack is to be established. The parameter is absent if the Block Ack is intended to be established on the same frequency band and channel where the ADDBA Request is transmitted.
TCLAS	TCLAS element	As defined in 8.4.2.33	Zero or more TCLAS elements. Specifies the rules and parameters by which an MSDU might be classified to the specified TID.
ADDBA Extension	ADDBA Extension element	As defined in 8.4.2.141	Specifies additional parameters associated with the Block Ack.

6.3.29.3 MLME-ADDBA.confirm

6.3.29.3.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.29.3.2 as follows:

MLME-ADDBA.confirm(
PeerSTAAddress,
DialogToken,
TID,
ResultCode,

BlockAckPolicy,
BufferSize,
BlockAckTimeout,
GCRGroupAddress,
Multi-band,
TCLAS,
ADDBA Extension,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.29.3.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the Block Ack initiation was attempted. The parameter is absent if the Block Ack is intended was attempted to be established on the same frequency band and channel where the ADDBA Request is transmitted.
TCLAS	TCLAS element	As defined in 8.4.2.33	Zero or more TCLAS elements. Specifies the rules and parameters by which an MSDU might be classified to the specified TID.
ADDBA Extension	ADDBA Extension element	As defined in 8.4.2.141	Specifies additional parameters associated with the Block Ack.

6.3.29.4 MLME-ADDBA.indication

6.3.29.4.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.29.4.2 as follows:

MLME-ADDBA.indication(
PeerSTAAddress,
DialogToken,
TID,
BlockAckPolicy,
BufferSize,
BlockAckTimeout,
GCRGroupAddress,
Multi-band,
TCLAS,
ADDBA Extension,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.29.4.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the Block Ack is to be established. The parameter is absent if the Block Ack is intended to be established on the same frequency band and channel where the ADDBA Request is transmitted.
TCLAS	TCLAS element	As defined in 8.4.2.33	Zero or more TCLAS elements. Specifies the rules and parameters by which an MSDU might be classified to the specified TID.
ADDBA Extension	ADDBA Extension element	As defined in 8.4.2.141	Specifies additional parameters associated with the Block Ack.

6.3.29.5 MLME-ADDBA.response

6.3.29.5.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.29.5.2 as follows:

MLME-ADDBA.response(
PeerSTAAddress,
DialogToken,
TID,
ResultCode,
BlockAckPolicy,
BufferSize,
BlockAckTimeout,
GCRGroupAddress,
<u>Multi-band,</u>
<u>TCLAS,</u>
<u>ADDBA Extension,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.29.5.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the Block Ack is intended to be established. The parameter is absent if the Block Ack is intended to be established on the same frequency band and channel where the ADDBA Response is transmitted.
TCLAS	TCLAS element	As defined in 8.4.2.33	Zero or more TCLAS elements. Specifies the rules and parameters by which an MSDU might be classified to the specified TID.
ADDBA Extension	ADDBA Extension element	As defined in 8.4.2.141	Specifies additional parameters associated with the Block Ack.

6.3.29.6 MLME-DELBA.request

6.3.29.6.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.29.6.2 as follows:

MLME-DELBA.request(
PeerSTAAddress,
Direction,
TID,
ReasonCode,
<u>Multi-band,</u>
<u>TCLAS,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.29.6.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where the Block Ack is to be deleted. The parameter is absent if the Block Ack to be deleted is established on the same frequency band and channel where the DELBA is transmitted.
TCLAS	TCLAS element	As defined in 8.4.2.33	Zero or more TCLAS elements. Specifies the rules and parameters by which an MSDU might be classified to the specified TID.

6.3.29.7 MLME-DELBA.indication

6.3.29.7.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.29.7.2 as follows:

MLME-DELBA.indication(
PeerSTAAddress,
Direction,
TID,
ReasonCode,
<u>Multi-band,</u>
<u>TCLAS,</u>
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.29.7.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number where Block Ack is to be deleted. The parameter is absent if the Block Ack deletion refers to the same frequency band and channel where the DELBA is transmitted.
TCLAS	TCLAS element	As defined in 8.4.2.33	Zero or more TCLAS elements. Specifies the rules and parameters by which an MSDU might be classified to the specified TID.

6.3.71 Network discovery and selection support

6.3.71.2 MLME-GAS.request

6.3.71.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.71.2.2 as follows:

MLME-GAS.request(
PeerSTAAddress,
DialogToken,
AdvertisementProtocolID,
Query,
QueryFailureTimeout,
Protected,
Multi-band
)

Insert the following row at the end of the untitled table in 6.3.71.2.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number to which the GAS transaction applies. The parameter is absent if the GAS transaction applies to the same frequency band and channel where the frame is transmitted.

6.3.71.3 MLME-GAS.confirm

6.3.71.3.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.71.3.2 as follows:

MLME-GAS.confirm(
PeerSTAAddress,
DialogToken,
ResultCode,
ResponseInfo,
Protected,
Multi-band
)

Insert the following row at the end of the untitled table in 6.3.71.3.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number to which the GAS transaction applies. The parameter is absent if the GAS transaction applies to the same frequency band and channel where the frame is transmitted.

6.3.71.4 MLME-GAS.indication

6.3.71.4.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.71.4.2 as follows:

MLME-GAS.indication(
PeerSTAAddress,
DialogToken,
AdvertisementProtocolID,
Query,
Protected,
Multi-band
)

Insert the following row at the end of the untitled table in 6.3.71.4.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number to which the GAS transaction applies. The parameter is absent if the GAS transaction applies to the same frequency band and channel where the frame is transmitted.

6.3.71.5 MLME-GAS.response

6.3.71.5.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.71.5.2 as follows:

MLME-GAS.response(
PeerSTAAddress,
DialogToken,
ResultCode,
ResponseInfo,
Protected,
Multi-band
)

Insert the following row at the end of the untitled table in 6.3.71.5.2:

Name	Type	Valid range	Description
Multi-band	Multi-band element	As defined in 8.4.2.140	Specifies the frequency band and channel number to which the GAS transaction applies. The parameter is absent if the GAS transaction applies to the same frequency band and channel where the frame is transmitted.

6.3.88 AP PeerKey management

Insert the following subclauses, 6.3.89 to 6.3.94.3.4 (including Figure 6-25b), after 6.3.88.3.4:

6.3.89 On-channel Tunneling operation

6.3.89.1 General

On-channel tunneling (OCT) primitives are used as part of multi-band operation (see 10.32). OCT frames are used to transport management frames between peer MLME entities of multi-band capable devices.

The operation of the OCT is illustrated in Figure 6-25b.

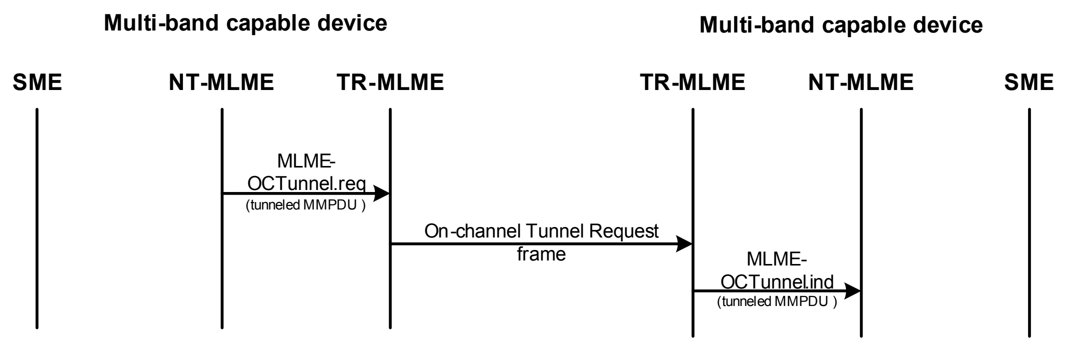


Figure 6-25b—Operation of OCT

An initiator MLME of a STA that might not be currently enabled to transmit generates a MLME-OCTunnel.request primitive to a local MLME entity of a STA that is enabled to transmit. This request carries the contents of a management frame and replaces transmission on-the-air of that frame.

The recipient MLME generates the MLME-OCTunnel.indication primitive to the local MLME entity identified in the On-channel Tunnel Request frame.

The direct MLME-to-MLME primitive exchange should be viewed as shorthand for an exchange through the SMEs and multi-band entity, i.e., an MLME addresses another local MLME entity by sending that primitive through its SME and the multi-band entity to the SME of the MLME entity of a STA that is enabled to transmit, which reflects that primitive to the appropriate recipient.

6.3.89.2 MLME-OCTunnel.request

6.3.89.2.1 Function

This primitive requests transmission of an On-channel Tunnel Request frame.

6.3.89.2.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-OCTunnel.request(
PeerSTAAddress,
OCT MMPDU,
Multi-band peer
)

Name	Type	Valid range	Description
PeerSTAAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA to which the On-channel Tunnel Request frame is transmitted.
OCT MMPDU	OCT MMPDU structure	As defined in the On-channel Tunnel Request frame format (see 8.5.21.7)	The OCT MMPDU carries the MMPDU to be tunneled to the specified MLME entity of the specified STA.
Multi-band peer	Multi-band element	As defined in the Multi-band element format (see 8.4.2.140)	The Multi-band element identifies the peer MLME entity that should receive the OCT MMPDU.

6.3.89.2.3 When generated

This primitive is generated by another MLME to request that an On-channel Tunnel Request frame be sent to another STA.

6.3.89.2.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit an On-channel Tunnel Request frame.

6.3.89.3 MLME-OCTunnel.indication

6.3.89.3.1 Function

This primitive indicates that an On-channel Tunnel Request frame was received.

6.3.89.3.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-OCTunnel.indication(
PeerSTAAddress,
OCT MMPDU,
Multi-band local
)

Name	Type	Valid range	Description
PeerSTAAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA from which the On-channel Tunnel Request frame was received.
OCT MMPDU	OCT MMPDU structure	As defined in the On-channel Tunnel Request frame format (see 8.5.21.7)	The OCT MMPDU carries the MMPDU that is being tunneled to the local MLME entity.
Multi-band local	Multi-band element	As defined in the Multi-band element format (see 8.4.2.140)	The Multi-band element identifies the local MLME entity that should receive the OCT MMPDU.

6.3.89.3.3 When generated

This primitive is generated by the MLME to notify another MLME when a valid On-channel Tunnel Request frame is received.

6.3.89.3.4 Effect on receipt

The recipient of this primitive is an MLME entity in a multi-band device.

On receipt of this primitive, the MLME retrieves the tunneled frame and processes it as though it were received on-the-air.

6.3.90 Multi-band operation

6.3.90.1 General

This subclause describes the management procedures associated with the multi-band operation mechanism.

6.3.90.2 MLME-FSTSetup.request

6.3.90.2.1 Function

This primitive requests transmission of an FST Setup Request frame.

6.3.90.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTSetup.request(
        FSTResponderAddress,
        FSTSetupRequest
        )
```

Name	Type	Valid range	Description
FSTResponderAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA to which the FST Setup Request frame is transmitted.
FSTSetupRequest	FST Setup Request Action field	As defined in the FST Setup Request frame format	Specifies the parameters of the FST Setup.

6.3.90.2.3 When generated

This primitive is generated by the SME to request that an FST Setup Request frame be sent to another STA.

6.3.90.2.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit an FST Setup Request frame.

6.3.90.3 MLME-FSTSetup.indication

6.3.90.3.1 Function

This primitive indicates that an FST Setup Request frame was received.

6.3.90.3.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTSetup.indication(
        FSTInitiatorAddress,
        FSTSetupRequest
        )
```

Name	Type	Valid range	Description
FSTInitiatorAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA from which the FST Setup Request frame was received.
FSTSetupRequest	FST Setup Request Action field	As defined in FST Setup Request frame	Specifies the parameters of the FST Setup.

6.3.90.3.3 When generated

This primitive is generated by the MLME when a valid FST Setup Request frame is received.

6.3.90.3.4 Effect on receipt

On receipt of this primitive, the SME operates according to the procedure in 10.32.

6.3.90.4 MLME-FSTSetup.response

6.3.90.4.1 Function

This primitive requests that an FST Setup Response frame be transmitted to the FST initiator STA.

6.3.90.4.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-FSTSetup.response(
FSTInitiatorAddress,
FSTSetupResponse
)

Name	Type	Valid range	Description
FSTInitiatorAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA to which the FST Setup Response frame is transmitted.
FSTSetupResponse	FST Setup Response Action field	As defined in FST Setup Response frame	Specifies the parameters of the FST Setup.

6.3.90.4.3 When generated

This primitive is generated by the SME to request that an FST Setup Response frame is be transmitted to the FST initiator STA.

6.3.90.4.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit an FST Setup Response frame.

6.3.90.5 MLME-FSTSetup.confirm

6.3.90.5.1 Function

This primitive indicates that an FST Setup Response frame was received.

6.3.90.5.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-FSTSetup.confirm(
FSTResponderAddress,
FSTSetupResponse
)

Name	Type	Valid range	Description
FSTResponderAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA from which the FST Setup Response frame was received.
FSTSetupResponse	FST Setup Response Action field	As defined in FST Setup Response frame	Specifies the parameters of the FST Setup.

6.3.90.5.3 When generated

This primitive is generated by the MLME when a valid FST Setup Response frame is received.

6.3.90.5.4 Effect on receipt

On receipt of this primitive, the SME operates according to the procedure in 10.32.

6.3.90.6 MLME-FSTAck.request

6.3.90.6.1 Function

This primitive requests transmission of an FST Ack Request frame.

6.3.90.6.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTAck.request(
        FSTResponderAddress,
        FSTAckRequest
        )
```

Name	Type	Valid range	Description
FSTResponderAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA to which the FST Ack Request frame is transmitted.
FSTAckRequest	FST Ack Request Action field	As defined in FST Ack Request frame	Specifies the parameters of the FST Ack Request.

6.3.90.6.3 When generated

This primitive is generated by the SME to request that an FST Ack Request frame be sent to another STA.

6.3.90.6.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit an FST Ack Request frame.

6.3.90.7 MLME-FSTAck.indication

6.3.90.7.1 Function

This primitive indicates that an FST Ack Request frame was received.

6.3.90.7.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTAck.indication(
        FSTInitiatorAddress,
        FSTAckRequest
        )
```

Name	Type	Valid range	Description
FSTInitiatorAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA from which the FST Ack Request frame was received.
FSTAckRequest	FST Ack Request Action field	As defined in FST Ack Request frame	Specifies the parameters of the FST Ack Request.

6.3.90.7.3 When generated

This primitive is generated by the MLME when a valid FST Ack Request frame is received.

6.3.90.7.4 Effect on receipt

On receipt of this primitive, the MLME operates according to the procedure in 10.32.

6.3.90.8 MLME-FSTAck.response

6.3.90.8.1 Function

This primitive requests that an FST Ack Response frame be transmitted to the FST initiator STA.

6.3.90.8.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTAck.response(
        FSTInitiatorAddress,
        FSTAckResponse
        )
```

Name	Type	Valid range	Description
FSTInitiatorAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA to which the FST Ack Response frame is transmitted.
FSTAckResponse	FST Ack Response Action field	As defined in FST Ack Response frame	Specifies the parameters of the FST Ack Response.

6.3.90.8.3 When generated

This primitive is generated by the SME to request that an FST Ack Response frame be transmitted to the FST initiator STA.

6.3.90.8.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit an FST Ack Response frame.

6.3.90.9 MLME-FSTAck.confirm

6.3.90.9.1 Function

This primitive indicates that an FST Ack Response frame was received.

6.3.90.9.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTAck.confirm(
        FSTResponderAddress,
        FSTAckResponse
        )
```

Name	Type	Valid range	Description
FSTResponderAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA from which the FST Ack Response frame was received.
FSTAckResponse	FST Ack Response Action field	As defined in FST Ack Response frame	Specifies the parameters of the FST Ack Response.

6.3.90.9.3 When generated

This primitive is generated by the MLME when a valid FST Ack Response frame is received.

6.3.90.9.4 Effect on receipt

On receipt of this primitive, the MLME operates according to the procedure in 10.32.

6.3.90.10 MLME-FSTTeardown.request

6.3.90.10.1 Function

This primitive requests that an FST Tear Down frame be transmitted to the FST initiator STA.

6.3.90.10.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTTeardown.request(
        FSTPeerSTAAddress,
        FSTTeardown
        )
```

Name	Type	Valid range	Description
FSTPeerSTAAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA to which the FST Tear Down frame is transmitted.
FSTTeardown	FST Tear Down Action field	As defined in FST Tear Down frame	Specifies the parameters of the FST teardown.

6.3.90.10.3 When generated

This primitive is generated by the SME to request that an FST Tear Down frame be transmitted to the FST peer STA.

6.3.90.10.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit an FST Tear Down frame.

6.3.90.11 MLME-FSTTeardown.indication

6.3.90.11.1 Function

This primitive indicates that an FST Tear Down frame was received.

6.3.90.11.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-FSTTeardown.indication(
        FSTPeerSTAAddress,
        FSTAckResponse
        )
```

Name	Type	Valid range	Description
FSTPeerSTAAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA from which the FST Tear Down frame was received.
FSTTeardown	FST Tear Down Action field	As defined in FST Tear Down frame	Specifies the parameters of the FST teardown.

6.3.90.11.3 When generated

This primitive is generated by the MLME when a valid FST Tear Down frame is received.

6.3.90.11.4 Effect on receipt

On receipt of this primitive, the MLME operates according to the procedure in 10.32.

6.3.90.12 MLME-FSTIncoming.request

6.3.90.12.1 Function

This primitive announces an incoming FST from another band/channel. This primitive does not result in the transmission of a frame.

6.3.90.12.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-FSTIncoming.request(
FSTInitiatorAddress,
FSTResponderAddress,
FSTSetupRequest,
FSTSetupResponse,
FSTIsInitiator
)

Name	Type	Valid range	Description
FSTInitiatorAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA that is the FST initiator.
FSTResponderAddress	MAC Address	Any valid individual MAC address	Specifies the MAC address of the STA that is the FST responder.
FSTSetupRequest	FST Setup Request Action field	As defined in FST Setup Request frame	Specifies the parameters of the last FST Setup Request frame exchanged between the initiator and responder.
FSTSetupResponse	FST Setup Response Action field	As defined in FST Setup Response frame	Specifies the parameters of the last FST Setup Response frame exchanged between the initiator and responder.
FSTIsInitiator	Boolean	true, false	Indicates the role that the STA performs in the FST. Set to true if the STA performs in the role of initiator STA, and set to false otherwise.

6.3.90.12.3 When generated

This primitive is generated by the SME to announce that an FST session is being transferred from another band/channel.

6.3.90.12.4 Effect on receipt

On receipt of this primitive, the MLME is notified of an incoming FST session. The MLME does not transmit a frame as a result of this primitive.

6.3.91 DMG relay operation

6.3.91.1 General

This subclause describes the management procedures associated with DMG relay.

6.3.91.2 MLME-RELAYSearch.request

6.3.91.2.1 Function

This primitive requests a list of relay DMG STAs (RDSs) in the BSS.

6.3.91.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-RELAYSearch.request(
        DestinationMACAddress
        )
```

Name	Type	Valid range	Description
DestinationMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the non-PCP/non-AP STA that is the intended immediate recipient of the data flow.

6.3.91.2.3 When generated

This primitive is generated by the SME at a non-PCP/non-AP STA to request the PCP/AP for a list of RDSs in the BSS.

6.3.91.2.4 Effect on receipt

This primitive initiates a relay search procedure. The MLME subsequently issues an MLME-RELAYSearch.confirm primitive that reflects the results.

6.3.91.3 MLME-RELAYSearch.confirm

6.3.91.3.1 Function

This primitive reports a list of RDSs in the BSS.

6.3.91.3.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-RELAYSearch.confirm(
        RelayCapableSTAInfo,
        ResultCode
        )
```

Name	Type	Valid range	Description
RelayCapableSTAInfo (0 or more)	As defined in frame format	As defined in 8.4.1.44	As described in 8.4.1.44
ResultCode	Enumeration	SUCCESS, REFUSED	Indicates the results of the corresponding MLME-RELAYSearch.request.

6.3.91.3.3 When generated

This primitive is generated when a valid Relay Search Response frame is received.

6.3.91.3.4 Effect on receipt

The SME is notified of the results of the relay search procedure.

6.3.91.4 MLME-RELAYSearch.indication

6.3.91.4.1 Function

This primitive reports to the SME the request for obtaining a list of RDSs in the BSS.

6.3.91.4.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-RELAYSearch.indication(
        SourceMACAddress
        )
```

Name	Type	Valid range	Description
SourceMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the non-PCP/non-AP STA that is the intended immediate recipient of the data flow.

6.3.91.4.3 When generated

This primitive is generated by the MLME as a result of the receipt of a request to obtain a list of RDSs in the BSS. The receipt of the request resulted from a relay search procedure that was initiated by the STA indicated by the source MAC address specified in the primitive.

6.3.91.4.4 Effect on receipt

The SME is notified of a request by a specified non-PCP/non-AP STA to obtain a list of RDSs in the BSS.

6.3.91.5 MLME-RELAYSearch.response

6.3.91.5.1 Function

This primitive is used to provide the results of a Relay Search Request.

6.3.91.5.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-RELAYSearch.response(
PeerMACAddress,
RelayCapableSTAInfo,
StatusCode
)

Name	Type	Valid range	Description
PeerMACAddress	MACAddress	Any valid individual MAC address	The address of the MAC entity to which the Relay Search Response frame was sent.
RelayCapableSTAInfo (0 or more)	As defined in frame format	As defined in 8.4.1.44	As described in 8.4.1.44
StatusCode	As defined in frame format	As defined in 8.4.1.9	As described in 8.4.1.9

6.3.91.5.3 When generated

This primitive is generated by the SME to provide the results of a Relay Search Request.

6.3.91.5.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit a Relay Search Response frame.

6.3.91.6 MLME-RLS.request

6.3.91.6.1 Function

This primitive requests the set up of a relay link with a specified peer MAC entity via a specified relay MAC entity.

6.3.91.6.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-RLS.request(
DestinationMACAddress,
RelayMACAddress,

DestinationCapabilityInformation,
RelayCapabilityInformation,
RelayTransferParameterSet
)

Name	Type	Valid range	Description
DestinationMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the non-PCP/non-AP STA that is the intended immediate recipient of the data flow.
RelayMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the selected RDS.
DestinationCapabilityInformation	As defined in frame format	As defined in frame format	Indicates the Relay capabilities info field within the Relay capabilities element of the target destination relay endpoint DMG STA (REDS).
RelayCapabilityInformation	As defined in frame format	As defined in frame format	Indicates the Relay capabilities info field within the Relay capabilities element of the selected RDS.
RelayTransferParameterSet	As defined in frame format	As defined in frame format	Specifies the parameters for the relay operation.

6.3.91.6.3 When generated

This primitive is generated by the SME at a non-PCP/non-AP STA to set up a relay link with another non-PCP/non-AP STA.

6.3.91.6.4 Effect on receipt

This primitive initiates a relay link set up procedure.

6.3.91.7 MLME-RLS.confirm

6.3.91.7.1 Function

This primitive reports the results of a relay link set up attempt with a specified peer MAC entity.

6.3.91.7.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-RLS.confirm(
PeerMACAddress,
RelayMACAddress,
ResultCode
)

Name	Type	Valid range	Description
PeerMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the non-PCP/non-AP STA from which the frame was received.
RelayMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the selected RDS
ResultCode	Enumeration	SUCCESS, REFUSED	Indicates the results of the corresponding MLME-RLS.request.

6.3.91.7.3 When generated

This primitive is generated when a valid RLS Response frame is received.

6.3.91.7.4 Effect on receipt

The SME is notified of the results of the relay link set up procedure.

6.3.91.8 MLME-RLS.indication

6.3.91.8.1 Function

This primitive reports the establishment of a relay link with a specified peer MAC entity.

6.3.91.8.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-RLS.indication(
        SourceMACAddress,
        RelayMACAddress,
        SourceCapabilityInformation,
        RelayCapabilityInformation,
        RelayTransferParameterSet
        )
```

Name	Type	Valid range	Description
SourceMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the STA that is the intended immediate recipient of the data flow.
RelayMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the selected RDS
SourceCapabilityInformation	As defined in frame format	As defined in frame format	Specifies the operational capability definitions to be used by the peer MAC entity.

Name	Type	Valid range	Description
RelayCapabilityInformation	As defined in frame format	As defined in frame format	Indicates the Relay capabilities info field within the Relay capabilities element of the selected RDS
RelayTransferParameterSet	As defined in frame format	As defined in frame format	Specifies the parameters for the relay operation

6.3.91.8.3 When generated

This primitive is generated by the MLME as result of the establishment of a relay link with a specific peer MAC entity, and that resulted from a relay link set up procedure that was initiated by that specific source MAC entity.

6.3.91.8.4 Effect on receipt

The SME is notified of the establishment of the relay link set up.

6.3.91.9 MLME-RLS.response

6.3.91.9.1 Function

This primitive is used to provide the results of an RLS Request.

6.3.91.9.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-RLS.response(
        PeerMACAddress,
        DestinationStatusCode,
        RelayStatusCode
        )
```

Name	Type	Valid range	Description
PeerMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the peer STA.
DestinationStatusCode	As defined in frame format	As defined in 8.4.1.9	As described in 8.4.1.9
RelayStatusCode	As defined in frame format	As defined in 8.4.1.9	As described in 8.4.1.9

6.3.91.9.3 When generated

This primitive is generated by the SME to provide the results of a RLS Request.

6.3.91.9.4 Effect on receipt

On receipt of this primitive, the MLME constructs and attempts to transmit an RLS Response frame.

6.3.91.10 MLME-RLSTeardown.request

6.3.91.10.1 Function

This primitive requests the teardown of the relay link with a specified peer MAC entity.

6.3.91.10.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME- RLSTeardown.request(
DestinationMACAddress,
RelayMACAddress,
Reason
)

Name	Type	Valid range	Description
DestinationMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the non-PCP/non-AP STA that is the intended immediate recipient of the data flow.
RelayMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the selected RDS.
Reason	Enumeration	REQUESTED, TIMEOUT	Indicates the reason why the relay link is being torn down.

6.3.91.10.3 When generated

This primitive is generated by the SME at a STA for tearing down a relay link with another non-PCP/non-AP STA.

6.3.91.10.4 Effect on receipt

This primitive initiates a relay link teardown procedure. The MLME subsequently issues an MLME-RLSTeardown.confirm primitive that reflects the results.

6.3.91.11 MLME-RLSTeardown.indication

6.3.91.11.1 Function

This primitive indicates the teardown of an already established relay link with a specific peer MAC entity.

6.3.91.11.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-RLSTeardown.indication(
SourceMACAddress,
Reason
)

Name	Type	Valid range	Description
SourceMACAddress	MACAddress	Any valid individual MAC address	Specifies the MAC address of the non-PCP/non-AP STA that is the intended immediate recipient of the data flow.
Reason	Enumeration	REQUESTED, TIMEOUT	Indicates the reason why the relay link is being torn down.

6.3.91.11.3 When generated

This primitive is generated by the MLME as result of the teardown of a relay link with a specific peer MAC entity, and that resulted from a relay link teardown procedure that was initiated either by that specific peer MAC entity or by the local MAC entity.

6.3.91.11.4 Effect on receipt

The SME is notified of the relay link teardown.

6.3.92 Quieting adjacent BSS operation

6.3.92.1 General

This subclause describes the management procedure associated with the QAB operation.

The primitives defined are MLME-QAB.request, MLME-QAB.confirm, MLME-QAB.indication, and MLME-QAB.response.

6.3.92.2 MLME-QAB.request

6.3.92.2.1 Function

This primitive requests transmission of a (protected) QAB Request frame.

6.3.92.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-QAB.request(
        DialogToken,
        RequesterAP Address,
        ResponderAP Address,
        QuietPeriodRequest,
        Protected,
        VendorSpecificInfo
        )
```

Name	Type	Valid range	Description
DialogToken	Integer	1–255	The Dialog Token to identify the QAB transaction.
RequesterAP Address	MACAddress	Any valid individual MAC address	The address of the MAC entity from which the (protected) QAB request frame was sent.
ResponderAP Address	MACAddress	Any valid individual MAC address	The address of the peer MAC entity to which the (protected) QAB request was sent.
QuietPeriodRequest	A set of information subfields	As described in 8.4.2.152	As described in 8.4.2.152.
Protected	Boolean	true, false	Specifies whether the request is sent using a robust management frame. If true, the request is sent using the Protected QAB request frame. If false, the request is sent using the QAB request frame.
VendorSpecificInfo	A set of elements	As defined in 8.4.2.28	Zero or more elements.

6.3.92.2.3 When generated

This primitive is generated by the STA management entity (SME) to request that a (Protected) QAB frame be sent by a STA.

6.3.92.2.4 Effect on receipt

On receipt of this primitive, the MLME constructs and transmits a (Protected) QAB request frame.

6.3.92.3 MLME-QAB.confirm

6.3.92.3.1 Function

This primitive reports the result of a transmission of a QAB Request frame.

6.3.92.3.2 Semantics of the service primitive

The primitive parameters as follows:

```
MLME-QAB.confirm(
        DialogToken,
        RequesterAP Address,
        ResponderAP Address,
        QuietPeriodResponse,
        ResultCode,
        VendorSpecificInfo
        )
```

Name	Type	Valid range	Description
DialogToken	Integer	1–255	The Dialog Token to identify the QAB transaction.
RequesterAP Address	MACAddress	Any valid individual MAC address	The address of the MAC entity to which the (protected) QAB Response frame was addressed.
ResponderAP Address	MACAddress	Any valid individual MAC address	The address of the peer MAC entity from which the (protected) QAB Response was received.
QuietPeriodResponse	A set of information subfields	As described in 8.4.2.153	As described in 8.4.2.153.
ResultCode	Enumeration	SUCCESS	Reports the result of an QAB request.
VendorSpecificInfo	A set of elements	As defined in 8.4.2.28	Zero or more elements.

6.3.92.3.3 When generated

This primitive is generated by the MLME when a QAB request completes. Possible unspecified failure causes include an inability to provide the Quite Period Request element.

6.3.92.3.4 Effect on receipt

The SME is notified of the results of the QAB request procedure.

6.3.92.4 MLME-QAB.indication

6.3.92.4.1 Function

This primitive indicates that a (Protected) QAB Request frame was received.

6.3.92.4.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-QAB.indication(
        DialogToken
        PeerMACAddress,
        QuietPeriodRequest,
        Protected,
        VendorSpecificInfo
        )
```

Name	Type	Valid range	Description
DialogToken	Integer	1–255	The Dialog Token to identify the QAB transaction.
PeerMACAddress	MACAddress	Any valid individual MAC address	The address of the peer MAC entity from which the QAB Request frame was received.

Name	Type	Valid range	Description
QuietPeriodRequest	A set of information subfields	As described in 8.4.2.152	As described in 8.4.2.152.
Protected	Boolean	true, false	Specifies whether the request was received using a robust management frame. If true, the request was received using the Protected QAB Request frame. If false, the request was received using the QAB Request frame.
VendorSpecificInfo	A set of elements	As defined in 8.4.2.28	Zero or more elements.

6.3.92.4.3 When generated

This primitive is generated by the MLME when a valid (Protected) QAB Request frame is received.

6.3.92.4.4 Effect on receipt

On receipt of this primitive, the SME decides whether to schedule quiet periods as requested.

6.3.92.5 MLME-QAB.response

6.3.92.5.1 Function

This primitive is used to provide the results of a QAB Request.

6.3.92.5.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-QAB.response(
        DialogToken,
        RequesterAP Address,
        ResponderAP Address,
        QuietPeriodResponse,
        VendorSpecificInfo
        )
```

Name	Type	Valid range	Description
DialogToken	Integer	1–255	The Dialog Token to identify the QAB transaction.
RequesterAP Address	MACAddress	Any valid individual MAC address	The address of the MAC entity to which the (protected) QAB Response frame was sent.
ResponderAP Address	MACAddress	Any valid individual MAC address	The address of the peer MAC entity from which the (protected) QAB Response was sent.

Name	Type	Valid range	Description
QuietPeriodResponse	A set of information subfields	As described in 8.4.2.153	As described in 8.4.2.153.
VendorSpecificInfo	A set of elements	As defined in 8.4.2.28	Zero or more elements.

6.3.92.5.3 When generated

This primitive is generated by the SME to provide the results of a QAB Request.

6.3.92.5.4 Effect on receipt

On receipt of this primitive, the MLME provides the results of a QAB Request.

6.3.93 DMG beamforming

6.3.93.1 General

This subclause describes the management procedures associated with DMG beamforming.

6.3.93.2 MLME-BF-TRAINING.request

6.3.93.2.1 Function

This primitive requests that beamforming training occur with a peer DMG STA.

6.3.93.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-BF-TRAINING.request(
        PeerSTAAddress,
        RequestBRP
        )
```

Name	Type	Valid range	Description
PeerSTAAddress	MACAddress	Any valid individual MAC address	Specifies the address of the peer MAC entity with which to perform beamforming training.
RequestBRP	Boolean	True, false	If true, the beam refinement protocol (BRP) is performed as part of the beamforming training. If false, only sector-level sweep (SLS) is performed.

6.3.93.2.3 When generated

This primitive is generated by the SME to request that beamforming training be performed with a peer DMG STA.

6.3.93.2.4 Effect on receipt

On receipt of this primitive, the MLME invokes the MAC sublayer beamforming training procedures defined in 9.35.

6.3.93.3 MLME-BF-TRAINING.confirm

6.3.93.3.1 Function

This primitive reports the outcome of a requested beamforming training procedure.

6.3.93.3.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-BF-TRAINING.confirm(
        PeerSTAAddress,
        ResultCode
        )
```

Name	Type	Valid range	Description
PeerSTAAddress	MACAddress	Any valid individual MAC address	Specifies the address of the peer MAC entity with which beamforming training was performed or attempted.
ResultCode	Enumeration	SUCCESS, TIMEOUT	Indicates the result of the beamforming procedure.

6.3.93.3.3 When generated

This primitive is generated by the MLME to report the result of beamforming training with a peer DMG STA.

6.3.93.3.4 Effect on receipt

The SME is notified of the result of the procedure.

6.3.93.4 MLME-BF-TRAINING.indication

6.3.93.4.1 Function

This primitive indicates that beamforming training with a peer DMG STA, and at the request of that peer, has completed.

6.3.93.4.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-BF-TRAINING.indication(
        PeerSTAAddress,
        ResultCode
        )
```

Name	Type	Valid range	Description
PeerSTAAddress	MACAddress	Any valid individual MAC address	Specifies the address of the peer MAC entity with which beamforming training was performed.
ResultCode	Enumeration	SUCCESS, TIMEOUT	Indicates the result of the beamforming procedure.

6.3.93.4.3 When generated

This primitive is generated by the MLME to indicate successful completion of a beamforming training procedure requested by a peer DMG STA.

6.3.93.4.4 Effect on receipt

The SME is notified of the result of the procedure.

6.3.94 PN event report

6.3.94.1 General

This subclause describes the management procedures associated with PN event report.

6.3.94.2 MLME-PN-Exhaustion.indication

6.3.94.2.1 Function

This primitive indicates that the PN associated with a temporal key exceeds dot11PNExhaustionThreshold.

6.3.94.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-PN-Exhaustion.indication(
        Key ID,
        Key Type,
        Address
        )
```

Name	Type	Valid range	Description
Key ID	Integer	N/A	Key identifier.
Key Type	Integer	Group, Pairwise, PeerKey, IGTK	Defines whether this key is a group key, pairwise key, PeerKey, or Integrity Group key.
Address	MAC address	Any valid individual MAC address	This parameter is valid only when the Key Type value is Pairwise, or when the Key Type value is Group and is from an IBSS STA, or when the Key Type value is PeerKey.

6.3.94.2.3 When generated

This primitive is generated by the MLME when the PN associated with a temporal key exceeds dot11PNExhaustionThreshold.

6.3.94.2.4 Effect of receipt

On receipt of this primitive, the SME deletes the temporal key associated with the PN.

6.3.94.3 MLME-PN-Warning.indication

6.3.94.3.1 Function

This primitive indicates that the PN associated with a temporal key exceeds dot11PNWarningThreshold.

6.3.94.3.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-PN-Warning.indication(
Key ID,
Key Type,
Address
)

Name	Type	Valid range	Description
Key ID	Integer	N/A	Key identifier.
Key Type	Integer	Group, Pairwise, PeerKey, IGTK	Defines whether this key is a group key, pairwise key, PeerKey, or Integrity Group key
Address	MAC address	Any valid individual MAC address	This parameter is valid only when the Key Type value is Pairwise, or when the Key Type value is Group and is from an IBSS STA, or when the Key Type value is PeerKey.

6.3.94.3.3 When generated

This primitive is generated by the MLME when the PN associated with a temporal key exceeds dot11PNWarningThreshold.

6.3.94.3.4 Effect of receipt

On receipt of this primitive, the SME can create a new temporal key before the PN space is exhausted.

6.5 PLME SAP interface

6.5.8 PLME-TXTIME.confirm

6.5.8.2 Semantics of the service primitive

Change 6.5.8.2 as follows:

This primitive provides the following parameter:

PLME-TXTIME.confirm(TXTIME)

The TXTIME represents the time, in microseconds, required to transmit the PPDU described in the corresponding PLME-TXTIME.request primitive. If the calculated time includes a fractional microsecond, a non-DMG STA rounds the TXTIME value ~~is rounded~~ up to the next higher integer. A DMG STA does not round the TXTIME value up or down (see 21.12.3).

Insert the following subclauses, 6.5.9 to 6.5.10.4 (including Figure 6-27), after 6.5.8.4:

6.5.9 PLME-DMGTESTMODE.request

6.5.9.1 Function

This primitive requests that the DMG PHY entity enter a test mode operation. The parameters associated with this primitive are considered as recommendations and are optional in any particular implementation.

6.5.9.2 Semantics of the service primitive

The primitive parameters are as follows:

PLME-DMGTESTMODE.request(
TEST_ENABLE,
TEST_MODE,
SCRAMBLE_SEED,
MCS,
LENGTH,
PACKET_TYPE,
TRN_LEN,
TONE_PAIRING,
PAYLOAD_TYPE
)

Name	Type	Valid range	Description
TEST_ENABLE	Boolean	True, False	If true, enables the PHY test mode according to the remaining parameters.
TEST_MODE	integer	1, 2	TEST_MODE selects one of two operational states: 1 = transparent receive 2 = continuous packet transmit
SCRAMBLE_SEED	integer	0 – 0x7f	Selects the scrambling seed to be used for the transmit packets and sets the Scrambler Initialization field in the header.

Name	Type	Valid range	Description
MCS	integer	0 – 31	Selects the MCS to be used for the transmit packets and sets the MCS field in the header.
LENGTH	integer	0 – 262143	Selects the number of payload octets to be transmitted in each packet.
PACKET_TYPE	integer	0, 1	Sets the header Packet type field and determines the encoding of the BRP fields appended to the packet. 0 = TRN-R 1 = TRN-T
TRN_LEN	integer	0 – 16	Determines the number of BRP AGC and TRN-R/T fields that are appended to the packet and sets the Training Length field in the header. A value of n indicates that the AGC has 4n subfields and that the TRN-R/T field has 4n subfields. When n ≠ 0, the static DMG PHY characteristics aBRPminSCblocks and aBRPminOFDMblocks also apply.
TONE_PAIRING	integer	0, 1	For MCS 13-MCS17 selects static or dynamic tone pairing. 0 = STP 1 = DTP
PAYLOAD_TYPE	integer	0, 1, 2, 3, 4	Selects one of five data patterns to be used for the transmit portions of the tests. 0 = All 0 1 = All 1 2 = 8-bit count 3 = 32-bit count 4 = PN23

6.5.9.3 When generated

This primitive is generated at any time to enter the DMG PHY test mode.

6.5.9.4 Effect of receipt

Receipt of this primitive by the PHY causes the DMG PHY entity to enter the test mode of operation.

6.5.9.5 Payload Types

6.5.9.5.1 All 1

The payload data shall comprise octets, each with value 0xff.

6.5.9.5.2 All 0

The payload data shall comprise octets, each with value 0x00.

6.5.9.5.3 8-bit count

The payload data comprises octets with an incrementing or "counting" value, reset to 0 at the beginning of every packet.

The count is modulo 256. The first 32 octets shall be

0x000: 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
0x010: 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F

6.5.9.5.4 32-bit count

The payload data comprises 4-octet words with an incrementing or "counting" value, reset to 0 at the beginning of every packet.

The count is modulo 2147483648. The count value is transmitted least-significant octet first. The first 32 octets shall be

0x000: 00 00 00 00 01 00 00 00 02 00 00 00 03 00 00 00
0x010: 04 00 00 00 05 00 00 00 06 00 00 00 07 00 00 00

6.5.9.5.5 PN23

The payload data shall comprise octets drawn, LSB first, from a 2^{23}-1 length PRBS sequence generator as defined in ITU REC O.150 section 5.6 and illustrated in Figure 6-27.

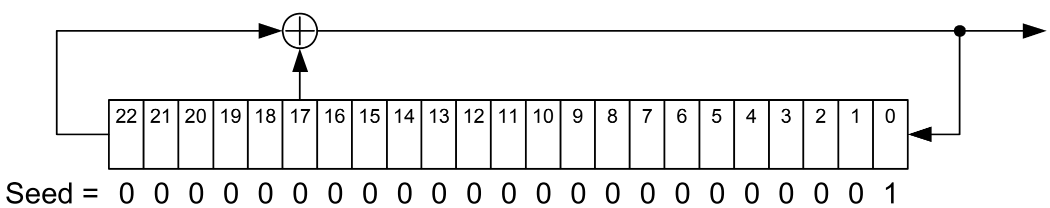


Figure 6-27—PN23 Generator

The PN generator is seeded with a 1 in the first stage and a 0 in all other stages at the beginning of the first packet transmitted after a PLME-DMGTESTOUTPUT.request primitive. This means, for reference, that the first 64 payload octets (prior to scrambling) shall be

0x000: 00 00 42 00 08 20 20 84 90 00 00 4A 00 28 24 A0
0x010: 84 92 42 08 43 00 88 20 20 C6 90 08 20 6A 84 B8
0x020: 24 A0 CE 92 6A 2C E3 84 1A 62 28 85 90 80 00 4A
0x030: 42 28 2C 80 A4 16 D2 08 43 4A 88 08 04 66 14 9A

6.5.10 PLME-DMGTESTOUTPUT.request

6.5.10.1 Function

This optional primitive is a request by the PLME to enable selected tests signals from the PHY. The parameters associated with this primitive are optional in any particular implementation.

6.5.10.2 Semantics of the service primitive

The primitive parameters are as follows:

```
PLME-DMGTESTMODE.request(
        TEST_OUTPUT
        )
```

Name	Type	Valid range	Description
TEST_OUTPUT	Boolean	True, False	If true, enables the selected test signals for testing DMG PHY.

TEST_OUTPUT enables and disables selected signals for debugging and testing the PHY. The signals that may be available are the received PHY type, MCS, HCS, payload content, uncorrected FEC codeword count, received EVM, RSSI.

The uncorrected FEC codeword count is the number of FEC codewords in the most recently received packet for which the FEC algorithm did not complete successfully due to transmission errors.

6.5.10.3 When generated

This primitive is generated at any time to enable the test outputs when in the DMG PHY test mode.

6.5.10.4 Effect of receipt

Receipt of this primitive by the DMG PHY causes the DMG PHY entity to enable the test outputs using the modes set by the most recent PLME-DMGTESTMODE.request primitive.

7. PHY service specification

7.3 Detailed PHY service specifications

7.3.4 Basic service and options

7.3.4.5 Vector descriptions

Insert the following row at the end of Table 7-4:

Table 7-4—Vector descriptions

Parameter	Associated vector	Value
ANT-CONFIG	PHYCONFIG-VECTOR	Indicates which antenna configuration(s) is to be used when receiving packets and which configuration is to be used when switching configurations during the reception of a packet. Values are implementation dependent.

7.3.5 PHY-SAP detailed service specification

Insert the following subclauses, 7.3.5.7a to 7.3.5.7a.4, after 7.3.5.7.4:

7.3.5.7a PHY-TXPLCPEND.indication

7.3.5.7a.1 Function

This primitive indicates the transmission completion of the PLCP header to the local MAC entity.

7.3.5.7a.2 Semantics of the service primitive

The semantics of the primitive are as follows:

PHY-TXPLCPEND.indication

This primitive has no parameters.

7.3.5.7a.3 When generated

The PHY-TXPLCPEND.indication primitive is generated by a transmitter PHY entity at the end of transmission of the last symbol containing the PLCP header.

7.3.5.7a.4 Effect of receipt

The receipt of this primitive by the MAC entity causes the MAC to record the time when this primitive is received only if TIME_OF_DEPARTURE_REQUESTED is true in the corresponding PHY_TXSTART.request primitive.

Insert the following subclauses, 7.3.5.16 to 7.3.5.16.4, after 7.3.5.15.4:

7.3.5.16 PHY-TxBusy.indication

7.3.5.16.1 Function

This primitive is an indication by the PHY to the local MAC entity(ies) of the current transmission state of the PHY.

7.3.5.16.2 Semantics of the service primitive

The primitive provides the following parameter:

PHY-TxBusy.indication (STATE)

The STATE parameter can be one of two values: BUSY or IDLE. The parameter value is BUSY if the PHY is transmitting a PPDU and thus not available to respond with a PHY-TXSTART.confirm primitive to a PHY-TXSTART.request primitive. Otherwise, the value of the parameter is IDLE.

7.3.5.16.3 When generated

The primitive is generated when the PHY issues a PHY-TXSTART.confirm primitive to one of the MAC entities coordinated by an MM-SME, and is generated to all coordinated MAC entities except to the one to which it responds with the PHY-TXSTART.confirm primitive. The STATE of the primitive is set to BUSY.

This primitive is generated within aTxPLCPDelay of the occurrence of a change in the state of the PLCP transmit state machine to the RX state. In this case, the STATE of the primitive is set to IDLE.

7.3.5.16.4 Effect of receipt

The effect of receipt of this primitive by the MAC is unspecified if the STATE of the primitive is set to IDLE. The effect of receipt of this primitive by the MAC is specified in 9.19.2.5 if the STATE of the primitive is set to BUSY.

8. Frame formats

8.2 MAC frame formats

8.2.3 General frame format

In Figure 8-1 (MAC frame format), change the octet range for Frame Body from ~~0-7951~~ to 0-7959.

Change the second paragraph of 8.2.3, and insert Table 8-0a as indicated below:

The Frame Body field is of variable size. The maximum frame body size is determined by the maximum MSDU size ~~(2304 octets)~~ (see Table 8-0a), plus the length of the Mesh Control field (6, 12, or 18 octets) if present, the maximum unencrypted MMPDU size excluding the MAC header and FCS ~~(2304 octets)~~ or the maximum A-MSDU size (see Table 8-0a) ~~(3839 or 7935 octets, depending upon the STA's capability)~~, plus any overhead from security encapsulation. The maximum MPDU length transmitted by a DMG STA is 7995 octets.

Table 8-0a—Maximum MSDU and A-MSDU sizes

STA type	Maximum MSDU size (octets)	Maximum A-MSDU size (octets)
non-DMG STA	2304	3839 or 7935, depending upon the STA's capability
DMG STA	7920	7935

8.2.4 Frame fields

8.2.4.1 Frame Control field

8.2.4.1.1 General

Change 8.2.4.1.1, and insert Figure 8-2a as follows:

The first three subfields of the Frame Control field are Protocol Version, Type, and Subtype. The remaining subfields of the Frame Control field depend on the setting of the Type and Subtype subfields.

When the value of the Type subfield is not equal to 1 or the value of the Subtype subfield is not equal to 6, ~~T~~the remaining subfields within the Frame Control field are ~~consists of~~ the following ~~subfields~~: ~~Protocol Version, Type, Subtype,~~ To DS, From DS, More Fragments, Retry, Power Management, More Data, Protected Frame, and Order. In this case, ~~T~~the format of the Frame Control field is illustrated in Figure 8-2.

	B0 B1	B2 B3	B4 B7	B8	B9	B10	B11	B12	B13	B14	B15
	Protocol Version	Type	Subtype	To DS	From DS	More Frag-ments	Retry	Power Manage-ment	More Data	Protected Frame	Order
Bits:	2	2	4	1	1	1	1	1	1	1	1

Figure 8-2—Frame Control field when Type is not equal to 1 or Subtype is not equal to 6

When the value of the Type subfield is equal to 1 and the value of the Subtype subfield is equal to 6, the remaining subfields within the Frame Control field are the following: Control Frame Extension, Power Management, More Data, Protected Frame, and Order. In this case, the format of the Frame Control field is illustrated in Figure 8-2a.

	B0 B1	B2 B3	B4 B7	B8 B11	B12	B13	B14	B15
	Protocol Version	Type	Subtype	Control Frame Extension	Power Management	More Data	Protected Frame	Order
Bits:	2	2	4	4	1	1	1	1

Figure 8-2a—Frame Control field when Type is equal to 1 and Subtype is equal to 6

8.2.4.1.3 Type and Subtype fields

Change the following rows in Table 8-1:

Table 8-1—Valid type and subtype combinations

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
01	Control	0000–01~~1~~01	Reserved
01	Control	0110	Control Frame Extension
11	Extension	0000	DMG Beacon
11	~~Reserved~~ Extension	000~~0~~1–1111	Reserved

Insert the following paragraph, including Table 8-1a, at the end of 8.2.4.1.3:

The Control Frame Extension subtype is used to increase the subtype space by reusing bits b8–b11. These additional Control frames are defined in Table 8-1a.

Table 8-1a—Control Frame Extension

Type value b3 b2	Subtype value b7 b6 b5 b4	Control Frame Extension value b11 b10 b9 b8	Description
01	0110	0000	Reserved
01	0110	0001	Reserved
01	0110	0010	Poll
01	0110	0011	SPR
01	0110	0100	Grant
01	0110	0101	DMG CTS
01	0110	0110	DMG DTS
01	0110	0111	Grant ACK

Table 8-1a—Control Frame Extension *(continued)*

Type value b3 b2	Subtype value b7 b6 b5 b4	Control Frame Extension value b11 b10 b9 b8	Description
01	0110	1000	SSW
01	0110	1001	SSW-Feedback
01	0110	1010	SSW-ACK
01	0110	1011–1111	Reserved

8.2.4.1.4 To DS and From DS fields

Change Table 8-2 as follows:

Table 8-2—To/From DS combinations in data frame

To DS and From DS values	Meaning
To DS = 0 From DS = 0	A data frame direct from one STA to another STA within the same IBSS or the same PBSS, a data frame direct from one non-AP STA to another non-AP STA within the same infrastructure BSS, or a data frame outside the context of a BSS.
To DS = 1 From DS = 0	A data frame destined for the DS or being sent by a STA associated with an AP to the Port Access Entity in that AP.
To DS = 0 From DS = 1	A data frame exiting the DS or being sent by the Port Access Entity in an AP, or a group addressed Mesh Data frame with Mesh Control field present using the three-address MAC header format.
To DS = 1 From DS = 1	A data frame using the four-address MAC header format. This standard defines procedures for using this combination of field values only in a mesh BSS.

Insert the following paragraph at the end of 8.2.4.1.4:

In Control frames of subtype Control Frame Extension, the To DS and From DS fields are not defined, and their bit positions are part of the Control Frame Extension field (see 8.2.4.1.3, Table 8-1a).

8.2.4.1.5 More Fragments field

Insert the following paragraph at the end of 8.2.4.1.5:

In Control frames of subtype Control Frame Extension, the More Fragments field is not defined, and its bit position is part of the Control Frame Extension field (see 8.2.4.1.3, Table 8-1a).

8.2.4.1.6 Retry field

Insert the following paragraph at the end of 8.2.4.1.6:

In Control frames of subtype Control Frame Extension, the Retry field is not defined, and its bit position is part of the Control Frame Extension field (see 8.2.4.1.3, Table 8-1a).

8.2.4.1.8 More Data field

Change 8.2.4.1.8 as follows:

The More Data field is 1 bit in length and is used differently by a non-DMG STA and by a DMG STA.

A non-DMG STA uses the More Data field to indicate to a STA in PS mode that more BUs are buffered for that STA at the AP. The More Data field is valid in individually addressed data or management type frames transmitted by an AP to a STA in PS mode. A value of 1 indicates that at least one additional buffered BU is present for the same STA.

A non-DMG STA optionally sets ~~T~~the More Data field ~~is optionally set~~ to 1 in individually addressed data type frames transmitted by a CF-Pollable STA to the PC in response to a CF-Poll to indicate that the STA has at least one additional buffered MSDU available for transmission in response to a subsequent CF-Poll.

For a non-DMG STA in which the More Data Ack subfield of its QoS Capability element is 1 and that has APSD enabled, an AP optionally sets the More Data field to 1 in ACK frames to this STA to indicate that the AP has a pending transmission for the STA.

For a STA with TDLS peer PSM enabled and the More Data Ack subfield equal to 1 in the QoS Capability element of its transmitted TDLS Setup Request frame or TDLS Setup Response frame, a TDLS peer STA optionally sets the More Data field to 1 in ACK frames to this STA to indicate that it has a pending transmission for the STA.

The More Data field is 1 in individually addressed frames transmitted by a mesh STA to a peer mesh STA that is either in light sleep mode or in deep sleep mode for the corresponding mesh peering, when additional BUs remain to be transmitted to this peer mesh STA.

A non-DMG STA sets ~~T~~the More Data field ~~is set~~ to 0 in all other directed frames.

A non-DMG STA sets ~~T~~the More Data field ~~is set~~ to 1 in group addressed frames transmitted by the AP when additional group addressed bufferable units (BUs) that are not part of an active GCR-SP remain to be transmitted by the AP during this beacon interval. The More Data field is set to 0 in group addressed frames transmitted by the AP when no more group addressed BUs that are not part of an active GCR-SP remain to be transmitted by the AP during this beacon interval and in all group addressed frames transmitted by non-AP STAs.

The More Data field is set to 1 in group addressed frames transmitted by the AP when additional group addressed BUs that are part of an active GCR-SP remain to be transmitted by the AP during this GCR-SP. The More Data field is set to 0 in group addressed frames transmitted by the AP when no more group addressed BUs that are part of an active GCR-SP remain to be transmitted by the AP during this GCR-SP.

The More Data field is 1 in group addressed frames transmitted by a mesh STA when additional group addressed BUs remain to be transmitted. The More Data field is 0 in group addressed frames transmitted by a mesh STA when no more group addressed BUs remain to be transmitted.

A DMG STA sets the More Data field as follows:

- In directed frames, it is set to 1 to indicate that the STA has MSDUs or A-MSDUs buffered for transmission to the frame's recipient during the current SP or TXOP.
- It is set to 1 in group addressed frames transmitted by the AP when additional group addressed BUs remain to be transmitted by the AP during this beacon interval. The More Data field is set to 0 in group addressed frames transmitted by the AP when no more group addressed BUs remain to be transmitted by the AP during this beacon interval.

A DMG STA does not set the More Data bit to 1 if it does not have any MSDUs or A-MSDUs buffered for transmission to the frame's recipient during the current SP or TXOP.

8.2.4.1.9 Protected Frame field

Change 8.2.4.1.9 as follows:

The Protected Frame field is 1 bit in length. The Protected Frame field is set to 1 if the Frame Body field contains information that has been processed by a cryptographic encapsulation algorithm. The Protected Frame field is set to 1 only within data frames and within management frames of subtype Authentication, and individually addressed robust management frames. The Protected Frame field is set to 0 in all other frames, except in Control frames of subtype Control Frame Extension where this field is reserved. When the Protected Frame field is equal to 1, the Frame Body field is protected utilizing the cryptographic encapsulation algorithm and expanded as defined in Clause 11. The Protected Frame field is set to 0 in Data frames of subtype Null Function, CF-ACK (no data), CF-Poll (no data), CF-ACK+CF-Poll (no data), QoS Null (no data), QoS CF-Poll (no data), and QoS CF-ACK+CF-Poll (no data) (see, for example, 11.4.2.2 and 11.4.3.1 that show that the frame body needs to be 1 octet or longer to apply the encapsulation).

8.2.4.1.10 Order field

Insert the following note at the end of 8.2.4.1.10:

NOTE—The Order field is always set to 0 for frames transmitted by a DMG STA.

8.2.4.2 Duration/ID field

Change Table 8-3 as follows:

Table 8-3—Duration/ID field encoding

Bits 0–13	Bit 14	Bit 15	Usage
0–32 767		0	Duration value (in microseconds) within all frames other than PS-Poll frames transmitted during the CP, within all frames transmitted by a DMG STA, and under HCF for frames transmitted during the CFP
0	0	1	Fixed value under point coordination function (PCF) within frames transmitted during the CFP. Reserved for DMG STAs.
1–16 383	0	1	Reserved
0	1	1	Reserved
1–2007	1	1	AID in PS-Poll frames. Reserved for DMG STAs.
2008–16 383	1	1	Reserved

8.2.4.3 Address fields

8.2.4.3.4 BSSID field

Insert the following paragraph after the first paragraph of 8.2.4.3.4:

The value of this field in a PBSS is the MAC address of the PCP.

8.2.4.5 QoS Control field

8.2.4.5.1 QoS Control field structure

Change 8.2.4.5.1, and insert Table 8-4a as follows:

The QoS Control field is a 16-bit field that identifies the TC or TS to which the frame belongs as well as various other QoS-related, A-MSDU–related, and mesh-related information about the frame that varies by frame type, subtype, and type of transmitting STA. The QoS Control field is present in all data frames in which the QoS subfield of the Subtype field is equal to 1 (see 8.2.4.1.3).

When not transmitted within a DMG PPDU, e~~E~~ach QoS Control field comprises five or eight subfields, as defined for the particular sender (HC or non-AP STA) and frame type and subtype. The usage of these subfields and the various possible layouts of the QoS Control field are described 8.2.4.5.2 to 8.2.4.5.12 and illustrated in Table 8-4.

See 9.12.1 for constraints on the contents of the QoS Control field when present in an A-MPDU.

Table 8-4 remains unchanged.

The format of the QoS Control field for MPDUs transmitted within a DMG PPDU is provided in Table 8-4a. Data subtypes not shown in the table are not transmitted within a DMG PPDU.

Table 8-4a—QoS Control field for frames transmitted within a DMG PPDU

Applicable frame (sub-)types	Bits 0–3	Bit 4	Bits 5–6	Bit 7	Bit 8	Bit 9	Bits 10–14	Bit 15
QoS Data	TID	EOSP	Ack Policy	A-MSDU Present	A-MSDU Type	RDG/ More PPDU	Reserved	AC Constraint
QoS Null	TID	EOSP	Ack Policy	Reserved	Reserved	RDG/ More PPDU	Reserved	AC Constraint

8.2.4.5.2 TID subfield

Change Table 8-5 as follows:

Table 8-5—TID subfield

Access policy	Usage	Allowed values in bits 0–3 (TID subfield)
EDCA	UP for either TC or TS, regardless of whether admission control is required	0–7
HCCA, SPCA	TSID	8–15
HEMM, SEMM	TSID, regardless of access mechanism used	8–15

8.2.4.5.3 EOSP (end of service period) subfield

Change the first paragraph of 8.2.4.5.3 as follows:

The EOSP subfield is 1 bit in length and is used by the HC to indicate the end of the current service period (SP) and by a DMG STA to indicate the end of the current SP or the end of the current allocated CBAP with individually addressed destination AID. The HC sets the EOSP subfield to 1 in its transmission and retransmissions of the SP's final frame to end a scheduled/unscheduled SP and sets it to 0 otherwise. To end an SP allocation or a CBAP allocation with individually addressed destination AID, the DMG STA sets the EOSP subfield to 1 in its final frame transmission and retransmissions within the allocation; otherwise, the DMG STA sets the EOSP subfield to 0.

8.2.4.5.4 Ack Policy subfield

Change the following row in Table 8-6:

Table 8-6—Ack Policy subfield in QoS Control field of QoS data frames

Bits in QoS Control field		Meaning
Bit 5	**Bit 6**	
0	0	Normal Ack or Implicit Block Ack Request. In a frame that is a non-A-MPDU frame: The addressed recipient returns an ACK or QoS +CF-Ack frame after a short interframe space (SIFS) period, according to the procedures defined in 9.3.2.8 and 9.19.3.5. For a non-DMG STA, t~~T~~his is the only permissible value for the Ack Policy subfield for individually addressed QoS Null (no data) frames. In a frame that is part of an A-MPDU: The addressed recipient returns a BlockAck MPDU, either individually or as part of an A-MPDU starting a SIFS after the PPDU carrying the frame, according to the procedures defined in 9.3.2.9, 9.21.7.5, 9.21.8.3, 9.25.3, 9.25.4, and 9.29.3.

8.2.4.5.9 A-MSDU Present subfield

Insert the following note at the end of 8.2.4.5.9:

NOTE—For a DMG STA, when the A-MSDU Present subfield is set to 1, one of two A-MSDU formats can be present in the Frame Body. The specific A-MSDU format present is indicated by the A-MSDU Type subfield.

Insert the following subclauses, 8.2.4.5.13 to 8.2.4.5.15, after 8.2.4.5.12:

8.2.4.5.13 A-MSDU Type subfield

The A-MSDU Type subfield is 1 bit in length and indicates the type of A-MSDU present in the Frame Body. When the A-MSDU Type subfield is set to 0, the Frame Body field contains a Basic A-MSDU as defined in 8.3.2.2.1. When the A-MSDU Type subfield is set to 1, the Frame Body field contains a Short A-MSDU as defined in 8.3.2.2.3. The A-MSDU Type subfield is reserved if the A-MSDU Present subfield is set to 0.

8.2.4.5.14 RDG/More PPDU subfield

The RDG/More PPDU subfield of the QoS Control field for DMG frames is interpreted differently depending on whether it is transmitted by an RD initiator or an RD responder, as defined in Table 8-13.

8.2.4.5.15 AC Constraint subfield

The AC Constraint subfield of the QoS Control field for DMG frames indicates whether the mapped AC of an RD data frame is constrained to a single AC, as defined in Table 8-12.

8.2.4.6 HT Control field

Insert the following note after Table 8-12 (AC Constraint subfield values):

NOTE—The AC of the last data frame received from the RD initiator is determined directly from the TID of the received frame if the TID is between 0 and 7 inclusive or from the UP field of the TSPEC identified by the TID of the received frame if the TID is between 8 and 15 inclusive.

8.2.5 Duration/ID field (QoS STA)

8.2.5.1 General

Insert the following paragraph as the new first paragraph in 8.2.5.1:

The value in the Duration/ID field within Poll, SPR, Grant, Grant ACK, DMG CTS, DMG DTS, SSW, SSW-Feedback, and SSW-ACK frames transmitted by a DMG STA are described in 8.3.1.11 to 8.3.1.18. The value in the Duration/ID field within DMG Beacon frames transmitted by a DMG STA is described in 8.3.4.1.

8.2.5.3 Setting for QoS CF-Poll frames

Insert the following note at the end of 8.2.5.3:

NOTE—DMG STAs do not transmit QoS CF-Poll frames.

8.2.5.4 Setting for frames sent by a TXOP holder under HCCA

Insert the following note at the end of 8.2.5.4:

NOTE—DMG STAs do not use HCCA.

8.2.5.5 Settings within a PSMP sequence

Insert the following note at the end of 8.2.5.5, and number the previous note as “NOTE 1”:

NOTE 2—DMG STAs do not transmit PSMP frames.

8.2.5.6 Settings within a dual CTS sequence

Insert the following note at the end of 8.2.5.6:

NOTE—DMG STAs do not transmit CTS frames.

8.3 Format of individual frame types

8.3.1 Control frames

8.3.1.3 CTS frame format

Insert the following note at the end of 8.3.1.3:

NOTE—DMG STAs do not transmit CTS frames.

8.3.1.5 PS-Poll frame format

Insert the following note at the end of 8.3.1.5:

NOTE—DMG STAs do not transmit PS-Poll frames.

8.3.1.6 CF-End frame format

Change the second and third paragraphs in 8.3.1.6, and insert the new fourth and fifth paragraphs as follows:

~~The BSSID field is the address of the STA contained in the AP. The RA field is the broadcast group address.~~

When transmitted by a non-DMG STA, t~~T~~he Duration field is set to 0. When transmitted by a DMG STA, the Duration field is set to the time required to complete the CF-End truncation sequence of which it is part (see 9.33.8): Duration = (i – 1) × (TXTIME(CF-End) + SIFS), where *i* is in the range [1,3] and indicates the order of the CF-End frame in the truncation sequence in the reverse direction (i.e., *i*=1 corresponds to the last CF-End frame in the sequence).

When transmitted by a non-DMG STA, the RA field is the broadcast group address. When transmitted by a DMG STA, the RA field is the MAC address of the STA that is the intended immediate recipient of the directed data or management frame, or the broadcast group address.

When transmitted by a non-DMG STA, the BSSID field is the address of the STA contained in the AP. When transmitted by a DMG STA, the TA field is the MAC address of the STA transmitting the frame.

8.3.1.7 CF-End+CF-Ack frame format

Insert the following note at the end of 8.3.1.7:

NOTE—DMG STAs do not transmit CF-End+CF-Ack frames.

8.3.1.8 Block Ack Request (BlockAckReq) frame format

8.3.1.8.1 Overview

Change the following row in Table 8-15:

Table 8-15—BAR Ack Policy subfield

Value	Meaning
0	Normal Acknowledgment. The BAR Ack Policy subfield is set to this value when the sender requires immediate acknowledgment. The addressee returns an ACK. See 9.26.1.7. The value 0 is not used in frames transmitted by a DMG STA.

Insert the following paragraph after the seventh paragraph ("The values of the Multi-TID, …") of 8.3.1.8.1:

DMG STAs use only the Compressed BlockAckReq variant and the Extended Compressed BlockAckReq variant. The other variants are not used by DMG STAs. Non-DMG STAs do not use the Extended Compressed BlockAckReq variant.

Change the third row of Table 8-16 as indicated below:

Table 8-16—BlockAckReq frame variant encoding

Multi_TID subfield value	Compressed Bitmap subfield value	GCR subfield value	BlockAckReq frame variant
1	0	0	~~Reserved~~ Extended Compressed BlockAckReq

Insert the following subclause, 8.3.1.8.6, after 8.3.1.8.5:

8.3.1.8.6 Extended Compressed BlockAckReq variant

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

The BAR Information field of the Extended Compressed BlockAckReq frame contains the Block Ack Starting Sequence Control subfield, as shown in Figure 8-21. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAckReq frame is sent. The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.

8.3.1.9 Block Ack (BlockAck) frame format

8.3.1.9.1 Overview

Change the following row in Table 8-17:

Table 8-17—BA Ack Policy subfield

Value	Meaning
0	Normal Acknowledgment. The BAR Ack Policy subfield is set to this value when the sender requires immediate acknowledgment. The addressee returns an ACK. The value 0 is not used for data sent under HT-delayed BlockAck during a PSMP sequence. The value 0 is not used in frames transmitted by DMG STAs.

Insert the following paragraph after the seventh paragraph ("The values of the Multi-TID, …") of 8.3.1.9.1:

Non-DMG STAs do not use the Extended Compressed BlockAck variant.

Change the third row of Table 8-18 as follows:

Table 8-18—BlockAck frame variant encoding

Multi_TID subfield value	Compressed Bitmap subfield value	GCR subfield value	BlockAck frame variant
1	0	0	~~Reserved~~ Extended Compressed BlockAck

Insert the following subclause, 8.3.1.9.6 (including Figure 8-28b), after 8.3.1.9.5:

8.3.1.9.6 Extended Compressed BlockAck variant

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

The BA Information field of the Extended Compressed BlockAck frame is shown in Figure 8-28b. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAck frame is sent. The value of this subfield is defined in 9.21.7.5. The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.

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

	Block Ack Starting Sequence Control	Block Ack Bitmap	RBUFCAP
Octets:	2	8	1

Figure 8-28b—BA information field (Extended Compressed BlockAck)

The RBUFCAP field contains an unsigned integer that is the number of MPDU buffers available to store received MPDUs at the time of transmission of the Extended Compressed BlockAck frame (9.36).

8.3.1.10 Control Wrapper frame

Insert the following note at the end of 8.3.1.10:

NOTE—DMG STAs do not transmit Control Wrapper frames.

Insert the following subclauses, 8.3.1.11 to 8.3.1.19 (including Figure 8-29a to Figure 8-29i), after 8.3.1.10:

8.3.1.11 Poll frame format

The format of the Poll frame is shown in Figure 8-29a.

	Frame Control	Duration	RA	TA	Response Offset	FCS
Octets:	2	2	6	6	2	4

Figure 8-29a—Poll frame format

The Duration field is set to include the duration, in microseconds, of the remaining Poll frame transmissions (see 9.33.7.2), plus all appropriate IFSs (9.3.2.3), plus the duration of the SPR frame transmissions.

The RA field contains the MAC address of the STA being polled.

The TA field contains the MAC address of the PCP or AP.

The Response Offset field indicates the offset, in units of 1 µs, beginning SIFS after the end of the Poll frame when the SPR frame in response to this Poll frame is transmitted.

8.3.1.12 Service Period Request (SPR) frame format

The format of the SPR frame is shown in Figure 8-29b.

	Frame Control	Duration	RA	TA	Dynamic Allocation Info	BF Control	FCS
Octets:	2	2	6	6	5	2	4

Figure 8-29b—SPR frame format

When an SPR frame is sent in response to a Poll frame (see 9.33.7), the Duration field in the SPR frame is set to the value of the Duration field contained in the Poll frame, minus the value of the Response Offset field contained in the Poll frame multiplied by its unit as specified in 8.3.1.11, minus SIFS, minus the time taken to transmit the SPR frame. When the SPR frame is not sent in response to a Poll frame (see 9.33.9 and 10.4.13) and transmitted within an SP or a TXOP allocation, the Duration field is set to the time left in the allocation excluding the SPR transmission time. In all other cases, the Duration field is set to 0.

The RA field contains the MAC address of the PCP or AP.

The TA field contains the MAC address of the STA transmitting the SP request.

The Dynamic Allocation Info field is defined in 8.4a.2.

The BF Control field is defined in 8.4a.5.

8.3.1.13 Grant frame format

The format of the Grant frame is shown in Figure 8-29c.

	Frame Control	Duration	RA	TA	Dynamic Allocation Info	BF Control	FCS
Octets:	2	2	6	6	5	2	4

Figure 8-29c—Grant frame format

For individually addressed Grant frames, the Duration field in the Grant frame is set to cover the time, in microseconds, to transmit the remaining Grant frame(s) if required, the related IFS (9.3.2.3), 2×SIFS, and the Allocation Duration carried in the Dynamic Allocation Info field. For broadcast Grant frames, the Duration field is set to cover for the duration of all remaining Grant frames plus the granted time, in microseconds.

The RA field contains the MAC address of the STA receiving the SP grant.

The TA field contains the MAC address of the STA that has transmitted the Grant frame.

The Dynamic Allocation Info field is defined in 8.4a.2.

The BF Control field is defined in 8.4a.5.

8.3.1.14 DMG CTS frame format

The frame format for the DMG CTS frame is as defined in Figure 8-29d.

	Frame Control	Duration	RA	TA	FCS
Octets:	2	2	6	6	4

Figure 8-29d—DMG CTS frame format

For all DMG CTS frames sent in response to RTS frames, the duration value is the value obtained from the Duration field of the immediately previous RTS frame, minus the time, in microseconds, required to transmit the DMG CTS frame and its SIFS interval. Otherwise, the Duration field is set to the remaining duration of the TXOP or SP. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer.

The RA field of the frame is copied from the TA field of the immediately previous RTS frame to which the DMG CTS is a response.

The TA field is the MAC address of the STA transmitting the DMG CTS frame.

8.3.1.15 DMG DTS frame format

The frame format for the DMG Denial to Send (DTS) frame is as defined in Figure 8-29e.

	Frame Control	Duration	RA	NAV-SA	NAV-DA	FCS
Octets:	2	2	6	6	6	4

Figure 8-29e—DMG DTS frame format

The Duration field is set to the value of the transmitting STA's NAV–(TXTIME(DMG DTS)+SIFS) or the remaining time in the SP at the end of the DMG DTS transmission, whichever is smaller. The transmitting STA's NAV is the value of its NAV at the start of the DMG DTS frame transmission.

The RA field of the frame is copied from the TA field of the immediately previous RTS frame to which the DMG DTS is a response.

The NAV-SA and the NAV-DA fields contain the MAC addresses of the source DMG STA and the destination DMG STA, respectively, whose exchange of an RTS and DMG CTS caused the last update to the NAV at the transmitting STA.

8.3.1.16 Sector sweep (SSW) frame format

The frame format for the SSW frame is as defined in Figure 8-29f.

	Frame Control	Duration	RA	TA	SSW	SSW Feedback	FCS
Octets:	2	2	6	6	3	3	4

Figure 8-29f—SSW frame format

The Duration field is set to the time until the end of the SSW frame transmission that has the CDOWN subfield within the SSW field equal to 0 or until the end of the current allocation (see 9.35), whichever comes first.

The RA field contains the MAC address of the STA that is the intended receiver of the sector sweep.

The TA field contains the MAC address of the transmitter STA of the sector sweep frame.

The SSW field is defined in 8.4a.1.

The SSW Feedback field is defined in 8.4a.3.

8.3.1.17 Sector sweep feedback (SSW-Feedback) frame format

The format of the SSW-Feedback frame is shown in Figure 8-29g.

	Frame Control	Duration	RA	TA	SSW Feedback	BRP Request	Beamformed Link Maintenance	FCS
Octets:	2	2	6	6	3	4	1	4

Figure 8-29g—SSW-Feedback frame format

The Duration field is set to 0 when the SSW-Feedback frame is transmitted within an association beamforming training (A-BFT). Otherwise, it is set to the time, in microseconds, until the end of the current allocation.

The RA field contains the MAC address of the STA that is the intended destination of the SSW-Feedback frame.

The TA field contains the MAC address of the STA transmitting the SSW-Feedback frame.

The SSW Feedback field is defined in 8.4a.3.

The BRP Request field is defined in 8.4a.4.

The Beamformed Link Maintenance field is defined in 8.4a.6.

8.3.1.18 Sector sweep ACK (SSW-ACK) frame format

The format of the SSW-ACK frame is shown in Figure 8-29h.

	Frame Control	Duration	RA	TA	SSW Feedback	BRP Request	Beamformed Link Maintenance	FCS
Octets:	2	2	6	6	3	4	1	4

Figure 8-29h—SSW-ACK frame format

The Duration field is set to the value of the Duration within the immediately preceding SSW-Feedback frame, minus SIFS, minus the time required to transmit the SSW-ACK frame.

The RA field contains the MAC address of the STA that is the intended destination of the SSW-ACK frame.

The TA field contains the MAC address of the STA transmitting the SSW-ACK frame.

The SSW Feedback field is defined in 8.4a.3.

The BRP Request field is defined in 8.4a.4.

The Beamformed Link Maintenance field is defined in 8.4a.6.

8.3.1.19 Grant ACK frame format

The format of the Grant ACK frame is shown in Figure 8-29i. The Grant ACK frame is sent only in CBAPs as a response to the reception of a Grant frame that has the Beamforming Training field equal to 1.

	Frame Control	Duration	RA	TA	Reserved	BF Control	FCS
Octets:	2	2	6	6	5	2	4

Figure 8-29i—Grant ACK frame format

The Duration field is set to the value obtained from the Duration/ID field of the immediately previous Grant frame minus the time, in microseconds, required to transmit the Grant ACK frame and its SIFS interval.

The RA field of the Grant ACK frame is copied from the Address 2 field of the immediately previous Grant frame.

The TA field contains the MAC address of the STA that has transmitted the Grant ACK frame.

The BF Control field is defined in 8.4a.5.

8.3.2 Data frames

8.3.2.1 Data frame format

In Figure 8-30 (Data frame), change the octet range for Frame Body from ~~0–7951~~ to 0–7959.

Change the note after the first paragraph in 8.3.2.1 as follows:

NOTE—The maximum frame body size shown in Figure 8-30 is for ~~CCMP~~ GCMP encryption of a maximum-size A-MSDU (note that TKIP encryption is not allowed in this case and any Mesh Control fields are part of the A-MSDU subframes). The corresponding maximum for CCMP encryption is 7951 octets. The maximum frame body size if A-MSDUs are not used is 2346 octets for GCMP encryption of a maximum-size MSDU, 2338 octets for CCMP encryption of a maximum-size MSDU, and 2342 octets for TKIP encryption of a maximum-size MSDU, including in all cases an 18-octet Mesh Control field. The frame body size might in all cases be greater if a vendor-specific cipher suite is used.

Change Table 8-19 as follows:

Table 8-19—Address field contents

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

Change the 13th paragraph in 8.3.2.1 as follows:

The BSSID of the Data frame is determined as follows:

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

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

c) If the STA is transmitting a data frame when dot11OCBActivated is true, the BSSID is the wildcard BSSID.

d) If the STA is a member of an MBSS, the BSSID is the address of the transmitter and is equal to TA.

e) If the STA participates in a PBSS, the BSSID is the address of the STA contained in the PCP of the PBSS.

Insert the following notes at the end of 8.3.2.1:

NOTE 1—The QoS Data and QoS Null subtypes are the only Data subtypes transmitted by a DMG STA.

NOTE 2—The HT Control field is not present in frames transmitted by a DMG STA.

Change 8.3.2.2 as follows (including inserting new text and two new subclause titles):

8.3.2.2 Aggregate MSDU (A-MSDU) format

8.3.2.2.1 General

An A-MSDU is a sequence of A-MSDU subframes as shown in Figure 8-31. Each A-MSDU subframe consists of an A-MSDU subframe header followed by an MSDU and 0 to 3 octets of padding as shown in Figure 8-32 and Figure 8-33a (in 8.3.2.2.3). ~~Each A-MSDU subframe (except the last) is padded so that its length is a multiple of 4 octets. The last A-MSDU subframe has no padding.~~

Figure 8-31 remains unchanged.

Octets:	6	6	2	0–2304 (non-DMG STA) 0–7920 (DMG STA)	0–3
	DA	SA	Length	MSDU	Padding

Figure 8-32—Basic A-MSDU subframe structure

Two A-MSDU subframe formats are defined: the Basic A-MSDU subframe described in 8.3.2.2.2 and the Short A-MSDU subframe described in 8.3.2.2.3. Unless otherwise noted, in this standard, the term A-MSDU applies to both the Basic A-MSDU and the Short A-MSDU. The Basic A-MSDU uses only the Basic A-MSDU subframe format, while the Short A-MSDU uses only the Short A-MSDU subframe format.

8.3.2.2.2 Basic A-MSDU subframe format

In the Basic A-MSDU subframe, each A-MSDU subframe (except the last) is padded so that its length is a multiple of 4 octets. The last A-MSDU subframe has no padding.

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

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

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

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

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

NOTE 2—The maximum MPDU length that can be transported using A-MPDU aggregation is 4095 octets for non-DMG STAs and 7995 octets for DMG STAs. An A-MSDU cannot be fragmented. Therefore, a non-DMG STA cannot transport an A-MSDU of a length that exceeds 4065 octets (4095 minus the QoS data MPDU overhead) ~~cannot be transported~~ in an A-MPDU.

When Mesh Data frames are aggregated, the Aggregate MSDU subframe header includes Mesh DA, Mesh SA, Length, and Mesh Control. The A-MSDU subframe structure for Mesh Data is defined in Figure 8-33.

Figure 8-33 remains unchanged.

The Mesh DA and Mesh SA fields contain the addresses of the destination mesh STA and the source mesh STA, respectively, determined in 9.32.3.

The Length field contains the length in octets of the MSDU.

The format of the Mesh Control field is described in 8.2.4.7.3.

NOTE—It is possible to have different Mesh DA, Mesh SA, and Mesh Control in Subframe Headers of the same AMSDU as long as they all map to the same Address 1 and Address 2 values.

Insert the following subclause, 8.3.2.2.3 (including Figure 8-33a), after 8.3.2.2.2:

8.3.2.2.3 Short A-MSDU subframe format

The Short A-MSDU subframe is shown in Figure 8-33a. In the Short A-MSDU subframe, each A-MSDU subframe (except the last) is padded so that its length excluding the A-MSDU subframe header is a multiple of 4 octets. The last A-MSDU subframe has no padding.

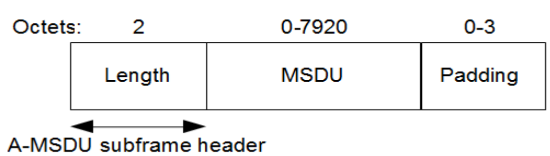


Figure 8-33a—Short A-MSDU subframe structure

The Short A-MSDU subframe header consists of a Length field that contains the length in octets of the MSDU.

NOTE—The Short A-MSDU subframe format is not transmitted by non-DMG STAs.

8.3.3 Management frames

8.3.3.1 Format of management frames

In Figure 8-34 (Management frame format), change the octet range for Frame Body from ~~0–2320~~ to 0–2328.

Change the note after the first paragraph in 8.3.3.1 as follows:

NOTE—The maximum frame body size shown in Figure 8-34 is for ~~CCMP~~ GCMP encryption with a maximum-size MMPDU (note TKIP encryption is not allowed and any Mesh Control field is held within the MMPDU, not as a separate header). The frame body size might be greater if a vendor-specific cipher suite is used.

Insert the following paragraph after the note after the fourth paragraph ("The address fields for the Multihop … in the Mesh Control field.") in 8.3.3.1:

Within a PBSS, the BSSID field of a management frame is set to the MAC address in use by the STA contained in the PCP of the PBSS.

8.3.3.2 Beacon frame format

Insert the following row into Table 8-20 before the Last row:

Table 8-20—Beacon frame body

Order	Information	Notes
59	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.

8.3.3.5 Association Request frame format

Change the following rows in Table 8-22, and insert the new rows into the table before the Last row:

Table 8-22—Association Request frame body

Order	Information	Notes
4	Supported Rates	This field is not present if dot11DMGOptionImplemented is true.
5	Extended Supported Rates	The Extended Supported Rates element is present if there are more than eight supported rates, and it is optional otherwise. This element is not present if dot11DMGOptionImplemented is true.
19	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.
20	DMG Capabilities	The DMG Capabilities element is present if dot11DMGOptionImplemented is true.
21	Multiple MAC Sublayers	The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true.

8.3.3.6 Association Response frame format

Change the following rows in Table 8-23, and insert the new rows into the table before the Last row:

Table 8-23—Association Response frame body

Order	Information	Notes
4	Supported Rates	This field is not present if dot11DMGOptionImplemented is true.
5	Extended Supported Rates	The Extended Supported Rates element is present if there are more than eight supported rates, and it is optionally present otherwise. This element is not present if dot11DMGOptionImplemented is true.
23	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.
24	DMG Capabilities	The DMG Capabilities element is present if dot11DMGOptionImplemented is true.
25	DMG Operation	The DMG Operation element is present if dot11DMGOptionImplemented is true.
26	Multiple MAC Sublayers	The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true.

8.3.3.7 Reassociation Request frame format

Change the following rows in Table 8-24, and insert the new rows into the table before the Last row:

Table 8-24—Reassociation Request frame body

Order	Information	Notes
5	Supported Rates	This field is not present if dot11DMGOptionImplemented is true.
6	Extended Supported Rates	The Extended Supported Rates element is present if there are more than eight supported rates, and it is optional otherwise. This element is not present if dot11DMGOptionImplemented is true.
24	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.
25	DMG Capabilities	The DMG Capabilities element is present if dot11DMGOptionImplemented is true.
26	Multiple MAC Sublayers	The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true.

8.3.3.8 Reassociation Response frame format

Change the following rows in Table 8-25, and insert the new rows into the table before the Last row:

Table 8-25—Reassociation Response frame body

Order	Information	Notes
4	Supported Rates	This field is not present if dot11DMGOptionImplemented is true.
5	Extended Supported Rates	The Extended Supported Rates element is present if there are more than eight supported rates, and it is optional otherwise. This element is not present if dot11DMGOptionImplemented is true.
27	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.
28	DMG Capabilities	The DMG Capabilities element is present if dot11DMGOptionImplemented is true.
29	DMG Operation	The DMG Operation element is present if dot11DMGOptionImplemented is true.
30	Multiple MAC Sublayers	The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true.

8.3.3.9 Probe Request frame format

Change the following rows in Table 8-26, and insert the new rows into the table before the Last row:

Table 8-26—Probe Request frame body

Order	Information	Notes
2	Supported Rates	This field is not present if dot11DMGOptionImplemented is true.
4	Extended Supported Rates	The Extended Supported Rates element is present if there are more than eight supported rates, and it is optionally present otherwise. This element is not present if dot11DMGOptionImplemented is true.
14	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.
15	DMG Capabilities	The DMG Capabilities element is present if dot11DMGOptionImplemented is true.
16	Multiple MAC Sublayers	The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true.

8.3.3.10 Probe Response frame format

Change the following rows in Table 8-27, and insert the new rows into the table before the Last–l row:

Table 8-27—Probe Response frame body

Order	Information	Notes
5	Supported Rates	This field is not present if dot11DMGOptionImplemented is true.
19	Extended Supported Rates	The Extended Supported Rates element is present if there are more than eight supported rates, and it is optionally present otherwise. This element is not present if dot11DMGOptionImplemented is true.
57	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.
58	DMG Capabilities	The DMG Capabilities element is present if dot11DMGOptionImplemented is true.
59	DMG Operation	The DMG Operation element is present if dot11DMGOptionImplemented is true.
60	Multiple MAC Sublayers	The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true.
61	Antenna Sector ID Pattern	The Antenna Sector ID Pattern element is optionally present if dot11DMGOptionImplemented is true.

8.3.3.11 Authentication frame format

Insert the following row into Table 8-28 before the Last row:

Table 8-28—Authentication frame body

Order	Information	Notes
16	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.

Insert the following subclauses, 8.3.4 and 8.3.4.1 (including Figure 8-34a through Figure 8-34d and Table 8-33a), after 8.3.3.15:

8.3.4 Extension frames

8.3.4.1 DMG Beacon

The format of the DMG Beacon is shown in Figure 8-34a.

In addition to supporting functions such as network synchronization (see 10.1), the DMG Beacon frame can also be used as training frame for beamforming (see 9.35).

	Frame Control	Duration	BSSID	Body	FCS
Octets:	2	2	6	Variable	4

Figure 8-34a—DMG Beacon frame format

The Duration field is set to the time remaining until the end of the beacon transmission interval (BTI).

The BSSID field contains the BSSID.

The body of the DMG Beacon frame contains the elements listed in Table 8-33a.

Table 8-33a—DMG Beacon frame body

Order	Information	Notes
1	Timestamp	See 8.4.1.10
2	Sector Sweep	See 8.4a.1
3	Beacon Interval	See 8.4.1.3
4	Beacon Interval Control	See Figure 8-34b.
5	DMG Parameters	See 8.4.1.46
6	Clustering Control	Optional. See Figure 8-34c and Figure 8-34d.
7	DMG Capabilities	The DMG Capabilities element is optionally present.
8	Extended Schedule	The Extended Schedule element is optionally present.
9	RSN	The RSNE is optionally present if dot11RSNAEnabled is true.
10	Multiple BSSID	One or more Multiple BSSID elements are optionally present if dot11MgmtOptionMultiBSSIDEnabled is true.
11	DMG Operation	The DMG Operation element is optionally present.
12	Next DMG ATI	The Next DMG ATI element is optionally present.
13	DMG BSS Parameter Change	The DMG BSS Parameter Change element is optionally present.
14	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.
Last – *n*	One or more elements can appear in this frame. These elements follow all other elements that are not vendor-specific elements and precede all other elements that are vendor-specific elements that are part of the Last field in the frame. Except for the Multi-band element, an element can be included only once in the frame.	Optional
Last	Vendor Specific	One or more vendor-specific elements are optionally present. These elements follow all other elements.

The format of the Beacon Interval Control field is shown in Figure 8-34b.

	B0	B1	B2 B5	B6	B7 B9	B10 B13	B14
	CC Present	Discovery Mode	Next Beacon	ATI Present	A-BFT Length	FSS	IsResponderTXSS
Bits:	1	1	4	1	3	4	1

	B15 B18	B19	B20 B26	B27 B30	B31 B36	B37 B42	B43	B44 B47
	Next A-BFT	Fragmented TXSS	TXSS Span	N BIs A-BFT	A-BFT Count	N A-BFT in Ant	PCP Association Ready	Reserved
Bits:	4	1	7	4	6	6	1	4

Figure 8-34b—Beacon Interval Control field

The CC Present field is set to 1 to indicate that the Clustering Control field is present in the DMG Beacon. Otherwise, the Clustering Control field is not present.

The Discovery Mode field is set to 1 if the STA is generating the DMG Beacon following the procedure described in 10.1.3.2b. Otherwise, this field is set to 0.

The Next Beacon field indicates the number of beacon intervals following the current beacon interval during which the DMG Beacon is not be present.

The ATI Present field is set to 1 to indicate that the announcement transmission interval (ATI) is present in the current beacon interval. Otherwise, the ATI is not present.

The A-BFT Length field specifies the size of the A-BFT following the BTI, and is defined in units of a sector sweep slot (9.35.5). The value of this field is in the range of 1 to 8, with the value being equal to the bit representation plus 1.

The FSS field specifies the number of SSW frames allowed per sector sweep slot (9.35.5). The value of this field is in the range of 1 to 16, with the value being equal to the bit representation plus 1.

The IsResponderTXSS field is set to 1 to indicate the A-BFT following the BTI is used for responder transmit sector sweep (TXSS). This field is set to 0 to indicate responder receive sector sweep (RXSS). When this field is set to 0, the FSS field specifies the length of a complete receive sector sweep by the STA sending the DMG Beacon frame.

The Next A-BFT field indicates the number of beacon intervals during which the A-BFT is not be present. A value of 0 indicates that the A-BFT immediately follows this BTI.

The Fragmented TXSS field is set to 1 to indicate the TXSS is a fragmented sector sweep, and is set to 0 to indicate the TXSS is a complete sector sweep.

The TXSS Span field indicates the number of beacon intervals it takes for the STA sending the DMG Beacon frame to complete the TXSS phase. This field is always greater than or equal to one.

The N BIs A-BFT field indicates the interval, in number of beacon intervals, at which the STA sending the DMG Beacon frame allocates an A-BFT. A value of 1 indicates that every beacon interval contains an A-BFT.

The A-BFT Count field indicates the number of A-BFTs since the STA sending the DMG Beacon frame last switched RX DMG antennas for an A-BFT. A value of 0 indicates that the DMG antenna used in the forthcoming A-BFT differs from the DMG antenna used in the last A-BFT. This field is reserved if the value of the Number of RX DMG Antennas field within the STA's DMG Capabilities element is 1.

The N A-BFT in Ant field indicates how many A-BFTs the STA sending the DMG Beacon frame receives from each DMG antenna in the DMG antenna receive rotation. This field is reserved if the value of the Number of RX DMG Antennas field within the STA's DMG Capabilities element is 1.

The PCP Association Ready field is set to 1 to indicate that the PCP is ready to receive Association Request frames from non-PCP STAs and is set to 0 otherwise. This field is reserved when transmitted by a non-PCP STA.

The DMG Parameters field is defined in 8.4.1.46.

If the value of Discovery Mode field is 0, the Clustering Control field is formatted as shown in Figure 8-34c. If the value of the Discovery Mode field is 1, the Clustering Control field is formatted as shown in Figure 8-34d.

	B0 B7	B8 B55	B56 B57	B58 B62	B63
	Beacon SP duration	Cluster ID	Cluster Member Role	ClusterMaxMem	Reserved
Bits:	8	48	2	5	1

Figure 8-34c—Clustering Control field format if the Discovery Mode field is 0

	B0 B47	B48 B63
	A-BFT Responder Address	Reserved
Bits:	48	16

Figure 8-34d—Clustering Control field format if the Discovery Mode field is 1

If ECPAC Policy Enforced field is set to 0, the Beacon SP Duration subfield indicates the duration, in units of 8 µs, of the Beacon SPs in the cluster. If ECPAC Policy Enforced field is set to 1, the Beacon SP Duration subfield indicates the maximum duration, in units of 8 µs, of the beacon header interval (BHI) of the BSS, and the minimum duration of Beacon SPs in the cluster (see 9.34.2.2).

The cluster to which the transmitter of the Clustering Control field belongs is identified by the Cluster ID subfield. The MAC address of the synchronization PCP (S-PCP)/S-AP is the Cluster ID of the cluster.

The Cluster Member Role subfield identifies the role that the transmitting STA assumes within the cluster. A value of 0 means that the STA is currently not participating in clustering. A value of 1 means that the STA acts as the S-PCP/S-AP of the cluster. A value of 2 means that the STA participates in the cluster, but not as the S-PCP/S-AP. The value 3 is reserved.

The ClusterMaxMem subfield defines the maximum number of PCPs and/or APs, including the S-PCP/S-AP, that can participate in the cluster. The value of the ClusterMaxMem subfield is computed in relation to the beacon interval value (9.34.2). The value 0 is reserved. Values 8 and above are reserved if the ECPAC Policy Enforced field is set to 0. The value 1 is assigned to the S-PCP/S-AP.

The A-BFT Responder Address subfield contains the MAC address of the STA that is allowed to transmit during the A-BFT, if present, that follows the BTI.

Change the title of 8.4 as follows:

8.4 Management and Extension frame body components

8.4.1 Fields that are not information elements

8.4.1.3 Beacon Interval field

Insert the following note at the end of 8.4.1.3:

NOTE—A value of 0 in the Beacon Interval field transmitted by a DMG STA indicates that the TBTT of the next BTI is unknown.

8.4.1.4 Capability Information field

Change the second paragraph of 8.4.1.4 as follows:

The length of the Capability Information field is 2 octets. The format of the Capability Information field is defined in Figure 8-38 when transmitted by a non-DMG STA and in Figure 8-38a when transmitted by a DMG STA. No subfield is supplied for ERP as a STA supports ERP operation if it includes all of the Clause 19 mandatory rates in its supported rate set.

Change the title for Figure 8-38 as follows:

Figure 8-38—Capability Information field (non-DMG STA)

Insert the following figure, Figure 8-38a, after Figure 8-38:

	B0 B7	B8	B9 B11	B12	B13 B15
	DMG Parameters	Spectrum Management	Reserved	Radio Measurement	Reserved
Bits:	8	1	3	1	3

Figure 8-38a—Capability Information field (DMG STA)

Insert the following paragraph at the end of 8.4.1.4:

The DMG Parameters field is defined in 8.4.1.46.

8.4.1.8 AID field

Change 8.4.1.8 as follows:

In infrastructure BSS operation, the AID field is a value assigned by a~~n~~ PCP/AP during association that represents the 16-bit ID of a STA. In mesh BSS operation, the AID field is a value that represents the 16-bit ID of a neighbor peer mesh STA. An AID value is assigned by a mesh STA that receives and accepts a Mesh Peering Open frame to the transmitter of the Mesh Peering Open frame during the mesh peering establishment process (see 13.3.1). The length of the AID field is 2 octets. The AID field is illustrated in Figure 8-42.

Figure 8-42 remains unchanged.

A non-DMG STA assigns ~~T~~the value ~~assigned as~~ of the AID ~~is~~ in the range of 1 to 2007 and ~~is~~ placesd it in the 14 LSBs of the AID field, with the two MSBs of the AID field each set to 1 (see 8.2.4.2).

A DMG STA assigns the value of the AID field in the range of 1 to 254. The value 255 is reserved as the broadcast AID, and the value 0 corresponds to the PCP/AP. A DMG STA sets the 8 MSBs of the AID field to 0.

8.4.1.9 Status Code field

Change the second paragraph in 8.4.1.9 as follows:

If an operation is successful, then the status code is set to 0. A status code of 85 also indicates a successful operation. If an operation results in failure, the status code indicates a failure cause. The failure cause codes are defined in Table 8-37.

Change the following rows in Table 8-37, and insert the new rows into the table in numeric order:

Table 8-37—Status codes

Status code	Name	Meaning
33		Association denied because QoS AP or PCP has insufficient bandwidth to handle another QoS STA
39	REJECTED_WITH_SUGGESTED_CHANGES	The allocation or TS has not been created because the request cannot be honored; however, a suggested TSPEC/DMG TSPEC is provided so that the initiating STA may attempt to set another allocation or TS with the suggested changes to the TSPEC/DMG TSPEC
47	REJECTED_FOR_DELAY_PERIOD	The TS or allocation has not been created; however, the PCP/HC may be capable of creating a TS or allocation, in response to a request, after the time indicated in the TS Delay element
56		Requested TCLAS processing is not supported by the PCP/AP
57		The PCP/AP has insufficient TCLAS processing resources to satisfy the request
58		The TS has not been created because the request cannot be honored; however, the PCP/HC suggests the STA to transition to other BSSs to set up the TS.
68		Request refused because PCP/AP does not support unauthenticated access
83	REJECT_WITH_SCHEDULE	Reject with recommended schedule
84		Reject because no wakeup schedule specified
85		Success, the destination STA is in power save mode
86	PENDING_ADMITTING_FST_SESSION	FST pending, in process of admitting FST session
87	PERFORMING_FST_NOW	Performing FST now

Table 8-37—Status codes *(continued)*

Status code	Name	Meaning
88	PENDING_GAP_IN_BA_WINDOW	FST pending, gap(s) in Block Ack window
89	REJECT_U-PID_SETTING	Reject because of U-PID setting
90–91		Reserved
96	REJECT_DSE_BAND	Reject since the request is for transition to a frequency band subject to DSE procedures and FST Initiator is a dependent STA
97–98		Reserved
99	DENIED_WITH_SUGGESTED_BAND_AND_CHANNEL	The association has been denied; however, one or more Multi-band elements are included that can be used by the receiving STA to join the BSS
103	DENIED_DUE_TO_SPECTRUM_MANAGEMENT	Association denied because the information in the Spectrum Management field is unacceptable
104–65 535		Reserved

8.4.1.11 Action field

Change the second paragraph in 8.4.1.11 as follows:

The Category field is set to one of the nonreserved values shown in the "Code" column of Table 8-38. Action frames of a given category are referred to as <*category name*> *Action frames*. For example, frames in the QoS category are called *QoS Action frames*. The "Action frame" column in Table 8-38 identifies exceptions, if any, that specific frames within a category have with respect to the "Robust" column.

Change Table 8-38 as follows:

Table 8-38—Category values

Code	Meaning	Sub-clause	Robust	Group addressed privacy	Action frame
0	Spectrum management	8.5.2	Yes	No	
1	QoS	8.5.3	Yes	No	
2	DLS	8.5.4	Yes	No	
3	Block Ack	8.5.5	Yes	No	
4	Public	8.5.8	No	No	
5	Radio measurement	8.5.7	Yes	No	DMG: Link Measurement Request and Link Measurement Report are not robust frames
6	Fast BSS Transition	8.5.9	Yes	No	
7	HT	8.5.12	No	No	

Table 8-38—Category values *(continued)*

Code	Meaning	Sub-clause	Robust	Group addressed privacy	Action frame
8	SA Query	8.5.10	Yes	No	
9	Protected Dual of Public Action	8.5	Yes	No	
10	WNM	8.5.14	Yes	No	
11	Unprotected WNM	8.5.15	No	No	
12	TDLS	8.5.13	— See NOTE	No	
13	Mesh	8.5.17	Yes	Yes	
14	Multihop	8.5.18	Yes	Yes	
15	Self-protected	8.5.16	No	No	
16	DMG ~~Reserved~~	8.5.20	Yes	No	
17	Reserved (used by WFA)	—	—	—	
18	Fast session transfer	8.5.21	Yes	No	
19	Robust AV Streaming	8.5.19	Yes	—	
20	Unprotected DMG	8.5.22	No	No	
~~18~~21–125	Reserved	—	—	—	
126	Vendor-specific Protected	8.5.6	Yes	No	
127	Vendor-specific	8.5.6	No	No	
128–255	Error	–	–	–	

NOTE—TDLS Action fields are always transported encapsulated within a data frame (see 10.22.1), so the question of whether these frames are Robust is not applicable.

Insert the following subclauses, 8.4.1.44 to 8.4.1.46 (including Figure 8-80b, Figure 8-80c, Table 8-53a, and Table 8-53b), after 8.4.1.43:

8.4.1.44 Relay Capable STA Info field

The format of the Relay Capable STA Info field is defined in Figure 8-80b.

	B0 B7	B8 B23
	AID	Relay Capabilities Info
Bits:	8	16

Figure 8-80b—Relay Capable STA Info field

The AID field contains the AID of the relay capable STA that is associated with the PCP or AP.

The Relay Capabilities Info field is defined in 8.4.2.150.

8.4.1.45 Band ID field

The Band ID field is 1 octet in length and is defined in Table 8-53a.

Table 8-53a—Band ID field

Band ID value	Meaning
0	TV white spaces
1	Sub-1 GHz (excluding TV white spaces)
2	2.4 GHz
3	3.6 GHz
4	4.9 and 5 GHz
5	60 GHz
6–255	Reserved

8.4.1.46 DMG Parameters field

The format of the DMG Parameters field is shown in Figure 8-80c.

	B0 B1	B2	B3	B4	B5	B6 B7
	BSS Type	CBAP Only	CBAP Source	DMG Privacy	ECPAC Policy Enforced	Reserved
Bits:	2	1	1	1	1	2

Figure 8-80c—DMG Parameters

The BSS Type subfield is defined in Table 8-53b. An AP sets the BSS Type subfield to 3 within transmitted DMG Beacon, Probe Response, or (Re)Association Response frames. A PCP sets the BSS Type subfield to 2 within transmitted DMG Beacon, Probe Response, or (Re)Association Response frames. A STA within an IBSS sets the BSS Type subfield to 1 within transmitted DMG Beacon or Probe Response frames.

Table 8-53b—The BSS Type subfield

Subfield value	BSS Type	Transmitted by DMG STA
3	Infrastructure BSS	AP
2	PBSS	PCP
1	IBSS	Any non-AP and non-PCP DMG STA
0	Reserved	

The CBAP Only, CBAP Source, and ECPAC Policy Enforced subfields are valid only when transmitted within a DMG Beacon, Probe Response, or (Re)Association Response frames and are set as follows:

— The CBAP Only subfield indicates the type of link access provided by the STA sending the DMG Beacon frame in the data transfer interval (DTI) (see 9.33.2) of the beacon interval. The CBAP Only subfield is set to 1 when the entirety of the DTI portion of the beacon interval is allocated as a CBAP. The CBAP Only subfield is set to 0 when the allocation of the DTI portion of the beacon interval is provided through the Extended Schedule element.
— The CBAP Source subfield is valid only if the CBAP Only subfield is 1. The CBAP Source subfield is set to 1 to indicate that the PCP/AP has higher priority to initiate transmissions during the CBAP than non-PCP/non-AP STAs. The CBAP Source subfield is set to 0 otherwise.
— The ECPAC Policy Enforced subfield is set to 1 to indicate that medium access policies specific to the centralized PCP/AP cluster are required as defined in 9.34.3.4. The ECPAC Policy Enforced subfield is set to 0 to indicate that medium access policies specific to the centralized PCP/AP cluster are not required.

The DMG Privacy subfield is set to 1 if dot11RSNAEnabled is true. Otherwise, this subfield is set to 0.

8.4.2 Information elements

8.4.2.1 General

Change the following rows in Table 8-54, and insert the new rows into the table in numeric order:

Table 8-54—Element IDs

Element	Element ID	Length (in octets)	Extensible
TSPEC (see 8.4.2.32)	13	57 (non-DMG) or 59 (DMG)	Non-DMG: no DMG: yes
Nontransmitted BSSID Capability (see 8.4.2.74)	83	4 (non-DMG) or 24 (DMG)	
Wakeup Schedule	143	10	Yes
Extended Schedule	144	17 to 257	Yes
STA Availability	145	4 to 257	Yes
DMG TSPEC	146	16 to 253	Yes
Next DMG ATI	147	8	Yes
DMG Capabilities	148	19	Yes
Reserved	149–150		
DMG Operation	151	12	Yes
DMG BSS Parameter Change	152	9	Yes
DMG Beam Refinement	153	7	Yes
Channel Measurement Feedback	154	6 to 257	Yes
Reserved	155–156		
Awake Window	157	4	Yes
Multi-band	158	24 to 257	Yes

Table 8-54—Element IDs *(continued)*

Element	Element ID	Length (in octets)	Extensible
ADDBA Extension	159	3	Yes
NextPCP List	160	4 to 257	Yes
PCP Handover	161	15	Yes
DMG Link Margin	162	10	Yes
Switching Stream	163	6 to 257	Yes
Session Transition	164	13	Yes
Dynamic Tone Pairing Report	165	34	Yes
Cluster Report	166	3 to 257	Yes
Relay Capabilities	167	4	Yes
Relay Transfer Parameter Set	168	10	Yes
BeamLink Maintenance	169	3	Yes
Multiple MAC Sublayers	170	8 to 254	Yes
U-PID	171	11	Yes
DMG Link Adaptation Acknowledgment	172	7	Yes
Reserved	~~143~~–173		
Quiet Period Request	175	19	Yes
Reserved	176		
Quiet Period Response	177	12	Yes
Reserved	178–181		
ECPAC Policy	182	13 or 17	Yes
Cluster Time Offset	183	3	Yes
Reserved	184–189		
Antenna Sector ID Pattern	190	6	Yes
Reserved	~~175~~191–220		

8.4.2.21 Channel Switch Announcement element

Change the first paragraph in 8.4.2.21 as follows:

The Channel Switch Announcement element is used by an AP in a BSS, a STA in an IBSS, ~~or~~ a mesh STA in an MBSS, or a PCP in a PBSS to advertise when it is changing to a new channel and the channel number of the new channel. The format of the Channel Switch Announcement element is shown in Figure 8-102.

8.4.2.23 Measurement Request element

8.4.2.23.1 General

Insert the following rows into Table 8-59 in numeric order, and update the Reserved row accordingly:

Table 8-59—Measurement Type definitions for measurement requests

Name	Measurement Type	Measurement Use
Directional channel quality request	13	Radio Measurement, Spectrum Management, and WNM
Directional measurement request	14	Radio Measurement, Spectrum Management, and WNM
Directional statistics request	15	Radio Measurement, Spectrum Management, and WNM

Insert the following subclauses, 8.4.2.23.16 to 8.4.2.23.18 (including Figure 8-139a to Figure 8-139e, Table 8-80a, and Table 8-80b), after 8.4.2.23.15:

8.4.2.23.16 Directional channel quality request

The Measurement Request field corresponding to a directional channel quality request is shown in Figure 8-139a. This Measurement Request is transmitted from a Requesting STA to a Requested STA to perform measurements towards a Target STA.

	Operating Class	Channel Number	AID	Reserved	Measurement Method
Octets:	1	1	1	1	1

	Measurement Start Time	Measurement Duration	Number of Time Blocks	Optional Subelements
Octets:	8	2	1	Variable

Figure 8-139a—Measurement request field format for directional channel quality request

Operating Class field indicates the channel set for which the measurement request applies. Operating Class and Channel Number together specify the channel frequency and spacing for which the measurement request applies. Valid values of Operating Class are shown in Annex E.

Channel Number field indicates the channel number for which the measurement request applies. Channel Number is defined within a Operating Class as shown in Annex E.

The AID field indicates the Target STA.

The Measurement Method field indicates the method that is to be used by the Requested STA to carry out this measurement request and report back in the measurement report. If this field is set to 0, it indicates ANIPI. If this field is set to 1, it indicates RSNI. Other values are reserved.

The Measurement Start Time field is set to the TSF timer at the time at which the requested measurement starts. A value of 0 indicates that the measurement starts immediately.

The Measurement Duration field is set to the preferred or mandatory duration of the requested measurement, expressed in units of TUs. See 10.11.4.

The Number of Time Blocks field indicates the number of time blocks within the Measurement Duration. The ratio (Measurement Duration/Number of Time Blocks) provides the duration of an individual measurement unit.

The Optional Subelements field format contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as shown in Figure 8-402. Any optional subelements are ordered by nondecreasing Subelement ID.

The Subelement ID field values for the defined optional subelements are shown in Table 8-80a. A Yes in the Extensible column of a subelement listed in Table 8-80a indicates that the Length of the subelement might be extended in future revisions or amendments of this standard. When the Extensible column of an element is set to Subelements, then the subelement might be extended in future revisions or amendments of this standard by defining additional subelements within the subelement. See 9.23.9.

Table 8-80a—Optional Subelement IDs for directional channel quality request

Subelement ID	Name	Length field (octets)	Extensible
0	Reserved		
1	Directional Channel Quality Reporting Information	2	Yes
2–220	Reserved		
221	Vendor Specific	1–244	
222–255	Reserved		

The Directional Channel Quality Reporting Information subelement indicates the condition for issuing a Directional Channel Quality Report. Directional Channel Quality Reporting Information subelement data field format is shown in Figure 8-139b and contains a 1-octet Reporting Condition subfield and a 1-octet Directional Channel Quality Reference Value subfield. The Reporting Condition is described in Table 8-80b. The Directional Channel Quality Reference value is a Directional Channel Quality value and is the reference value for the indicated Reporting Condition.

	Reporting Condition	Directional Channel Quality Reference Value
Octets:	1	1

Figure 8-139b—Directional Channel Quality Reporting Information data field format

Table 8-80b—Reporting Condition for Directional Channel Quality Report

Condition for report to be issued	Reporting condition
Report to be issued after each measurement (default, used when Directional Channel Quality Reporting Information subelement is not included in Directional Channel Quality Request).	0
Report to be issued when measured ANIPI or RSNI is equal to or greater than the reference value.	1
Report to be issued when measured ANIPI or RSNI is equal to or less than the reference value.	2
Reserved	3–255

The Vendor Specific subelements have the same format as their corresponding elements (see 8.4.2.28). Multiple Vendor Specific subelements can be included in the list of Optional Subelements.

8.4.2.23.17 Directional measurement request

The Measurement Request field corresponding to a directional measurement request is shown in Figure 8-139c. This Measurement Request is transmitted from a Requesting STA to a Requested STA to perform directional channel measurements in all sectored receiving directions.

	Operating Class	Channel Number	Measurement Start Time	Measurement Duration per Direction	Measurement Method	Optional Subelements
Octets	1	1	8	2	1	Variable

Figure 8-139c—Measurement Request field format for directional measurement request

Operating Class field indicates the channel set for which the measurement request applies. Operating Class and Channel Number together specify the channel frequency and spacing for which the measurement request applies. Valid values of Operating Class are shown in Annex E.

Channel Number field indicates the channel number for which the measurement request applies. Channel Number is defined within a Operating Class as shown in Annex E.

The Measurement Start Time field is set to the TSF timer at the time at which the requested measurement starts. A value of 0 indicates that the measurement starts immediately.

The Measurement Duration per Direction field is set to the preferred or mandatory duration of the requested measurement in each receiving direction, expressed in units of TUs.

The Measurement Method field indicates the method that is to be used by the Requested STA to carry out this measurement request and report back in the measurement report. If this field is set to 0, it indicates ANIPI. If this field is set to 1, it indicates RCPI. If the field is set to 2, it indicates Channel Load. Other values are reserved.

The Optional Subelements field format contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as shown in Figure 8-402. Any optional subelements are ordered by nondecreasing Subelement ID.

8.4.2.23.18 Directional statistics request

The Measurement Request field corresponding to a directional statistics request is shown in Figure 8-139d. This Measurement Request is transmitted from a Requesting STA to a Requested STA to perform directional channel measurements in all sectored receiving directions.

	Operating Class	Channel Number	Measurement Start Time	Measurement Duration per Direction	Measurement Method	Directional Statistics Bitmap	Optional Subelements
Octets	1	1	8	2	1	1	Variable

Figure 8-139d—Measurement Request field format for directional statistics request

Operating Class field indicates the channel set for which the measurement request applies. Operating Class and Channel Number together specify the channel frequency and spacing for which the measurement request applies. Valid values of Operating Class are shown in Annex E.

Channel Number field indicates the channel number for which the measurement request applies. Channel Number is defined within a Operating Class as shown in Annex E.

The Measurement Start Time field is set to the TSF timer at the time at which the requested measurement starts. A value of 0 indicates that the measurement starts immediately.

The Measurement Duration per Direction field is set to the preferred or mandatory duration of the requested measurement in each receiving direction, expressed in units of TUs.

The Measurement Method field indicates the method that is to be used by the Requested STA to carry out this measurement request and report back in the measurement report. If this field is set to 0, it indicates ANIPI. If this field is set to 1, it indicates RCPI. If the field is set to 2, it indicates Channel Load. Other values are reserved.

The Directional Statistics Bitmap field format is shown in Figure 8-139e. The Maximum field set to 1 indicates that the maximum measurement result among all directions is expected in the measurement report. The Minimum field set to 1 indicates that the minimum measurement result among all directions is expected in the measurement report. The Average field set to 1 indicates that the average measurement result among all directions is expected in the measurement report. The Variance field set to 1 indicates that the variance of measurement results among all directions is expected in the measurement report. Other bits are reserved.

	B0	B1	B2	B3	B4 B7
	Maximum	Minimum	Average	Variance	Reserved
Bits:	1	1	1	1	4

Figure 8-139e—Directional Statistics Bitmap field format

The Optional Subelements field format contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as shown in Figure 8-402. Any optional subelements are ordered by nondecreasing Subelement ID.

8.4.2.24 Measurement Report element

8.4.2.24.1 General

Insert the following rows into Table 8-81, and update the Reserved row accordingly:

Table 8-81—Measurement Type definitions for measurement reports

Name	Measurement Type	Measurement Use
Directional channel quality report	13	Radio Measurement, Spectrum Management, and WNM
Directional measurement report	14	Radio Measurement, Spectrum Management, and WNM
Directional statistics report	15	Radio Measurement, Spectrum Management, and WNM

Insert the following subclauses, 8.4.2.24.15 to 8.4.2.24.17 (including Figure 8-182a to Figure 8-182d and Table 8-98a to Table 8-98c), after 8.4.2.24.14:

8.4.2.24.15 Directional channel quality report

The format of the Measurement Report field of a directional channel quality report is shown in Figure 8-182a.

	Operating Class	Channel Number	AID	Reserved	Measurement Method	Measurement Start Time
Octets:	1	1	1	1	1	8

	Measurement Duration	Number of Time Blocks (N)	Measurement for Time Block 1	…	Measurement for Time Block N	Optional Subelements
Octets:	2	1	1		1	Variable

Figure 8-182a—Measurement report field format for directional channel quality report

Operating Class field indicates the channel set for which the measurement report applies. Operating Class and Channel Number together specify the channel frequency and spacing for which the measurement report applies. Valid values of Operating Class are shown in Annex E.

Channel Number field indicates the channel number for which the measurement report applies. Channel Number is defined within a Operating Class as shown in Annex E.

The AID field indicates the Target STA.

The Measurement Method field indicates the method used by the STA to carry out this measurement request and the format of the Measurement for Time Block field(s). If this field is set to 0, it indicates that the Measurement for Time Block fields are expressed in ANIPI. If this field is set to 1, it indicates that the Measurement for Time Block fields are expressed in RSNI. Other values are reserved.

Measurement Start Time field is set to the value of the measuring STA's TSF timer at the time the measurement started.

The Measurement Duration field is set to the duration of the measurement, expressed in units of TUs.

The Number of Time Blocks field indicates the number of time blocks within the Measurement Duration. The ratio (Measurement Duration/Number of Time Blocks) provides the duration of an individual measurement unit.

The Measurement for Time Block fields are set to the ANIPI or average RSNI value measured during each (Measurement Duration/Number of Time Blocks) measurement units. The measurement units are set in the report in increasing order of start times. ANIPI is set to the average noise plus interference power value measured during the indicated Measurement Duration using the same units and accuracy as defined for ANPI in 10.11.9.4. Average RSNI is set according to 8.4.2.43, where RCPI is defined in the RCPI measurement subclause in Clause 21.

The Optional Subelements field format contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as shown in Figure 8-402. Any optional subelements are ordered by nondecreasing Subelement ID.

The Subelement ID field values for the defined optional subelements are shown in Table 8-98a. A Yes in the Extensible column of a subelement listed in Table 8-98a indicates that the Length of the subelement might be extended in future revisions or amendments of this standard. When the Extensible column of an element is set to Subelements, then the subelement might be extended in future revisions or amendments of this standard by defining additional subelements within the subelement. See 9.23.9.

Table 8-98a—Optional Subelement IDs for directional channel quality report

Subelement ID	Name	Length field (octets)	Extensible
0–220	Reserved		
221	Vendor Specific	1–255	
222–255	Reserved		

The Vendor Specific subelements have the same format as their corresponding elements (see 8.4.2.28). Multiple Vendor Specific subelements can be included in the list of Optional Subelements.

8.4.2.24.16 Directional measurement report

The format of the Measurement Report field of a directional measurement report is shown in Figure 8-182b.

	Operating Class	Channel Number	Measurement Start Time	Measurement Duration per Direction	Measurement Method	Measurement Results	Optional Subelements
Octets	1	1	8	2	1	Variable	Variable

Figure 8-182b—Measurement Report field format for directional measurement report

Operating Class field indicates the channel set for which the measurement report applies. Operating Class and Channel Number together specify the channel frequency and spacing for which the measurement report applies. Valid values of Operating Class are shown in Annex E.

Channel Number field indicates the channel number for which the measurement report applies. Channel Number is defined within a Operating Class as shown in Annex E.

The Measurement Start Time field is set to the value of the measuring STA's TSF timer at the time the measurement started.

The Measurement Duration per Direction field is set to the duration of the measurement in each receiving direction, expressed in units of TUs.

The Measurement Method field indicates the method used by the STA to carry out the measurement request and the format of values in the Measurement for Direction fields. If this field is set to 0, it indicates that the values in the Measurement for Direction fields are expressed in ANIPI. If this field is set to 1, it indicates that the values in the Measurement for Direction fields are expressed in RCPI. If this field is set to 2, it indicates that the values in the Measurement for Direction fields are expressed in Channel Load. Other values are reserved. ANIPI is defined in 8.4.2.24.15. RCPI indicates the received channel power of the corresponding Link Measurement Request frame in a dBm scale, as defined in the RCPI measurement subclause in Clause 21.

The format of the Measurement Results field is shown in Figure 8-182c. The Measurement for Direction fields are set to the format of values specified in the Measurement Method field.

	Number of Directions	Measurement for Direction 1	Measurement for Direction 2	…	Measurement for Direction N
Octets:	1	Variable	Variable	…	Variable

Figure 8-182c—Measurement Results field format

The Optional Subelements field format contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as shown in Figure 8-402. Any optional subelements are ordered by nondecreasing SubelementID.

The Subelement ID field values for the defined optional subelements are shown in Table 8-98b. A Yes in the Extensible column of a subelement listed in Table 8-98b indicates that the Length of the subelement might be extended in future revisions or amendments of this standard. When the Extensible column of an element is set to Subelements, then the subelement might be extended in future revisions or amendments of this standard by defining additional subelements within the subelement. See 9.23.9.

Table 8-98b—Optional Subelement IDs for directional measurement report

Subelement ID	Name	Length field (octets)	Extensible
0–220	Reserved		
221	Vendor Specific	1–255	
222–255	Reserved		

The Vendor Specific subelements have the same format as their corresponding elements (see 8.4.2.28). Multiple Vendor Specific subelements can be included in the list of Optional Subelements.

8.4.2.24.17 Directional statistics report

The format of the Measurement Report field of a directional statistics report is shown in Figure 8-182d.

	Operating Class	Channel Number	Measurement Start Time	Measurement Duration per Direction	Measurement Method	Directional Statistics Bitmap	Measurement Results	Optional Subelements
Octets	1	1	8	2	1	1	Variable	Variable

Figure 8-182d—Measurement Report field format for directional statistics report

Operating Class field indicates the channel set for which the measurement report applies. Operating Class and Channel Number together specify the channel frequency and spacing for which the measurement report applies. Valid values of Operating Class are shown in Annex E.

Channel Number field indicates the channel number for which the measurement report applies. Channel Number is defined within a Operating Class as shown in Annex E.

The Measurement Start Time field is set to the value of the measuring STA's TSF timer at the time the measurement started.

The Measurement Duration per Direction field is set to the duration of the measurement in each receiving direction, expressed in units of TUs.

The Measurement Method field indicates the method used by the STA to carry out the measurement request and the format of values in the Measurement Results field. If this field is set to 0, it indicates that the values in the Measurement Results field are expressed in ANIPI. If this field is set to 1, it indicates that the values in the Measurement Results field are expressed in RCPI. If this field is set to 2, it indicates that the values in the Measurement Results field are expressed in Channel Load. Other values are reserved.

The Directional Statistics Bitmap field format is described in 8.4.2.23.18. When the Maximum field is set, it indicates that the maximum measurement result among all directions is included in the Measurement Results field. When the Minimum field is set, it indicates that the minimum measurement result among all directions is included in the Measurement Results field. If the Average field is set, it indicates that the average measurement result among all directions is included in the Measurement Results field. If the Variance field is set, it indicates that the variance of measurement results among all directions is included in the Measurement Results field. Other bits are reserved.

The Measurement Results field is set based on the values in the Measurement Method field and the Directional Statistics Bitmap field. If two or more subfields in the Directional Statistics Bitmap are set to 1, the corresponding measurement results are included in the Measurement Results field in the same sequence as they appear in the Directional Statistics Bitmap field.

The Optional Subelements field format contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as shown in Figure 8-402. Any optional subelements are ordered by nondecreasing Subelement ID.

The Subelement ID field values for the defined optional subelements are shown in Table 8-98c. A Yes in the Extensible column of a subelement listed in Table 8-98c indicates that the Length of the subelement might be extended in future revisions or amendments of this standard. When the Extensible column of an element is set to Subelements, then the subelement might be extended in future revisions or amendments of this standard by defining additional subelements within the subelement. See 9.23.9.

Table 8-98c—Optional Subelement IDs for directional statistics report

Subelement ID	Name	Length field (octets)	Extensible
0–220	Reserved		
221	Vendor Specific	1–255	
222–255	Reserved		

The Vendor Specific subelements have the same format as their corresponding elements (see 8.4.2.28). Multiple Vendor Specific subelements can be included in the list of Optional Subelements.

8.4.2.27 RSNE

8.4.2.27.2 Cipher suites

Insert the following row into Table 8-99 in numeric order, and update the Reserved row accordingly:

Table 8-99—Cipher suite selectors

OUI	Suite type	Meaning
00-0F-AC	8	GCMP – default for a DMG STA

Insert the following row at the end of Table 8-100:

Table 8-100—Cipher suite usage

Cipher suite selector	GTK	PTK	IGTK
GCMP	Yes	Yes	No

8.4.2.27.4 RSN capabilities

Insert Bit 8 for the RSN Capabilities field in 8.4.2.27.4 in numeric order as follows:

— Bit 8: Joint Multi-band RSNA. A STA sets the Joint Multi-band RSNA subfield to 1 to indicate that it supports the Joint Multi-band RSNA (11.5.19). Otherwise, this subfield is set to 0.

Change the description of Bit 13 in 8.4.2.27.4 as follows:

— Bit 13: Extended Key ID for Individually Addressed Frames. This subfield is set to 1 to indicate that the STA supports Key ID values in the range of 0 to 1 for a PTKSA and STKSA when the cipher suite is CCMP or GCMP. A value of 0 indicates that the STA supports only Key ID 0 for a PTKSA and STKSA.

8.4.2.29 Extended Capabilities element

Change the following row in Table 8-103:

Table 8-103—Capabilities field

Bit	Information	Notes
47	~~Reserved~~ QAB Capability	Set to 1 if AP supports QAB Set to 0 otherwise

8.4.2.32 TSPEC element

Change the first paragraph of 8.4.2.32, and insert a new second paragraph as follows:

The TSPEC element contains the set of parameters that define the characteristics and QoS expectations of a traffic flow, in the context of a particular STA, for use by the PCP/HC and STA(s) or a mesh STA and its peer mesh STAs in support of QoS traffic transfer using the procedures defined in 10.4 and 10.23.15.3. The element information format comprises the items as defined in this subclause, and the structure is defined in Figure 8-196 when the element is transmitted in a non-DMG BSS and in Figure 8-196a when the element is transmitted in a DMG BSS.

A PTP TSPEC is a TSPEC exchanged between two non-AP DMG STAs. The format of the PTP TSPEC is the same as the non-PTP TSPEC; hence the element format described in this subclause applies to both the PTP TSPEC and the non-PTP TSPEC.

Change the title of Figure 8-196 as follows:

Figure 8-196—TSPEC element format (non-DMG)

Insert the following figure, Figure 8-196a, after Figure 8-196:

	Element ID	Length	TS Info	Nominal MSDU Size	Maximum MSDU Size	Minimum Service Interval	Maximum Service Interval	Inactivity Interval	Suspension Interval
Octets:	1	1	3	2	2	4	4	4	4

	Service Start Time	Minimum Data Rate	Mean Data Rate	Peak Data Rate	Burst Size	Delay Bound	Minimum PHY Rate	Surplus Bandwidth Allowance	Medium Time	DMG Attributes
Octets:	4	4	4	4	4	4	4	2	2	2

Figure 8-196a—TSPEC element format (DMG)

Change the now third paragraph of 8.4.2.32 as follows:

The TSPEC allows a set of parameters more extensive than may be needed, or may be available, for any particular instance of parameterized QoS traffic. Unless indicated otherwise, fields that follow the TS Info field are set to 0 for any unspecified parameter values. STAs set the value of any parameters to unspecified if they have no information for setting that parameter. ~~The~~A DMG STA that responds with an ADDTS Response frame and an HC may change the value of parameters that have been set unspecified by the STA to any value that it deems appropriate, including leaving them unspecified.

Change the following rows of Table 8-107:

Table 8-107—Direction subfield encoding

Bit 5	Bit 6	Usage
0	0	Uplink, defined as follows: — Non-DMG BSS: ~~(~~MSDUs or A-MSDUs are sent from the non-AP STA to HC~~)~~ — DMG BSS: MSDUs or A-MSDUs are sent by the non-AP originator of the ADDTS Request frame
1	0	Downlink, defined as follows: — Non-DMG BSS: ~~(~~MSDUs or A-MSDUs are sent from the HC to the non-AP STA~~)~~ — DMG BSS: MSDUs or A-MSDUs are sent by the non-AP recipient of the ADDTS Request frame

Change Table 8-108 as follows:

Table 8-108—Access Policy subfield

Bit 7	Bit 8	Usage
0	0	Reserved
1	0	Contention-based channel access (EDCA)
0	1	Controlled channel access (HCCA for non-DMG STAs and SPCA for DMG STAs)
1	1	Controlled and contention-based channel access (HCCA, EDCA mixed mode (HEMM) for non-DMG STAs; SPCA, EDCA mixed mode (SEMM) for DMG STAs)

Change the following list item in the dashed list after the now fifth paragraph in 8.4.2.32:

— The Aggregation subfield is 1 bit in length. The Aggregation subfield is valid only when the access method is HCCA or SPCA or when the access method is EDCA and the Schedule subfield is set to 1. It is set to 1 by a non-AP STA to indicate that an aggregate schedule is required. It is set to 1 by the AP if an aggregate schedule is being provided to the STA. It is set to 0 otherwise. In all other cases, the Aggregation subfield is reserved.

Change now paragraphs 13 to 16, and insert a new paragraph 17 in 8.4.2.32 as follows (note that footnote 23 remains unchanged):

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

~~and PHY overheads incurred in transferring the MSDUs or A-MSDUs.~~ The field is encoded as a piecewise linear function described as follows:

$$Minimum\ Data\ Rate\ (in\ units\ of\ bits\ per\ second) = \begin{cases} Minimum\ Data\ Rate\ field\ value, if\ field\ value\ \leq 2^{31} \\ 1024 \times (Minimum\ Data\ Rate\ field\ value - 2^{31}) + 2^{31}, if\ field\ value > 2^{31} \end{cases}$$

The Mean Data Rate[23] field is 4 octets long and ~~contains an unsigned integer that specifies~~ indicates the average data rate specified at the MAC_SAP~~, in bits per second,~~ for transport of MSDUs or A-MSDUs belonging to this TS within the bounds of this TSPEC. ~~The mean data rate does not include the MAC and PHY overheads incurred in transferring the MSDUs or A-MSDUs.~~ The field is encoded as a piecewise linear function described as follows:

$$Mean\ Data\ Rate\ (in\ units\ of\ bits\ per\ second) = \begin{cases} Mean\ Data\ Rate\ field\ value, if\ field\ value\ \leq 2^{31} \\ 1024 \times (Mean\ Data\ Rate\ field\ value - 2^{31}) + 2^{31}, if\ field\ value > 2^{31} \end{cases}$$

The Peak Data Rate field is 4 octets long and ~~contains an unsigned integer that specifies~~ indicates the maximum allowable data rate~~, in bits per second,~~ specified at the MAC_SAP for ~~transfer~~ transport of MSDUs or A-MSDUs belonging to this TS within the bounds of this TSPEC. The field is encoded as a piecewise linear function described as follows:

$$Peak\ Data\ Rate\ (in\ units\ of\ bits\ per\ second) = \begin{cases} Peak\ Data\ Rate\ field\ value, if\ field\ value\ \leq 2^{31} \\ 1024 \times (Peak\ Data\ Rate\ field\ value - 2^{31}) + 2^{31}, if\ field\ value > 2^{31} \end{cases}$$

If p is the peak rate in bits per second, then the maximum amount of data, belonging to this TS, arriving in any time interval $[t1, t2]$, where $t1 < t2$ and $t2 - t1 > 1$ TU, does not exceed $p \times (t2 - t1)$ bits.

The Minimum, Mean and Peak Data Rates do not include the MAC and PHY overheads incurred in transporting the MSDUs or A-MSDUs.

Change now paragraph 20 in 8.4.2.32 as follows (note that footnote 24 remains unchanged):

The Minimum PHY Rate field is 4 octets long and ~~contains an unsigned integer that specifies~~ indicates the desired minimum PHY rate ~~to use for this TS, in bits per second, that is required~~ for transport of ~~the~~ MSDUs or A-MSDUs belonging to this~~e~~ TS within the bounds of this TSPEC.[24] See 10.4.2 for constraints on the selection of this field. The field is encoded as a piecewise linear function described as follows:

$$Minimum\ PHY\ Rate\ (in\ units\ of\ bits\ per\ second) = \begin{cases} Minimum\ PHY\ Rate\ field\ value, if\ field\ value\ \leq 2^{31} \\ 1024 \times (Minimum\ PHY\ Rate\ field\ value - 2^{31}) + 2^{31}, if\ field\ value > 2^{31} \end{cases}$$

Insert the following paragraph (including its dashed list, Figure 8-198a, and Table 8-110a) at the end of 8.4.2.32:

The DMG Attributes field is defined in Figure 8-198a.

B0 B3	B4 B5	B6	B7	B8 B9	B10 B15
Allocation ID	Reserved	Allocation Direction	A-MSDU Subframe	Reliability	Reserved

Figure 8-198a—DMG Attributes field format

- The Allocation ID subfield is 4 bits in length. Traffic streams can share an allocation through TSPEC aggregation (see Annex Z). The Allocation ID subfield is used as follows:
  - When setting up a TS, the DMG STA that transmits an ADDTS Request frame containing a TSPEC or PTP TSPEC element sets the Allocation ID to a nonzero value to identify the allocation it requires to carry the TS. Alternatively, the same DMG STA sets the Allocation ID to 0 to indicate any CBAP allocation with the broadcast AID as Source AID.
  - When setting up a TS, the DMG STA that transmits the ADDTS Response frame containing the TSPEC or PTP TSPEC element sets the Allocation ID to a nonzero value that identifies the allocation carrying the TS. Alternatively, the same DMG STA sets the Allocation ID to 0 to indicate any CBAP allocation with the broadcast AID as Source AID and Destination AID.
  - When deleting a TS, the DMG STA that transmits the DELTS frame containing a TSPEC or PTP TSPEC element sets the Allocation ID to a nonzero value to identify the allocation that is carrying the TS to be deleted. Alternatively, the same DMG STA sets the Allocation ID to 0 to indicate no allocation exists to carry the TS to be deleted.
- The Allocation Direction subfield is 1 bit in length. It is equal to 1 when the originator of the ADDTS Request is also the source of the allocation identified by Allocation ID and is equal to 0 otherwise. The Allocation Direction subfield is equal to 0 when the Allocation ID subfield is equal to 0.
- The A-MSDU Subframe subfield is 1 bit in length and contains a value that indicates the A-MSDU subframe structure to be used for this TS. The A-MSDU Subframe subfield is set to 0 to indicate the Basic A-MSDU subframe structure and set to 1 to indicate the Short A-MSDU subframe structure.
- The Reliability subfield is 2 bits in length and contains an expected reliability index. The reliability index refers to the PER of the PHY (PSDU Packet Error Rate as in 21.3.3.9). The relation between the reliability index and the PER is shown in Table 8-110a.

  The Reliability subfield in an ADDTS Request frame that has the Direction subfield set to downlink or in an ADDTS Response frame that has the Direction field set to uplink indicates the receiver's expectation of the PER for this TS. The Reliability subfield in an ADDTS Request frame that has the Direction subfield set to uplink or in an ADDTS Response frame that has the Direction field set to downlink is reserved. The reliability information is provided by the SME using the MLME-ADDTS.request primitive and MLME-ADDTS.response primitives. Together with the link margin (9.37) and other implementation-specific information, this value can be used by the transmitter to estimate the MCS to be used for this particular TS.

Table 8-110a—Reliability subfield values

Reliability index	PER
0	Not specified
1	10^{-2}
2	10^{-3}
3	10^{-4}

8.4.2.33 TCLAS element

Change the first paragraph of 8.4.2.33 as follows:

The TCLAS element specifies an element that contains a set of parameters necessary to identify incoming MSDUs (from a higher layer in all STAs or from the DS in an AP) that belong to a particular TS. The TCLAS element is also used when the traffic does not belong to a TS, for example, by the FMS, DMS, and TFS services. If required, the TCLAS element is provided in ADDTS Request and ADDTS Response frames only for the downlink or bidirectional links. TCLAS element need not be provided for the uplink or direct-link transmissions, unless the PTP TSPEC is transmitted to a peer STA via a PCP/AP. The TCLAS element is always included when a PTP TSPEC is transmitted to a peer STA via a PCP/AP. The structure of this element is shown in Figure 8-199.

8.4.2.48 Multiple BSSID element

Change the fifth paragraph in 8.4.2.48 as follows:

When the Multiple BSSID element is transmitted in a Beacon, DMG Beacon, or Probe Response frame, the reference BSSID is the BSSID of the frame. More than one Multiple BSSID element may be included in a Beacon or DMG Beacon frame. The AP or DMG STA determines the number of Multiple BSSID elements. The AP or DMG STA does not fragment a nontransmitted BSSID profile subelement for a single BSSID across two Multiple BSSID elements unless the length of the nontransmitted BSSID profile subelement exceeds 255 octets. When the Multiple BSSID element is transmitted as a subelement in a Neighbor Report element, the reference BSSID is the BSSID field in the Neighbor Report element.

Change the first sentence in the eighth paragraph in 8.4.2.48 as follows:

The Nontransmitted BSSID Profile subelement contains a list of elements for one or more APs or DMG STAs that have nontransmitted BSSIDs and is defined as follows:

Change the tenth paragraph in 8.4.2.48 as follows:

The Multiple BSSID element is included in Beacon frames, as described in 8.3.3.2, in DMG Beacon frames, as described in 8.3.4.1, and Probe Response frames, as described in 8.3.3.10. The use of the Multiple BSSID element is described 10.11.14. Nontransmitted BSSID Advertisement procedures are described in 10.1.3.6.

8.4.2.51 Timeout Interval element (TIE)

Insert the following row into Table 8-122 in numeric order, and update the Reserved row accordingly:

Table 8-122—Timeout Interval Type field value

Timeout Interval Type	Meaning	Units
4	Time-to-Start (see 10.32.2.1)	Time units (TUs)

8.4.2.74 Nontransmitted BSSID Capability element

Insert the following paragraph after the first paragraph in 8.4.2.74:

When transmitted by a DMG STA, the Nontransmitted BSSID Capability element includes the DMG BSS Control and the Nontransmitted BSSID DMG Capability element fields. These fields are not present if this element is transmitted by non-DMG STAs.

Change Figure 8-321 as follows:

	Element ID	Length	Nontransmitted BSSID Capability	DMG BSS Control	Nontransmitted BSSID DMG Capabilities element
Octets:	1	1	2	1	19

Figure 8-321—Nontransmitted BSSID Capability element format

Insert the following paragraph as the new third paragraph in 8.4.2.74:

The DMG BSS Control field and the Nontransmitted BSSID DMG Capabilities element field are present in this element only when the element is transmitted by a DMG STA and are not present otherwise.

Change the now fifth and sixth paragraphs in 8.4.2.74 as follows:

The value of Length field is 2 when transmitted by a non-DMG STA and is 22 when transmitted by a DMG STA.

The Nontransmitted BSSID Capability field contains the Capability information field of the BSS when transmitted by a non-DMG STA. When transmitted by a DMG STA, the Nontransmitted BSSID Capability field is reserved.

Insert the following paragraphs (including Figure 8-321a) at the end of 8.4.2.74:

The DMG BSS Control field is defined in Figure 8-321a.

	B0 B1	B2 B7
	BSS Type	Reserved
Bits:	2	6

Figure 8-321a—DMG BSS Control field format

The BSS Type field is as defined in 8.3.4.1.

The Nontransmitted BSSID DMG Capabilities element field contains the DMG Capabilities element of the DMG STA.

Insert the following subclauses, 8.4.2.129 to 8.4.2.159 (including Figure 8-401l to Figure 8-401bo and Table 8-183f to Table 8-183u), after 8.4.2.128:

8.4.2.129 DMG BSS Parameter Change element

The DMG BSS Parameter Change element is formatted as illustrated in Figure 8-401l.

	Element ID	Length	Change Type Bitmap	TBTT Offset	BI Duration
Octets:	1	1	1	4	2

Figure 8-401l—DMG BSS Parameter Change element format

The Element ID field is equal to the value for the DMG BSS Parameter Change, specified in Table 8-54.

The Length field is set to 7.

The Change Type Bitmap field indicates the type of the parameter change to the BSS. This field is defined in Figure 8-401m.

	B0	B1	B2 B7
	Move	Size	Reserved
Bits:	1	1	6

Figure 8-401m—Change Type Bitmap field format

If the Move field is set to 1, it indicates a change in the TBTT of the BSS. The TBTT is not changed if the Move field is set to 0. If the Size field is set to 1, it indicates a change in the beacon interval duration. The beacon interval duration is not changed if the Size field is set to 0.

The TBTT Offset is expressed in microseconds. In any DMG BSS Parameter Change element included in DMG Beacon and/or Announce frame, the value of the TBTT Offset field represents the lower order 4 octets of the PCP/AP TSF timer of the first changed TBTT.

The BI Duration field indicates the beacon interval, expressed in TUs, following the indicated DMG BSS Parameter Change. The BI Duration field is reserved if the Size bit of the Change Type Bitmap field is set to 0.

8.4.2.130 DMG Capabilities element

8.4.2.130.1 General

The DMG Capabilities element contains a STA identifier and several fields that are used to advertise the support of optional DMG capabilities of a DMG STA. The element is present in Association Request, Association Response, Reassociation Request, Reassociation Response, Probe Request and Probe Response frames and can be present in DMG Beacon and Information request and response frames. The DMG Capabilities element is formatted as illustrated in Figure 8-401n.

	Element ID	Length	STA Address	AID	DMG STA Capability Information	DMG PCP/ AP Capability Information
Octets:	1	1	6	1	8	2

Figure 8-401n—DMG Capabilities element format

The Element ID field is equal to the value for the DMG Capabilities, specified in Table 8-54.

The Length field is set to 17.

The STA Address field contains the MAC address of the STA.

The AID field contains the AID assigned to the STA by the PCP/AP. The value of the AID field is ignored in Association Request, Reassociation Request and Probe Request frames and when used in an IBSS.

8.4.2.130.2 DMG STA Capability Information field

The DMG STA Capability Information field, shown in Figure 8-401o, represents the transmitting STA capabilities irrespective of the role of the STA.

	B0	B1	B2	B3	B4 B5	B6	B7 B13
	Reverse Direction	Higher Layer Timer Synchronization	TPC	SPSH and Interference Mitigation	Number of RX DMG Antennas	Fast Link Adaptation	Total Number of Sectors
Bit:	1	1	1	1	2	1	7

	B14 B19	B20	B21 B26	B27	B28 B51	B52
	RXSS Length	DMG Antenna Reciprocity	A-MPDU Parameters	BA with Flow Control	Supported MCS Set	DTP Supported
Bit:	6	1	6	1	24	1

	B53	B54	B55	B56	B57 B59	B60	B61	B62 B63
	A-PPDU Supported	Heartbeat	Supports Other_AID	Antenna Pattern Reciprocity	Heartbeat Elapsed Indication	Grant ACK Supported	RXSSTx-Rate Supported	Reserved
Bit:	1	1	1	1	3	1	1	2

Figure 8-401o—DMG STA Capability Information field format

The Reverse Direction field is set to 1 if the STA supports RD as defined in 9.25 and is set to 0 otherwise.

The Higher Layer Timer Synchronization field is set to 1 if the STA supports Higher Layer Timer Synchronization as defined in 10.23.5 and is set to 0 otherwise.

The TPC field is set to 1 if the STA supports the TPC as defined in 10.8 and is set to 0 otherwise.

The SPSH and Interference Mitigation field is set to 1 if the STA is capable of performing the function of SPSH and Interference Mitigation and if dot11RadioMeasurementActivated is true and is set to 0 otherwise (see 10.31).

The Number of RX DMG Antennas field indicates the total number of receive DMG antennas of the STA. The value of this field is in the range of 1 to 4, with the value being equal to the bit representation plus 1.

The Fast Link Adaptation field is set to 1 to indicate that the STA supports the fast link adaptation procedure described in 9.37.3. Otherwise, it is set to 0.

The Total Number of Sectors field indicates the total number of transmit sectors the STA uses in a transmit sector sweep combined over all DMG antennas. The value of this field is in the range of 1 to 128, with the value being equal to the bit representation plus 1.

The value represented by the RXSS Length field specifies the total number of receive sectors combined over all receive DMG antennas of the STA. The value represented by this field is in the range of 2 to 128 and is given by (RXSS Length+1)×2. The maximum number of SSW frames transmitted during an RXSS is equal to the value of (RXSS Length+1)×2 times the total number of transmit DMG antennas of the peer device.

The DMG Antenna Reciprocity field is set to 1 to indicate that the best transmit DMG antenna of the STA is the same as the best receive DMG antenna of the STA and vice versa. Otherwise, this field is set to 0.

The A-MPDU Parameters field is shown in Figure 8-401p.

	B0 B2	B3 B5
	Maximum A-MPDU Length Exponent	Minimum MPDU Start Spacing
Bits:	3	3

Figure 8-401p—A-MPDU parameters field format

The subfields of the A-MPDU Parameters field are defined in Table 8-183f.

Table 8-183f—Subfields of the A-MPDU Parameters field

Subfield	Definition	Encoding
Maximum A-MPDU Length Exponent	Indicates the maximum length of A-MPDU that the STA can receive.	This field is an integer in the range of 0 to 5. The length defined by this field is equal to $2^{(13 + \text{Maximum A-MPDU Length Exponent})} - 1$ octets.
Minimum MPDU Start Spacing	Determines the minimum time between the start of adjacent MPDUs within an A-MPDU that the STA can receive, measured at the PHY-SAP.	Set to 0 for no restriction Set to 1 for 16 ns Set to 2 for 32 ns Set to 3 for 64 ns Set to 4 for 128 ns Set to 5 for 256 ns Set to 6 for 512 ns Set to 7 for 1024 ns

The BA with Flow Control field is set to 1 if the STA supports BA with flow control as defined in 9.36 and is set to 0 otherwise.

The Supported MCS Set field indicates which MCSs a DMG STA supports. An MCS is identified by an MCS index, which is represented by an integer in the range of 0 to 31. The interpretation of the MCS index (i.e., the mapping from MCS to data rate) is PHY dependent. For the DMG PHY, see Clause 21. The structure of the Supported MCS Set field is defined in Figure 8-401q.

	B0 B4	B5 B9	B10 B14	B15 B19	B20	B21	B22 B23
	Maximum SC Rx MCS	Maximum OFDM Rx MCS	Maximum SC Tx MCS	Maximum OFDM Tx MCS	Low-Power SC PHY Supported	Code Rate 13/16	Reserved
Bits:	5	5	5	5	1	1	2

Figure 8-401q—Supported MCS Set field format

The Maximum SC Rx MCS subfield contains the value of the maximum MCS index the STA supports for reception of single-carrier frames. Values 0-3 of this field are reserved. Possible values for this subfield are shown in Table 21-18.

The Maximum OFDM Rx MCS subfield contains the value of the maximum MCS index the STA supports for reception of OFDM frames. If this field is set to 0, it indicates that the STA does not support reception of OFDM frames. Values 1-17 of this field are reserved. Possible values for this subfield are described in 21.5.3.1.2.

The Maximum SC Tx MCS subfield contains the value of the maximum MCS index the STA supports for transmission of single-carrier frames. Values 0-3 of this field are reserved. Possible values for this subfield are shown in Table 21-18.

The Maximum OFDM Tx MCS subfield contains the value of the maximum MCS index the STA supports for transmission of OFDM frames. If this field is set to 0, it indicates that the STA does not support transmission of OFDM frames. Values 1-17 of this field are reserved. Possible values for this subfield are described 21.5.3.1.2.

The Low-Power SC PHY Supported subfield is set to 1 to indicate that the STA supports the DMG low-power SC PHY mode (21.7). Otherwise, it is set to 0. If the STA supports the low-power SC PHY, it supports all low-power SC PHY MCSs indicated in Table 21-22.

The Code Rate 13/16 subfield specifies whether the STA supports rate 13/16. It is set to 1 to indicate that the STA supports rate 13/16 and is set to 0 otherwise. If this field is 0, MCSs with 13/16 code rate specified in Table 21-14 and Table 21-18 are not supported regardless of the value in Maximum SC/OFDM Tx/Rx MCS subfields.

The DTP Supported field is set to 1 to indicate that the STA supports DTP as described in 9.38 and 21.5.3.2.4.6.3. Otherwise, it is set to 0.

The A-PPDU Supported field is set to 1 to indicate that the STA supports A-PPDU aggregation as described in 9.13a. Otherwise, it is set to 0.

The Supports Other_AID field is set to 1 to indicate that the STA sets its AWV configuration according to the Other_AID subfield in the BRP Request field during the BRP procedure as described in 9.35.6.4.4 and 21.10.2.2.6, if the value of the Other_AID subfield is different from zero. Otherwise, this field is set to 0.

The Heartbeat field is set to 1 to indicate that the STA expects to receive a frame from the PCP/AP during the ATI (9.33.3) and expects to receive a frame with the DMG Control modulation from a source DMG STA at the beginning of an SP (9.33.6.2) or TXOP (9.19.2). Otherwise, it is set to 0.

The Antenna Pattern Reciprocity field is set to 1 to indicate that the transmit antenna pattern associated with an AWV is the same as the receive antenna pattern for the same AWV. Otherwise, this field is set to 0.

The Heartbeat Elapsed Indication field is used to calculate the value of the Heartbeat Elapsed Time. The Heartbeat Elapsed Time is expressed in milliseconds and is computed according to the following equation:

$$Heartbeat\ Elapsed\ Time = \begin{cases} 0, if\ Heartbeat\ Elapsed\ Indication = 0 \\ 2^{Heartbeat\ Elapsed\ Indication} \times 0.25, if\ Heartbeat\ Elapsed\ Indication > 0 \end{cases}$$

The Grant ACK Supported field is set to 1 to indicate that the STA is capable of responding to a Grant frame with a Grant ACK frame. Otherwise, this field is set to 0.

The RXSSTxRate Supported field is set to 1 to indicate that the STA can perform an RXSS with SSW frames transmitted at MCS 1 of the DMG SC modulation class. Otherwise, it is set to 0.

8.4.2.130.3 DMG PCP/AP Capability Information field

The DMG PCP/AP Capability Information field, illustrated in Figure 8-401r, represents the capabilities when the transmitting STA performs in the role of PCP/AP and that are in addition to the capabilities in the DMG STA Capability Information field.

	B0	B1	B2	B3 B10	B11
	TDDTI	Pseudo-static Allocations	PCP Handover	MAX Associated STA Number	Power Source
Bit:	1	1	1	8	1

	B12	B13	B14	B15
	Decentralized PCP/AP Clustering	PCP Forwarding	Centralized PCP/AP Clustering	Reserved
Bit:	1	1	1	1

Figure 8-401r—DMG PCP/AP Capability Information field format

The TDDTI (time division data transfer interval) field is set to 1 if the STA, while operating as a PCP/AP, is capable of providing channel access as defined in 9.33.6 and 10.4 and is set to 0 otherwise.

The Pseudo-static Allocations field is set to 1 if the STA, while operating as a PCP/AP, is capable of providing pseudo-static allocations as defined in 9.33.6.4 and is set to 0 otherwise. The Pseudo-static Allocations field is set to 1 only if the TDDTI field in the DMG PCP/AP Capability Information field is set to 1. The Pseudo-static Allocations field is reserved if the TDDTI field in the DMG PCP/AP Capability Information field is set to 0.

The PCP Handover field is set to 1 if the STA, while operating as a PCP, is capable of performing a PCP Handover as defined in 10.28.2 and is set to 0 if the STA does not support PCP Handover.

The MAX Associated STA Number field indicates the maximum number of STAs that the STA can perform association with if operating as a PCP/AP. The value of this field includes the STAs, if any, that are co-located with the PCP/AP.

The Power Source field is set to 0 if the STA is battery powered and is set to 1 otherwise.

The Decentralized PCP/AP Clustering field is set to 1 if the STA, when operating as a PCP/AP, is capable of performing Decentralized PCP/AP clustering and is set to 0 otherwise.

The PCP Forwarding field is set to 1 if the STA, while operating as a PCP, is capable of forwarding frames it receives from a non-PCP STA and destined to another non-PCP STA in the PBSS. This field is set to 0 otherwise.

The Centralized PCP/AP Clustering field is set to 1 if the STA, when operating as a PCP/AP, is capable of performing centralized PCP/AP clustering and is set to 0 otherwise. A PCP/AP that is incapable of performing centralized PCP/AP clustering is subject to requirements as described in 9.34.2.2.

8.4.2.131 DMG Operation element

The operational parameters of a BSS provided by the PCP/AP are determined by the DMG Operation element defined in Figure 8-401s.

	Element ID	Length	DMG Operation Information	DMG BSS Parameter Configuration
Octets:	1	1	2	8

Figure 8-401s—DMG Operation element format

The Element ID field is equal to the value for the DMG Operation, specified in Table 8-54.

The Length field is set to 10.

The DMG Operation Information field is shown in Figure 8-401t.

	B0	B1	B2	B3 B15
	TDDTI	Pseudo-static allocations	PCP Handover	Reserved
Bit:	1	1	1	13

Figure 8-401t—DMG Operation Information field format

The TDDTI field is set to 1 if the PCP/AP provides time division channel access as defined in 9.33.6 and is set to 0 otherwise.

The Pseudo-static allocations field is set to 1 if the PCP/AP provides pseudo-static allocations as defined in 9.33.6.4 and is set to 0 otherwise. The Pseudo-static allocations field is set to 1 only if the TDDTI field in the DMG Operation Information field is 1. The Pseudo-static allocations field is reserved if the TDDTI field in the DMG Operation Information field is 0.

The PCP Handover field is set to 1 if the PCP provides PCP Handover as defined in 10.28.2 and is set to 0 if the PCP does not provide PCP Handover.

The DMG BSS Parameter Configuration field is defined in Figure 8-401u.

	PSRequestSuspensionInterval	MinBHIDuration	BroadcastSTAInfoDuration	AssocRespConfirmTime
Octets:	1	2	1	1

	MinPPDuration	SPIdleTimeout	MaxLostBeacons
Octets:	1	1	1

Figure 8-401u—DMG BSS Parameter Configuration field format

The PSRequestSuspensionInterval subfield indicates the power save suspension interval and is specified in number of beacon intervals. While associated with a PCP/AP, a STA overrides the value of its local dot11PSRequestSuspensionInterval MIB variable with the value of this field when it receives this element from its PCP/AP.

The MinBHIDuration subfield indicates the minimum duration of the BHI, which can include the BTI, A-BFT, and ATI and is specified in microseconds. While associated with a PCP/AP, a STA overrides the value of its local dot11MinBHIDuration MIB variable with the value of this field when it receives this element from its PCP/AP.

The BroadcastSTAInfoDuration subfield indicates the amount of time that the PCP/AP expects to take to transmit information about associated STAs and is specified in number of beacon intervals. While associated with a PCP/AP, a STA overrides the value of its local dot11BroadcastSTAInfoDuration MIB variable with the value of this field when it receives this element from its PCP/AP.

The AssocRespConfirmTime subfield indicates the amount of time that the PCP/AP expects to take to respond to association requests and is specified in milliseconds. While associated with a PCP/AP, a STA overrides the value of its local dot11AssocRespConfirmTime MIB variable with the value of this field when it receives this element from its PCP/AP.

The MinPPDuration subfield indicates the minimum duration of the PP and GP as part of the dynamic allocation of service period mechanism and is specified in microseconds. While associated with a PCP/AP, a STA overrides the value of its local dot11MinPPDuration MIB variable with the value of this field when it receives this element from its PCP/AP.

The SPIdleTimeout subfield indicates time during which a STA expects to receive a frame from its peer STA and is specified in microseconds. While associated with a PCP/AP, a STA overrides the value of its local dot11SPIdleTimeout variable with the value of this field when it receives this element from its PCP/AP.

The MaxLostBeacons field contains the value of the dot11MaxLostBeacons attribute. While associated with a PCP/AP, a STA overrides the value of its local dot11MaxLostBeacons attribute with the value of this field when it receives this element from its PCP/AP.

8.4.2.132 DMG Beam Refinement element

The DMG Beam Refinement element is defined as shown in Figure 8-401v.

	B0 B7	B8 B15	B16	B17	B18	B19	B20
	Element ID	Length	Initiator	TX-train-response	RX-train-response	TX-TRN-OK	TXSS-FBCK-REQ
Bits:	8	8	1	1	1	1	1

	B21 B26	B27 B28	B29 B33	B34 B51	B52	B53	B54 B55
	BS-FBCK	BS-FBCK Antenna ID	FBCK-REQ	FBCK-TYPE	MID Extension	Capability Request	Reserved
Bits:	6	2	5	18	1	1	2

Figure 8-401v—DMG Beam Refinement element format

The Element ID field is equal to the value for the DMG Beam Refinement, specified in Table 8-54.

The Length field is set to 5.

A value of 1 in the Initiator field indicates that the sender is the beam refinement initiator. Otherwise, this field is set to 0.

A value of 1 in the TX-train-response field indicates that this packet is the response to a TX training request. Otherwise, this field is set to 0.

A value of 1 in the RX-train-response field indicates that the packet serves as an acknowledgment for a RX training request. Otherwise, this field is set to 0.

A value of 1 in the TX-TRN-OK field confirms a previous training request received by a STA. Otherwise, this field is set to 0.

A value of 1 in the TXSS-FBCK-REQ field indicates a request for transmit sector sweep feedback.

The BS-FBCK field specifies the sector that resulted in the best receive quality in the last received BRP-TX packet. If the last received packet was not a BRP-TX packet, this field is set to 0. The determination of the best sector is implementation dependent.

The BS-FBCK Antenna ID field specifies the antenna ID corresponding to the sector indicated by the BF-FBCK field.

The FBCK-REQ field is defined in Figure 8-401w and is described in Table 8-183g.

	B29	B30	B31 B32	B33
	SNR Requested	Channel Measurement Requested	Number of Taps Requested	Sector ID Order Requested
Bits:	1	1	2	1

Figure 8-401w—FBCK-REQ field format

Table 8-183g—FBCK-REQ field description

Field	Meaning
SNR Requested	If set to 1, the SNR subfield is requested as part of the channel measurement feedback. Otherwise, set to 0.
Channel Measurement Requested	If set to 1, the Channel Measurement subfield is requested as part of the channel measurement feedback. Otherwise, set to 0.
Number of Taps Requested	Number of taps in each channel measurement: 0x0 – 1 tap 0x1 – 5 taps 0x2 – 15 taps 0x3 – 63 taps
Sector ID Order Requested	If set to 1, the Sector ID Order subfield is requested as part of the channel measurement feedback. Otherwise, set to 0.

The FBCK-TYPE field is defined in Figure 8-401x and is described in Table 8-183h. When both N_{meas} and N_{beam} in this field are equal to 0, the Channel Measurement Feedback element is not present.

	B34	B35	B36	B37 B38	B39 B45	B46	B47 B51
	SNR Present	Channel Measurement Present	Tap Delay Present	Number of Taps Present	Number of Measurements	Sector ID Order Present	Number of Beams
Bits:	1	1	1	2	7	1	5

Figure 8-401x—FBCK-TYPE field format

Table 8-183h—FBCK-TYPE field description

Field	Meaning
SNR Present	Set to 1 to indicate that the SNR subfield is present as part of the channel measurement feedback. Set to 0 otherwise.
Channel Measurement Present	Set to 1 to indicate that the Channel Measurement subfield is present as part of the channel measurement feedback. Set to 0 otherwise.
Tap Delay Present	Set to 1 to indicate that the Tap Delay subfield is present as part of the channel measurement feedback. Set to 0 otherwise.
Number of Taps Present (N_{taps})	Number of taps in each channel measurement: 0x0 – 1 tap 0x1 – 5 taps 0x2 – 15 taps 0x3 – 63 taps
Number of Measurements (N_{meas})	Number of measurements in the SNR subfield and the Channel Measurement subfield. It is equal to the number of TRN-T subfields in the BRP-TX packet on which the measurement is based, or the number of received sectors if TXSS result is reported by setting TXSS-FBCK-REQ to 1.
Sector ID Order Present	Set to 1 to indicate that the Sector ID Order subfield is present as part of the channel measurement feedback. Set to 0 otherwise.
Number of Beams (N_{beam})	For the MIDC with multiple sector ID (MID) subphase only, indicates the number of sectors that the responder/initiator transmits during the MID subphase. Otherwise, indicates the number of beams in the Sector ID Order subfield for the MIDC subphase with the direction and the TX/RX antenna identification. The 1st bit is set to 0 for the initiator link and to 1 for the responder link. The 2nd bit is set to 0 for the transmitter antenna and to 1 for the receiver antenna. The 3rd to 5th bits represent the number of beams for beam combining. E.g. “01101” stands for $N_{beam}^{(I, RX)} = 5$.

A value of 1 in the MID Extension field indicates the intention to continue transmitting BRP-RX packets during the MID subphases. Otherwise, this field is set to 0.

A value of 1 in the Capability Request field indicates that the transmitter of the frame requests the intended receiver to respond with a BRP frame that includes the BRP Request field. Otherwise, this field is set to 0.

8.4.2.133 Wakeup Schedule element

The Wakeup Schedule element is defined in Figure 8-401y.

	Element ID	Length	BI Start Time	Sleep Cycle	Number of Awake/Doze BIs
Octets:	1	1	4	2	2

Figure 8-401y—Wakeup Schedule element format

The Element ID field is equal to the value for the Wakeup Schedule, specified in Table 8-54.

The Length field is set to 8.

The BI Start Time field indicates the lower order 4 octets of the TSF timer at the start of the next Awake BI.

The Sleep Cycle field indicates the non-PCP STA sleep cycle duration in beacon intervals, i.e., the sum of Awake BIs and Doze BIs that make up the sleep cycle. The Sleep Cycle field value can only be a power of two. Other values are reserved.

The Number of Awake/Doze BIs field indicates the number of Awake BIs at the beginning of each sleep cycle.

8.4.2.134 Extended Schedule element

The Extended Schedule element is formatted as illustrated in Figure 8-401z. Because the length parameter supports only 255 octets of payload in an element, the PCP/AP can split the Allocation fields into more than one Extended Schedule element entry in the same DMG Beacon or Announce frame. Despite this splitting, the set of Extended Schedule element entries conveyed within a DMG Beacon and Announce frame is considered to be a single schedule for the beacon interval, and in this standard referred to simply as Extended Schedule element unless otherwise noted. The Allocation fields are ordered by increasing allocation start time with allocations beginning at the same time arbitrarily ordered.

	Element ID	Length	Allocation 1	Allocation 2	…	Allocation n
Octets:	1	1	15	15	…	15

Figure 8-401z—Extended Schedule element format

The Element ID field is equal to the value for the Extended Schedule, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The Allocation field is formatted as illustrated in Figure 8-401aa.

	Allocation Control	BF Control	Source AID	Destination AID	Allocation Start	Allocation Block Duration	Number of Blocks	Allocation Block Period
Octets:	2	2	1	1	4	2	1	2

Figure 8-401aa—Allocation field format

The Allocation Control field is defined in Figure 8-401ab.

	B0 B3	B4 B6	B7	B8	B9	B10	B11	B12 B15
	Allocation ID	Allocation Type	Pseudo-static	Truncatable	Extendable	PCP Active	LP SC Used	Reserved
Bits:	4	3	1	1	1	1	1	4

Figure 8-401ab—Allocation Control field format

The Allocation ID field, when set to a nonzero value, identifies an airtime allocation from Source AID to Destination AID. Except for CBAP allocations with broadcast Source AID and broadcast Destination AID, the tuple (Source AID, Destination AID, Allocation ID) uniquely identifies the allocation. For CBAP allocations with broadcast Source AID and broadcast Destination AID, the Allocation ID is zero.

The AllocationType field defines the channel access mechanism during the allocation, with possible values listed in Table 8-183i.

Table 8-183i—AllocationType field values

Bit 4	Bit 5	Bit 6	Meaning
0	0	0	SP allocation
1	0	0	CBAP allocation
All other combinations			Reserved

The Pseudo-static field is set to 1 to indicate that this allocation is pseudo-static (9.33.6.4) and set to 0 otherwise.

For an SP allocation, the Truncatable field is set to 1 to indicate that the source DMG STA and destination DMG STA can request SP truncation and set to 0 otherwise. For a CBAP allocation, the Truncatable field is reserved.

For an SP allocation, the Extendable field is set to 1 to indicate that the source DMG STA and destination DMG STA can request SP extension and set to 0 otherwise. For a CBAP allocation, the Extendable field is reserved.

The PCP Active field is set to 1 if the PCP is available to receive transmissions during the CBAP or SP allocation and set to 0 otherwise. The PCP Active field is set to 1 if at least one of the Truncatable or Extendable fields are set to 1, or when transmitted by an AP.

The BF Control field is defined in 8.4a.5.

The Source AID field is set to the AID of the STA that initiates channel access during the SP or CBAP allocation or, in the case of a CBAP allocation, can also be set to the broadcast AID if all STAs are allowed to initiate transmissions during the CBAP allocation.

The Destination AID field indicates the AID of a STA that is expected to communicate with the source DMG STA during the allocation or broadcast AID if all STAs are expected to communicate with the source DMG STA during the allocation. The broadcast AID asserted in the Source AID and the Destination AID fields for an SP allocation indicates that during the SP a non-PCP/non-AP STA does not transmit unless it receives a Poll or Grant frame from the PCP/AP.

The Allocation Start field contains the lower 4 octets of the TSF at the time the SP or CBAP starts. The Allocation Start field can be specified at a future beacon interval when the pseudo-static field is set to 1.

The Allocation Block Duration field indicates the duration, in microseconds, of a contiguous time block for which the SP or CBAP allocation is made and cannot cross beacon interval boundaries. Possible values range from 1 to 32 767 for an SP allocation and 1 to 65 535 for a CBAP allocation.

The Number of Blocks field contains the number of time blocks making up the allocation.

The Allocation Block Period field contains the time, in microseconds, between the start of two consecutive time blocks belonging to the same allocation. The Allocation Block Period field is reserved when the Number of Blocks field is set to 1.

The LP SC Used subfield is set to 1 to indicate that the low-power SC PHY described in 21.7 is used in this SP. Otherwise, it is set to 0.

8.4.2.135 STA Availability element

The STA Availability element is used by a non-PCP/non-AP STA to inform a PCP/AP about the STA availability during the subsequent CBAPs (9.33.5) and to indicate participation in the Dynamic allocation of service periods (9.33.7). The PCP/AP uses the STA Availability element to inform the non-PCP/non-AP STAs of other STAs availability during subsequent CBAPs and participation of other STAs in the Dynamic allocation of service periods.

The format of the STA Availability element is illustrated in Figure 8-401ac.

	Element ID	Length	STA Info 1	…	STA Info n
Octets:	1	1	2	…	2

Figure 8-401ac—STA availability element format

The Element ID field is equal to the value for the STA Availability, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The format of the STA Info field is shown in Figure 8-401ad.

	B0 B7	B8	B9	B10 B15
	AID	CBAP	PP Available	Reserved
Bits:	8	1	1	6

Figure 8-401ad—STA Info field format

The AID field contains the AID of the STA for which availability is indicated.

The CBAP field is set to 1 to indicate that the STA is available to receive transmissions during CBAPs and set to 0 otherwise.

The PP Available field is set to 1 to indicate that the STA is available during PPs (9.33.7) and is set to 0 otherwise.

8.4.2.136 DMG TSPEC element

The DMG TSPEC element is present in the ADDTS Request frame sent by a non-PCP/non-AP DMG STA and contains the set of parameters needed to create or modify an airtime allocation. The DMG TSPEC element is also present in the ADDTS Response frame sent by a DMG PCP/AP and reflects the parameters, possibly modified, by which the allocation was created. The format of the DMG TSPEC element is shown in Figure 8-401ae.

	Element ID	Length	DMG Allocation Info	BF Control	Allocation Period
Octets:	1	1	3	2	2

	Minimum Allocation	Maximum Allocation	Minimum Duration	Number of Constraints	TSCONST
Octets:	2	2	2	1	Variable

Figure 8-401ae—DMG TSPEC element format

The Element ID field is equal to the value for the DMG TSPEC, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The DMG Allocation Info field is formatted as shown in Figure 8-401af.

	B0 B3	B4 B6	B7	B8	B9
	Allocation ID	AllocationType	Allocation Format	Pseudo-static	Truncatable
Bits:	4	3	1	1	1

	B10	B11	B12 B14	B15 B22	B23
	Extendable	LP SC Used	UP	Destination AID	Reserved
Bits:	1	1	3	8	1

Figure 8-401af—DMG Allocation Info field format

The Allocation ID field identifies an allocation if set to a nonzero value, and is used as follows:

— The STA that transmits an ADDTS Request containing the DMG TSPEC element sets the Allocation ID to a nonzero value to create a new allocation or modify an existing allocation.

— The STA that transmits an ADDTS Response containing the DMG TSPEC element sets the Allocation ID to a nonzero value to identify a created or modified allocation or sets it to zero if creating or modifying the allocation failed.

The AllocationType field defines the channel access mechanism used during the allocation, with values listed in Table 8-183i.

The Allocation Format field values are listed in Table 8-183j.

Table 8-183j—Allocation Format values

Allocation format value	Description
1	Isochronous allocation format
0	Asynchronous allocation format

The Pseudo-static field is set to 1 for a pseudo-static allocation and set to 0 otherwise.

For an SP allocation, the Truncatable field is set to 1 if the STA expects to truncate the SP, as described in 9.33.8. If the STA does not expect to truncate the SP, the Truncatable field is set to 0. The field is reserved for CBAP allocations.

For an SP allocation, the Extendable field is set to 1 if the STA expects to extend the SP, as described in 9.33.9. If the STA does not expect to extend the SP, the Extendable field is set to 0. The field is reserved for CBAP allocations.

The LP SC Used field is defined in 8.4.2.134.

The UP field indicates the lowest priority UP to be used for possible transport of MSDUs belonging to TCs with the same source and destination of the allocation.

The Destination AID field contains the AID of a STA that the requesting STA wishes to communicate with during the allocation.

The BF Control field is defined in 8.4a.5.

The Allocation Period is specified as a fraction or multiple of the beacon interval (BI) as defined in Table 8-183k.

Table 8-183k—Allocation Period values

B0–B14	B15	Meaning
0	0	Reserved
0	1	Not periodic or periodicity unknown
1–32 767	0	The allocation period is a multiple of the BI, i.e., allocation period = n x BI where n is the value represented by B0–B14
1–32 767	1	The allocation period is a fraction of the BI, i.e., allocation period = BI/n where n is the value represented by B0–B14.

For isochronous allocation format requests the Allocation Period, Minimum Allocation and Maximum Allocation fields are set as follows:

- The Allocation Period field indicates the period over which the allocation repeats.
- The Minimum Allocation field is set to the minimum acceptable allocation in microseconds in each allocation period.
- The Maximum Allocation field is set to the desired allocation in microseconds in each allocation period.

For asynchronous allocation format requests the Maximum Allocation field is reserved, and the Allocation Period and Minimum Allocation fields are set as follows:

— The Allocation Period field indicates the period over which the minimum allocation applies. The Allocation Period is an integral multiple of the beacon interval.
— The Minimum Allocation field specifies the minimum allocation in microseconds that the STA expects within the allocation period.

The Minimum Duration field specifies the minimum acceptable duration in microseconds. Possible values range from 1 to 32 767 for an SP allocation and 1 to 65 535 for a CBAP allocation. A value of 0 indicates no minimum specified.

The Number of Constraints field indicates the number of TSCONST fields contained in the element. The value of this field ranges from 0 to 15. Other values are reserved.

The Traffic Scheduling Constraint (TSCONST) field contains one or more Constraint subfields as illustrated in Figure 8-401ag.

	One or more Constraint subfields
Octets:	Variable

Figure 8-401ag—Traffic Scheduling Constraint field format

The Constraint subfield is defined as illustrated in Figure 8-401ah.

	TSCONST Start Time	TSCONST Duration	TSCONST Period	Interferer MAC address
Octets:	4	2	2	6

Figure 8-401ah—Constraint subfield format

The TSCONST Start Time field contains the lower 4 octets of the TSF at the time the scheduling constraint starts.

The TSCONST Duration field indicates the time, in microseconds, for which the scheduling constraint is specified.

The TSCONST Period field is specified as a fraction or multiple of the beacon interval (BI) as defined in Table 8-183l. This field is used to indicate a periodic scheduling constraint by specifying the temporal gap between two consecutive scheduling constraints.

Table 8-183l—TSCONST Period values

B0–B14	B15	Meaning
0	0	Reserved
0	1	Not periodic or periodicity unknown
1–32 767	0	The TSCONST period is a multiple of the BI, i.e., TSCONST period = n x BI where n is the value represented by B0–B14.
1–32 767	1	The TSCONST period is a fraction of the BI, i.e., TSCONST period = BI/n where n is the value represented by B0–B14.

The Interferer MAC Address field is set to the value of the TA field within a frame received during the interval of time indicated by this TSCONST field. If the value is unknown, the Interferer MAC Address field is set to the broadcast MAC address.

8.4.2.137 Next DMG ATI element

The Next DMG ATI element indicates the earliest start time for the next ATI in a subsequent beacon interval. See Figure 8-401ai.

	Element ID	Length	Start Time	ATI Duration
Octets:	1	1	4	2

Figure 8-401ai—Next DMG ATI element format

The Element ID field is equal to the value for the Next DMG ATI, specified in Table 8-54.

The Length field is set to 6.

The Start Time field contains the low-order 4 octets of the TSF for the earliest time at which the next ATI in a subsequent beacon interval starts.

The ATI Duration field contains the duration, in microseconds, of the next ATI in a subsequent beacon interval.

8.4.2.138 Channel Measurement Feedback element

The Channel Measurement Feedback element is used to carry the channel measurement feedback data that the STA has measured on the TRN-T fields of the BRP packet that contained the Channel Measurement request, to provide a list of sectors identified during a sector sweep, or during beam combination (9.35.6.3). The format and size of the Channel Measurement Feedback element are defined by the parameter values specified in the accompanying DMG Beam Refinement element.

The Channel Measurement Feedback element, as shown in Table 8-183m, is composed of 4 subfields: the SNR subfield, the Channel Measurement subfield, the Tap Delay subfield, and the Sector ID Order subfield.

Table 8-183m—Channel Measurement Feedback element format

Field	Size		Meaning
Element ID	8 bits		
Length	8 bits		
SNR	SNR_1	8 bits	SNR as measured in the first TRN-T field or at the first sector from which SSW frame is received.
	SNR_2	8 bits	SNR as measured in the second TRN-T field or at the second sector from which SSW frame is received.
	⋮		
	$SNR_{N_{meas}}$	8 bits	SNR as measured in the N_{meas} TRN-T field or at sector N_{meas} from which SSW frame is received.

Table 8-183m—Channel Measurement Feedback element format *(continued)*

Field	Size		Meaning
Channel Measurement	Channel Measurement 1	N_{taps}×16 bits	Channel measurement for the first TRN-T field
	Channel Measurement 2	N_{taps}×16 bits	Channel measurement for the second TRN-T field
	⋮		
	Channel Measurement N_{meas}	N_{taps}×16 bits	Channel measurement for the N_{meas} TRN-T field
Tap Delay	Relative Delay Tap #1	8 bits	The delay of Tap #1 in units of Tc relative to the path with the shortest delay detected.
	Relative Delay Tap #2	8 bits	The delay of Tap #2 in units of Tc relative to the path with the shortest delay detected.
	⋮		
	Relative Delay Tap #N_{taps}	8 bits	The delay of Tap #N_{taps} in units of Tc relative to the path with the shortest delay detected.
Sector ID Order	Sector ID_1	6 bits	Sector ID for SNR_1 being obtained, or sector ID of the first detected beam.
	Antenna ID_1	2 bits	Antenna ID corresponding to Sector ID_1.
	Sector ID_2	6 bits	Sector ID for SNR_2 being obtained, or sector ID of the second detected beam.
	Antenna ID_2	2 bits	Antenna ID corresponding to Sector ID_2.
	⋮		
	Sector ID_{Nmeas} or Sector ID_{Nbeam}	6 bits	Sector ID for SNR_{Nmeas} being obtained, or sector ID of the detected beam *Nbeam*.
	Antenna ID_{Nmeas} or Antenna ID_{Nbeam}	2 bits	Antenna ID corresponding to Sector ID_{Nmeas} or Sector ID_{Nbeam}

The Element ID field is equal to the value for the Channel Measurement Feedback, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The number of channel/SNR measurements reported, N_{meas}, is equal to the number of TRN-T subfields that were appended to the packet on which the measurements were performed. If the measurement reports the result of an SLS or of an MID, it is equal to the number of frames received during the sector sweep, or the number of packets used during the MID subphase.

The SNR subfield levels are unsigned integers referenced to a level of –8 dB. Each step is 0.25 dB. SNR values less than or equal to –8 dB are represented as 0. SNR values greater than or equal to 55.75 dB are represented as 0xFF.

The format of each channel measurement is specified in Table 8-183n.

Table 8-183n—Channel measurement

Field	Size	Meaning
Relative I Component Tap #1	8 bits	The in-phase component of impulse response for Tap #1, relative to the amplitude of the strongest tap measured.
Relative Q Component Tap #1	8 bits	The quadrature component of impulse response for Tap #1, relative to the amplitude of the strongest tap measured.
Relative I Component Tap #2	8 bits	The in-phase component of impulse response for Tap #2, relative to the amplitude of the strongest tap measured.
Relative Q Component Tap #2	8 bits	The quadrature component of impulse response for Tap #2, relative to the amplitude of the strongest tap measured.
⋮		
Relative I Component Tap #N_{taps}	8 bits	The in-phase component of impulse response for Tap #N_{taps}, relative to the amplitude of the strongest tap measured.
Relative Q Component Tap #N_{taps}	8 bits	The quadrature component of impulse response for Tap #N_{taps}, relative to the amplitude of the strongest tap measured.

Each channel measurement contains N_{taps} channel impulse taps. The channel impulse response reported for all N_{meas} measurements correspond to a common set of relative tap delays. If the Tap Delay subfield is not present, then the N_{taps} channel taps is interpreted as contiguous time samples, separated by Tc. The delay values in the Tap Delay subfield, when present, correspond to the strongest taps and are unsigned integers, in increments of Tc, starting from 0. Each channel tap is reported as an in-phase and quadrature component pair, with each component value represented as a twos complement number between –128 and 127. Unless all in-phase and quadrature component values are reported as zero, they are scaled such that the two most significant bits for at least one of the component values equal 01 or 10 (binary).

The Sector ID Order subfield indicates the TX sector IDs corresponding to the SNRs in the SNR subfield when the SNR Present subfield is set to 1 and Sector ID Order Present subfield is set to 1, in response to a BRP packet with the SNR Requested subfield set to 1. The Sector ID Order subfield indicates the TX sector IDs ranked in the decreasing order of link quality, determined in an implementation dependent manner, when the SNR Present subfield is set to 0 and the Sector ID Order Present subfield is set to 1 in response to setting the SNR Requested subfield to 0 and the Sector ID Order Requested subfield to 1. The FBCK-REQ field and the FBCK TYPE field in the DMG Beam Refinement element are used by the transmitter and receiver to, respectively, request for and indicate the Sector IDs and their order.

8.4.2.139 Awake Window element

The Awake Window element is defined as shown in Figure 8-401aj.

	Element ID	Length	Awake Window
Octets:	1	1	2

Figure 8-401aj—Awake Window element format

The Element ID field is equal to the value for the Awake Window, specified in Table 8-54.

The Length field is set to 2.

The Awake Window field is 2 octets and contains the length of the Awake Window measured in microseconds.

8.4.2.140 Multi-band element

The Multi-band element indicates that the STA transmitting this element (the transmitting STA) is within a multi-band device capable of operating in a frequency band or operating class or channel other than the one in which this element is transmitted and that the transmitting STA is able to accomplish a session transfer from the current channel to a channel using another STA in the same device, in the other or same band. The format of the Multi-band element is shown in Figure 8-401ak.

	Element ID	Length	Multi-band Control	Band ID	Operating Class	Channel Number	BSSID	Beacon Interval
Octets:	1	1	1	1	1	1	6	2

	TSF Offset	Multi-band Connection Capability	FSTSessionTimeOut	STA MAC Address (optional)	Pairwise Cipher Suite Count (optional)	Pairwise Cipher Suite List (optional)
Octets:	8	1	1	6	2	4×m

Figure 8-401ak—Multi-band element format

The Element ID field is equal to the value for the Multi-band, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The format of the Multi-band Control field is shown in Figure 8-401al.

	B0 B2	B3	B4	B5 B7
	STA Role	STA MAC Address Present	Pairwise Cipher Suite Present	Reserved
Bits:	3	1	1	3

Figure 8-401al—Multi-band Control field format

The STA Role field specifies the role the transmitting STA plays on the channel of the operating class indicated in this element. The possible values of the STA Role field are indicated in Table 8-183o. If the STA Role field is set to IBSS STA, the BSSID field contains the BSSID of the IBSS.

NOTE—A STA can perform in more than one role in a channel, and the STA Role field identifies the role that is most relevant for the STA for that channel.

Table 8-183o—STA Role field values

STA role	Value
AP	0
TDLS STA	1
IBSS STA	2
PCP	3

Table 8-183o—STA Role field values *(continued)*

STA role	Value
Non-PCP Non-AP STA	4
Reserved	5–7

The STA MAC Address Present field indicates whether the STA MAC Address field is present in the Multi-band element. If the present field is set to 1, the STA MAC Address field is present. If the present field is set to 0, the STA MAC Address field is not present.

The Pairwise Cipher Suite Present field indicates whether the Pairwise Cipher Suite Count field and the Pairwise Cipher Suite List field are present in the Multi-band element. If the present field is set to 1, the Pairwise Cipher Suite Count field and the Pairwise Cipher Suite List field are present. If the present field is set to 0, the Pairwise Cipher Suite Count field and the Pairwise Cipher Suite List field are not present.

The Band ID field provides the identification of the frequency band related to the Operating Class and Channel Number fields. The Band ID field is defined in 8.4.1.45.

Operating Class indicates the channel set for which the Multi-band element applies. Operating Class and Channel Number together specify the channel frequency and spacing for which the Multi-band element applies. Valid values of Operating Class are shown in Annex E. This field is set to 0 to indicate all operating classes within the frequency band specified by the value of the Band ID field.

The Channel Number field is set to the number of the channel the transmitting STA is operating on or intends to operate on. This field is set to 0 to indicate all channels within the frequency band specified by the value of the Band ID field.

The BSSID field specifies the BSSID of the BSS operating on the channel and frequency band indicated by the Channel Number and Band ID fields.

The Beacon Interval field specifies the size of the beacon interval for the BSS operating on the channel and frequency band indicated by the Channel Number and Band ID fields. This field is set to 0 if no BSS is in operation in the indicated channel and frequency band.

If the transmitting STA is a member of a PBSS or infrastructure BSS on both the channel indicated in this element and the channel on which the element is transmitted, then the TSF Offset field contains the time offset of the TSF of the PBSS or infrastructure BSS of which the transmitting STA is member on the channel indicated in this element relative to the TSF of the PBSS or infrastructure BSS corresponding to the BSSID indicated in the Address 3 field of the MPDU in which this element is transmitted. The value of the TSF Offset field is specified as a twos complement integer in microsecond units. If the transmitting STA is not a member of an infrastructure BSS or PBSS on both the channel indicated in this element and the channel on which the element is transmitted, then the TSF Offset field contains the value 0.

The Multi-band Connection Capability field is defined in Figure 8-401am. The Multi-band Connection Capability field indicates the connection capabilities supported by the STA on the channel and band indicated in this element.

	B0	B1	B2	B3	B4	B5 B7
	AP	PCP	DLS	TDLS	IBSS	Reserved
Bits:	1	1	1	1	1	3

Figure 8-401am—Multi-band Connection Capability field format

The AP field specifies whether the STA can function as an AP on the channel and band indicated in the element. It is set to 1 when the STA is capable to function as an AP, and it is set to 0 otherwise.

The PCP field specifies whether the STA can function as a PCP on the channel and band indicated in the element. It is set to 1 when the STA is capable to function as a PCP, and it is set to 0 otherwise.

The DLS field is set to 1 to indicate that the STA can perform a DLS on the channel and band indicated in the element. Otherwise, it is set to 0.

The TDLS field is set to 1 to indicate that the STA can perform a TDLS on the channel and band indicated in the element. Otherwise, it is set to 0.

The IBSS field is set to 1 to indicate that the STA is able to support IBSS on the channel and band indicated in the element. Otherwise, it is set to 0.

The FSTSessionTimeOut field is used in the FST Setup Request frame to indicate the timeout value for FST session setup protocol as defined in 10.32.1. The FSTSessionTimeOut field contains the duration, in TUs, after which the FST setup is terminated.

The STA MAC Address field contains the MAC address that the transmitting STA uses while operating on the channel indicated in this element. The STA MAC Address field is not present in this element if the STA MAC Address Present field is set to 0.

The Pairwise Cipher Suite Count field and the Pairwise Cipher Suite List field are defined in 8.4.2.27. These fields are not present in this element if the Pairwise Cipher Suite Present field is set to 0.

8.4.2.141 ADDBA Extension element

The ADDBA Extension element is shown in Figure 8-401an.

	Element ID	Length	ADDBA Capabilities
Octets:	1	1	1

Figure 8-401an—ADDBA Extension element format

The Element ID field is equal to the value for the ADDBA Extension, specified in Table 8-54.

The Length field is set to 1.

The ADDBA Capabilities field is shown in Figure 8-401ao.

	B0	B1 B7
	No-Fragmentation	Reserved
Bits:	1	7

Figure 8-401ao—ADDBA Capabilities field format

ADDBA Extension element can be included in the ADDBA Request and Response action frames. The ADDBA Request or ADDBA Response or both can contain the element.

The No-Fragmentation field determines whether a fragmented MSDU can be carried in the MPDU sent under the Block Ack agreement. When this field set to 1 in the ADDBA Request frame, it indicates that the originator is not fragmenting sent MSDUs. When this field set to 1 in the ADDBA Response frame, it indicates that the recipient is not capable of receiving fragmented MSDUs.

8.4.2.142 Next PCP List element

The Next PCP List element contains one or more AID of NextPCP i fields as shown in Figure 8-401ap.

	Element ID	Length	Token	AID of NextPCP 1	…	AID of NextPCP n
Octets:	1	1	1	1	…	1

Figure 8-401ap—Next PCP List element format

The Element ID field is equal to the value for the Next PCP List, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The Token field is set to 0 when the PBSS is initialized and incremented each time the NextPCP List is updated.

Each AID of NextPCP i field contains the AID value of a STA. The AID values are listed in the order described in 10.28.2.

8.4.2.143 PCP Handover element

The PCP Handover element is used to indicate which STA becomes the new PCP following an explicit or implicit handover procedure. The PCP Handover element is defined in Figure 8-401aq.

	Element ID	Length	Old BSSID	New PCP Address	Remaining BIs
Octets:	1	1	6	6	1

Figure 8-401aq—PCP Handover element format

The Element ID field is equal to the value for the PCP Handover, specified in Table 8-54.

The Length field is set to 13.

The Old BSSID field contains the BSSID of the PBSS from which control is being handed over.

The New PCP Address field indicates the MAC address of the new PCP following a handover.

The Remaining BIs field indicates the number of beacon intervals, from the beacon interval in which this element is transmitted, remaining until the handover takes effect.

8.4.2.144 DMG Link Margin element

8.4.2.144.1 General

The format of the DMG Link Margin element is shown in Figure 8-401ar. The DMG Link Margin element is included in a Link Measurement Report frame.

	Element ID	Length	Activity	MCS	Link Margin	SNR	Reference Timestamp
Octets:	1	1	1	1	1	1	4

Figure 8-401ar—DMG Link Margin element format

The Element ID field is equal to the value for the DMG Link Margin, specified in Table 8-54.

The Length field is set to 8.

The Activity field is set to a preferred action that the STA sending this element recommends that the peer STA indicated in the RA field of the Link Measurement Report frame execute. The method by which the sending STA determines a suitable action for the peer STA is implementation specific. The Activity field is defined in 8.4.2.144.2.

The MCS field is set to an MCS value that the STA sending this element recommends that the peer STA indicated in the RA field of the Link Measurement Report frame use to transmit frames to this STA. The reference PER for selection of the MCS is 10^{-2} for an MPDU length of 4096 octets. The method by which the sending STA determines a suitable MCS for the peer STA is implementation specific.

The Link Margin field contains the measured link margin of data frames received from the peer STA indicated in the RA field of the Link Measurement Report frame and is coded as a twos complement signed integer in units of decibels. A value of –128 indicates that no link margin is provided. The measurement method of link margin is beyond the scope of this standard.

The SNR field indicates the SNR measured during the reception of a PHY packet. Values are from –13 dB to 50.75 dB in 0.25 dB steps.

The Reference Timestamp field contains the lower 4 octets of the TSF timer value sampled at the instant that the MAC received the PHY-CCA.indication(IDLE) signal that corresponds to the end of the reception of the PPDU that was used to generate the feedback information contained in the Link Measurement Report frame.

8.4.2.144.2 Activity field

The Activity field values are defined in Table 8-183p.

Table 8-183p—Activity field values

Preferred Action value	Meaning
0	No change preferred
1	Change(d) MCS

Table 8-183p—Activity field values *(continued)*

Preferred Action value	Meaning
2	Decrease(d) transmit power
3	Increase(d) transmit power
4	Fast session transfer (FST)
5	Power conserve mode
6	Perform SLS
7–255	Reserved

8.4.2.145 DMG Link Adaptation Acknowledgment element

The format of the DMG Link Adaptation Acknowledgment element is shown in Figure 8-401as. The DMG Link Adaptation Acknowledgment element is carried in the Optional Subelements field of the Link Measurement Report frame.

	Element ID	Length	Activity	Reference Timestamp
Octets:	1	1	1	4

Figure 8-401as—DMG Link Adaptation Acknowledgment element format

The Element ID field is equal to the value for the DMG Link Adaptation Acknowledgment, specified in Table 8-54.

The Length field is set to 5.

The Activity field is set to the action that the STA sending this element has executed following the reception of the recommended activity in a Link Measurement Report frame. The method by which the sending STA determines the action is described in 9.37 and the Activity field is defined in 8.4.2.144.2.

The Reference Timestamp field contains the lower 4 octets of the TSF timer value sampled at the instant that the MAC received the PHY-CCA.indication(IDLE) signal that corresponds to the end of the reception of the PPDU that was used to generate the feedback information contained in the Link Measurement Report frame.

8.4.2.146 Switching Stream element

The Switching Stream element indicates the streams that the transmitting STA requests to be switched to a new frequency band or operating class or channel. The format of the Stream Switching element is shown in Figure 8-401at.

	Element ID	Length	Old Band ID	New Band ID	Non-QoS Data Frames	Number of Streams Switching	Switching Parameters
Octets:	1	1	1	1	1	1	2 × Number of Streams Switching

Figure 8-401at—Switching Stream element format

The Element ID field is equal to the value for the Switching Stream, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The Old Band ID field specifies the frequency band to which the information carried in this element is related. This field is defined in 8.4.1.45.

The New Band ID field specifies the frequency band to which the information contained in the Stream ID in New Band subfield of this element is related. This field is defined in 8.4.1.45.

The Non-QoS Data Frames field specifies whether non-QoS data frames can be transmitted in the frequency band indicated in the New Band ID field. If the Non-QoS Data Frames field is set to 0, non-QoS data frames cannot be transmitted in the frequency band indicated in the New Band ID field. If the Non-QoS Data Frames field is set to 1, non-QoS data frames can be transmitted in the frequency band indicated in the New Band ID field.

The Number of Streams Switching field specifies the number of streams to be switched.

The format of Switching Parameters field is shown in Figure 8-401au.

	B0 B3	B4	B5 B8	B9	B10	B11	B12 B15
	Stream ID in Old Band		Stream ID in New Band		Stream ID in New Band Valid	LLT Type	Reserved
	TID	Direction	TID	Direction			
Bits:	4	1	4	1	1	1	4

Figure 8-401au—Switching parameters field format

The Stream ID in Old Band and Stream ID in New Band subfields are comprised of the TID and Direction subfields. The subfields within the Stream ID in New Band subfield are reserved if the Stream ID in New Band Valid subfield is set to 0.

The TID subfield specifies the stream in the corresponding band.

The Direction field specifies whether the STA transmitting this element is the source or destination of the corresponding TID. It is set to 0 to indicate that the STA transmitting this element is the source of the TID, and it is set to 1 otherwise.

The Stream ID in New Band Valid subfield is set to 1 if the information contained in the Stream ID in New Band subfield is valid, that is, the TID specified within the Stream ID in New Band subfield has been established in the band identified in the New Band ID field. The Stream ID in New Band Valid subfield is set to 0 otherwise.

The LLT Type field is set to 1 to indicate that the stream-based Link Loss Countdown is used for the stream identified by the Stream ID in Old Band subfield. The LLT Type field is set to 0 to indicate that the STA-based Link Loss Countdown is used for the stream identified by the Stream ID in Old Band subfield. This field is reserved when the LLT field within the FST Setup Request or FST Setup Response frame containing this element is set to 0.

8.4.2.147 Session Transition element

The Session Transition element is formatted as illustrated in Figure 8-401av.

	Element ID	Length	FSTS ID	Session Control	New Band			Old Band		
					Band ID	Setup	Operation	Band ID	Setup	Operation
Octets:	1	1	4	1	1	1	1	1	1	1

Figure 8-401av—Session Transition element format

The Element ID field is equal to the value for the Session Transition, specified in Table 8-54.

The Length field is set to 11.

The FSTS ID field contains the identification of the FST session established between a pair of STAs as allocated by the initiator (10.32).

The Session Control field is defined in Figure 8-401aw.

	B0 B3	B4	B5 B7
	Session Type	Switch Intent	Reserved
Bit:	4	1	3

Figure 8-401aw—Session Control field format

The Session Type field is defined as shown in Table 8-183q and indicates the type of connection/session that is intended to be set up in the new band for this FST session.

Table 8-183q—Session Type field format

Value	Session type
0	Infrastructure BSS
1	IBSS
2	DLS
3	TDLS
4	PBSS
5–255	Reserved

When the Session Type field is set to IBSS and the STA Role field within the Multi-band element is set to IBSS STA, the BSSID field within the Multi-band element contains the MAC address of the BSSID of the IBSS. This indicates that the transmitting STA is not associated with an AP on the band and channel indicated in the Multi-band element.

The Switch Intent field is set to 1 to indicate that the FST Initiator that transmitted the FST Setup Request frame intends to switch to the band/channel indicated within the Band ID field of the FST Setup Request frame and in the Multi-band element, even if the FST transition does not succeed. Otherwise, this field is set to 0. This field is reserved when transmitted within an FST Setup Response frame.

The New Band and Old Band fields are used for the signaling described in 10.32.1. Both the New Band and Old Band fields contain a Band ID subfield, a Setup subfield, and an Operation subfield.

The Band ID subfield is defined in 8.4.1.45. If a Multi-band element is present in the frame containing this Session Transition element, the Band ID subfield refers to the Operating Class and Channel Number fields within the Multi-band element provided the value of both of these fields are nonzero.

The Setup subfield is set to 1 to indicate that the STA transmitting this element has an FST session established with the STA that the frame containing this element is addressed and in the band indicated within the Band ID subfield. Otherwise, it is set to 0. Other values are reserved.

The Operation subfield is set to 1 to indicate that the STA is operating in the band indicated within the Band ID subfield. Otherwise, it is set to 0. Other values are reserved.

NOTE—A STA that is operating in a band/channel is not required to be continuously in the Awake state on that band/channel.

8.4.2.148 Dynamic Tone Pairing (DTP) Report element

The DTP Report element is included in the DTP Response frame. The format of the DTP Report element is shown in Table 8-183r.

Table 8-183r—DTP Report element format

Element ID	8 bits	
Length	8 bits	
GroupPairIndex(0)	6 bits	Index of DTP group pair *n* in the range of 0 to N_G-1, for n = 0,1,2,…,N_G-1 where N_G=42
GroupPairIndex(1)	6 bits	
…	…	
GroupPairIndex(N_G-1)	6 bits	
Zero pad	4 bits	Zero padding to make the DTP Feedback element length a multiple of 8 bits

The Element ID field is equal to the value for the DTP Report, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

GroupPairIndex(*n*) subfields for n=0,1,..,N_G-1(where N_G=42) indicate DTP groups, which in turn determines how pairs of SQPSK symbols are mapped to OFDM tones when DTP is enabled, as described in 21.5.3.2.4.6.3. Valid values of GroupPairIndex(*n*) are in the range of 0 to N_G-1. Furthermore valid values of GroupPairIndex(0), GroupPairIndex(1),…, GroupPairIndex(N_G-*1*) are distinct and therefore represent a permutation of integers 0 to N_G-1.

All numeric fields are encoded in unsigned binary, least significant bit first.

8.4.2.149 Cluster Report element

The format of the Cluster Report element is shown in Figure 8-401ax. The Cluster Report element is included in management action frames, such as the Announce and the Information Response frames, transmitted to the PCP/AP of the BSS. Because the Length field supports only 255 octets of payload in an element, the STA can split the content of the Extended Schedule Element field, as described in 8.4.2.134, in different Cluster Report elements. The value of *n* in Figure 8-401ax is equal to 255-(2 + sizeof(Reported BSSID field) + sizeof(Reference Timestamp field) + sizeof(Clustering Control field) + sizeof(ECPAC Policy Element field) + sizeof(TSCONST field)).

	Element ID	Length	Cluster Report Control	Reported BSSID	Reference Timestamp	Clustering Control
Octets:	1	1	1	0 or 6	0 or 4	0 or 8

	ECPAC Policy Element	Extended Schedule Element	Number of Constraints	Traffic Scheduling Constraint (TSCONST)
Octets:	0, 13 or 17	0 or 17-n	1	Variable

Figure 8-401ax—Cluster Report element format

The Element ID field is equal to the value for the Cluster Report, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The Cluster Report Control field is defined in Figure 8-401ay.

	B0	B1	B2	B3	B4	B5	B6 B7
	Cluster Request	Cluster Report	Schedule Present	TSCONST Present	ECPAC Policy Enforced	ECPAC Policy Present	Reserved
Bits:	1	1	1	1	1	1	2

Figure 8-401ay—Cluster Report Control field format

The Cluster Request subfield is set to 1 to indicate that the STA is requesting the PCP/AP to start PCP/AP clustering (9.34). Otherwise, it is set to 0.

The Cluster Report subfield is set to 1 to indicate that this element contains a cluster report. If this subfield is set to 1, the Reported BSSID, Reference Timestamp and Clustering Control fields are present in this element. Otherwise, if the Cluster Report subfield is set to 0, none of the Reported BSSID, Reference Timestamp, Clustering Control, Extended Schedule Element, and TSCONST fields is present in this element.

The Schedule Present subfield is valid only if the Cluster Report subfield is set to 1; otherwise, it is reserved. The Schedule present subfield is set to 1 to indicate that the Extended Schedule Element field is present in this element. Otherwise, the Extended Schedule Element field is not present in this element.

The TSCONST Present subfield is valid only if the Cluster Report subfield is set to 1; otherwise, it is reserved. The TSCONST Present subfield is set to 1 to indicate that the Number of Constraints field and the TSCONST field are present in this element. Otherwise, these fields are not present in this element.

The ECPAC Policy Enforced subfield is valid only if the Cluster Report subfield is set to 1; otherwise, it is reserved. The ECPAC Policy Enforced subfield is defined in 8.3.4.1 and contains the ECPAC Policy Enforced subfield received in the DMG Beacon frame that generated this report.

The ECPAC Policy Present subfield is valid only if the Cluster Report subfield is set to 1; otherwise, it is reserved. The ECPAC Policy Present subfield is set to 1 to indicate that the ECPAC Policy Present Element field is present in this element. Otherwise, the ECPAC Policy Present Element field is not present in this element.

The Reported BSSID field contains the BSSID of the DMG Beacon frame that triggered this report.

The Reference Timestamp field contains the lower 4 octets of the TSF timer value sampled at the instant that the STA's MAC received a DMG Beacon frame that triggered this report.

The Clustering Control field is defined in 8.3.4.1 and contains the Clustering Control received in the DMG Beacon that triggered this report.

The ECPAC Policy Element field is defined in 8.4.2.153 and contains the ECPAC Policy element obtained from the PCP/AP that sent the DMG Beacon frame that generated this report (see 9.34.4).

The Extended Schedule Element field is defined in 8.4.2.134 and contains a single Extended Schedule element received in the DMG Beacon that generated this report. If an Extended Schedule element is not present in the received DMG Beacon, this field is set to all zeros.

The Number of Constraints field indicates the number of TSCONST fields contained in the element. The value of this field ranges from 0 to 15. Other values are reserved.

The Traffic Scheduling Constraint (TSCONST) field is defined in 8.4.2.136 and specifies periods of time with respect to the TBTT of the beacon interval of the BSS the STA participates where the STA experiences poor channel conditions, such as due to interference.

8.4.2.150 Relay Capabilities element

A STA that intends to participate in relay operation (10.35) advertises its capabilities through the Relay Capabilities element. The Relay Capabilities element is defined in Figure 8-401az. The Relay Capabilities element is not used in an IBSS.

	Element ID	Length	Relay Capabilities Info
Octets:	1	1	2

Figure 8-401az—Relay capabilities element format

The Element ID field is equal to the value for the Relay Capabilities, specified in Table 8-54.

The Length field is set to 2.

The Relay Capabilities Info field is defined in Figure 8-401ba.

	B0	B1	B2	B3	B4	B5 B6	B7	B8 B15
	Relay Supportability	Relay Usability	Relay Permission	A/C Power	Relay Preference	Duplex	Cooperation	Reserved
Bits:	1	1	1	1	1	2	1	8

Figure 8-401ba—Relay Capabilities Info field format

The Relay Supportability field indicates whether the STA is capable of relaying by transmitting and receiving frames between a pair of other STAs. A STA capable of relaying is named “relay STA.” This field is set to 1 if the STA supports relaying; otherwise, it is set to 0.

The Relay Usability field indicates whether the STA is capable of using frame-relaying through a relay STA. It is set to 1 if the STA supports transmission and reception of frames through a relay STA; otherwise, it set to 0.

The Relay Permission field indicates whether the PCP/AP allows relay operation (10.35) to be used within the PCP/AP’s BSS. It is set to 0 if relay operation is not allowed in the BSS; otherwise, it is set to 1. This field is reserved when transmitted by a non-PCP/non-AP STA.

The A/C Power field indicates whether the STA is capable of obtaining A/C power. It is set to 1 if the STA is capable of being supplied by A/C power; otherwise, it is set to 0.

The Relay Preference field indicates whether the STA prefers to become RDS rather than REDS. It is set to 1 if a STA prefers to be RDS; otherwise, it is set to 0.

The Duplex field indicates whether the STA is capable of full-duplex/amplify-and-forward (FD-AF) or half-duplex/decode-and-forward (HD-DF). It is set to 1 if the STA is not capable of HD-DF but is capable of only FD-AF. It is set to 2 if the STA is capable of HD-DF but is not capable of FD-AF. It is set to 3 if the STA is capable of both HD-DF and FD-AF. The value 0 is reserved.

The Cooperation field indicates whether a STA is capable of supporting Link cooperating. It is set to 1 if the STA supports both Link cooperating type and Link switching type. It is set to 0 if a STA supports only Link switching or if the Duplex field is set to 1.

8.4.2.151 Relay Transfer Parameter Set element

A source REDS that intends to transfer frames via an RDS advertises the parameters for the relay operation with the transmission of a Relay Transfer Parameter Set element (10.35). The Relay Transfer Parameter Set element is defined in Figure 8-401bb.

	Element ID	Length	Relay Transfer Parameter
Octets:	1	1	8

Figure 8-401bb—Relay Transfer Parameter Set element format

The Element ID field is equal to the value for the Relay Transfer Parameter Set, specified in Table 8-54.

The Length field is set to 8.

The Relay Transfer Parameter field is defined in Figure 8-401bc.

	B0	B1	B2	B3 B7	B8 B15	B16 B23	B24 B39	B40 B55	B56 B63
	Duplex-Mode	Cooperation-Mode	Tx-Mode	Reserved	Link Change Interval	Data Sensing Time	First Period	Second Period	Reserved
Bits:	1	1	1	5	8	8	16	16	8

Figure 8-401bc—Relay Transfer Parameter field format

The Duplex-Mode subfield indicates that the source REDS set the duplex mode of the RDS involved in RLS. The Duplex-Mode subfield value is set to 0 if the RDS operates in HD-DF mode. It is set to 1 if the RDS operates in FD-AF mode.

The Cooperation-Mode subfield indicates whether the source REDS sets the link cooperating of the RDS involved in RLS. This subfield is valid only when the RDS is capable of link cooperating type and Duplex-Mode subfield is set to 0. Otherwise, this subfield is reserved. The Cooperation-Mode subfield value is set to 0 if the RDS operates in link switching type. It is set to 1 if the RDS operates in link cooperation type.

The Tx-Mode subfield indicates that the source REDS sets the transmission mode of the RDS involved in RLS. This subfield is valid only when the RDS is capable of link–switching type and Duplex-Mode subfield is set to 1. Otherwise, this subfield is reserved. The Tx-Mode subfield value is set to 0 if a group of three STAs involved in the RLS operates in Normal mode and is set to 1 if the group operates in Alternation mode.

The Link Change Interval subfield indicates when the link of frame transmission between source REDS and destination REDS is changed. From the start position of one reserved contiguous SP, every time instant of Link Change Interval can have an opportunity to change the link. Within one Link Change Interval, only one link is used for frame transfer. The unit of this field is microseconds. This subfield is used only when the group involved in the RLS operates in link switching type.

The Data Sensing Time subfield indicates the defer time offset from the time instant of the next Link Change Interval when the link switching occurs. By default, it is set to SIFS plus SBIFS. This subfield is used only when the STAs involved in the RLS operate in link switching with Tx-Mode that is 0.

The First Period subfield indicates the period of the source REDS-RDS link in which the source REDS and RDS exchange frames. This subfield is used only when HD-DF RDS operates in link switching type.

The Second Period subfield indicates the period of the RDS-destination REDS link in which the RDS and destination REDS exchange frames and the following period of the RDS-source REDS link in which the RDS informs the source REDS of finishing one frame transfer. This subfield is used only when HD-DF RDS operates in link switching type.

8.4.2.152 Quiet Period Request element

The Quiet Period Request element defines a periodic sequence of quiet intervals that the requester AP requests the responder AP to schedule. The format of the Quiet Period Request element is shown in Figure 8-401bd.

	Element ID	Length	Request Token	Quiet Period Offset	Quiet Period	Quiet Duration	Repetition Count	Target BSSID
Octets:	1	1	2	2	4	2	1	6

Figure 8-401bd—Quiet Period Request element format

The Element ID field is equal to the value for the Quiet Period Request, specified in Table 8-54.

The Length field is set to 17.

The Request Token field is set to a nonzero value chosen by the requester AP.

The Quiet Period Offset field is set to the offset of the start of the first quiet interval from the QAB Request frame that contains this element, expressed in TUs. The reference time is the start of the preamble of the PPDU that contains this element.

The Quiet Period field is set to the spacing between the start of two consecutive quiet intervals, expressed in TUs.

The Quiet Duration field is set to duration of the quiet time, expressed in TUs.

The Repetition Count field is set to the number of requested quiet intervals.

NOTE—The periodic sequence of quiet intervals ends after the start of preamble of the PPDU containing the QAB IE + Quiet Period Offset + (Repetition Count-1) × Quiet Period + Quiet Duration (in TUs).

The Target BSSID field is set to the responder AP's BSSID.

8.4.2.153 Quiet Period Response element

The Quiet Period Response element defines the feedback information from the AP that received the Quiet Period Request element. The format of the Quiet Period Response element is shown in Figure 8-401be.

	Element ID	Length	Request Token	BSSID	Status Code
Octets:	1	1	2	6	2

Figure 8-401be—Quiet Period Response element format

The Element ID field is equal to the value for the Quiet Period Response, specified in Table 8-54.

The Length field is set to 10.

The Request Token field value is copied from the corresponding received Quiet Period Request element.

The BSSID field value is copied of the Target BSSID field of the corresponding received Quiet Period Request element.

The Status Code field is defined in 8.4.1.9.

8.4.2.154 BeamLink Maintenance element

The format of the BeamLink Maintenance element is shown in Figure 8-401bf. The BeamLink Maintenance element is included in management action frames, such as the Probe, Announce and the Information Request and Response frames, transmitted between non-PCP/non-AP DMG STA and PCP/AP DMG STA. The element is included in the Probe and Information Request and Response frames transmitted between non-PCP/non-AP DMG STAs.

	Element ID	Length	Beamformed Link Maintenance
Octets:	1	1	1

Figure 8-401bf—BeamLink Maintenance element format

The Element ID field is equal to the value for the BeamLink Maintenance, specified in Table 8-54.

The Length field is set to 1.

The Beamformed Link Maintenance field is defined in 8.4a.6.

8.4.2.155 Multiple MAC Sublayers (MMS) element

The format of Multiple MAC Sublayers (MMS) element is shown in Figure 8-401bg. The MMS element is included in management action frames, such as Probe Request, Association Request, Information Request, Announce, and Information Response frames, transmitted to the peer STA and the PCP/AP of the BSS.

	Element ID	Length	MMS Control	STA MAC Address	Interface Address(es)
Octets:	1	1	1	6	6 × n (variable)

Figure 8-401bg—MMS element format

The Element ID field is equal to the value for the Multiple MAC Sublayers, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The MMS Control field is defined in Figure 8-401bh.

	B0 B1	B2	B3	B4	B5 B7
	MMS Element Owner	Single AID	MM-SME Power Mode	BeamLink Cluster	Reserved
Bit:	2	1	1	1	3

Figure 8-401bh—MMS Control field format

The MMS Element Owner field is encoded as shown in Table 8-183s. If the MMS Element Owner field is set to No Owner, then the Interface address(es) field in the MMS element is reserved.

Table 8-183s—MMS Element Owner field definition

MMS Element Owner value		Meaning
B0	**B1**	
0	0	No Owner
1	0	Non-AP, Non-PCP MMS element
0	1	PCP MMS element
1	1	AP MMS element

Single AID field is one bit in length and is encoded as defined in Table 8-183t.

Table 8-183t—Single AID field definition

MMS element sent from	MMS element sent to	MMS Element Owner		Single AID	Meaning
		B0	B1	B3	
Non-PCP, non-AP STA	PCP/AP	1	0	1	Request to allocate single AID for MAC addresses included in the MMS element
Non-PCP, non-AP STA	PCP/AP	1	0	0	Do not allocate single AID for MAC addresses included in the MMS element
PCP/AP STA	Non-PCP, non-AP STA	1	0	1	Single AID is allocated for all MAC addresses in the MMS element
PCP/AP STA	Non-PCP, non-AP STA	1	0	0	Single AID is not allocated for all MAC addresses in the MMS element
Non-PCP, non-AP STA	Non-PCP, non-AP STA	1	0	1	Single AID is allocated for all MAC addresses in the MMS element
Non-PCP, non-AP STA	Non-PCP, non-AP STA	1	0	0	Single AID is not allocated for all MAC addresses in the MMS element
PCP/AP STA	Non-PCP, non-AP STA	0	1	1	Single AID is allocated for all MAC addresses in the non-PCP, non-AP STA MMS element
PCP/AP STA	Non-PCP, non-AP STA	0	1	0	Single AID is not allocated for all MAC addresses in the non-PCP, non-AP STA MMS element

The MM-SME Power Mode field is one bit in length and is set to 1 to indicate that when a STA advertised in the MMS element sent by the STA coordinated by an MM-SME moves from the Awake to the Doze state, then all other STAs advertised in the MMS element sent by the STA move to the Doze state. The STA coordinated by the MM-SME moves to the Awake state only when all STAs advertised in the MMS element move to the Awake state. The MM-SME Power Mode field is set to 0 to indicate that when a STA advertised in the MMS element sent by the STA moves from the Doze to the Awake state, then all other STAs advertised in the MMS element sent by the STA coordinated by the MM-SME move to the Awake state. The STA coordinated by the MM-SME moves to the Doze state only when all STAs advertised in the MMS element move to the Doze state.

The BeamLink Cluster field is one bit in length and is set to 1 if the DMG STA intends to maintain the same beamformed link for all the links within the MMSL cluster. Otherwise, this field is set to 0.

The STA MAC Address field contains the MAC address of the STA.

When present in the element, the Interface Address(es) field contains one or more MAC addresses that can be used to identify the STAs in addition to the STA MAC address, coordinated by the same MM-SME (see 10.33).

8.4.2.156 Upper Layer Protocol Identification element

The format of the Upper Layer Protocol Identification (U-PID) element is described in Figure 8-401bi. This element can be included in any variant of the ADDTS Request and ADDTS Response frames.

	Element ID	Length	No-LLC	LLC Header Copy
Octets:	1	1	1	Variable

Figure 8-401bi—Upper layer protocol identification (U-PID) element format

The Element ID field is equal to the value for the Upper Layer Protocol Identification, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The No-LLC field is set to 1 to indicate that MSDUs do not contain the LLC (Logical Link Control) header. It is set to 0 otherwise.

The LLC Header Copy field is not present if the value of the No-LLC field is 0; otherwise, it contains a copy of the LLC header field values if the value of the No-LLC field is 1. When the field is present, the size of the LLC Header Copy field is specified in Table 8-183u.

Table 8-183u—LLC Header Copy field size

LLC header type	LLC Header Copy field size (octets)
LLC header with 8-bit control field w/o SNAP	3
LLC header with 8-bit control field with SNAP	8
LLC header with 16-bit control field	4

NOTE—The structure of the LLC header is defined in IEEE Std 802.2-1998. The structure of the LLC with SNAP extension is defined in IEEE Std 802.2-1998.

8.4.2.157 ECPAC Policy element

The format of the ECPAC Policy element is shown in Figure 8-401bj.

	Element ID	Length	ECPAC Policy Detail	CCSR ID	Available Cluster Time Offset Bitmap	TXSS CBAP Offset (optional)	TXSS CBAP Duration (optional)	TXSS CBAP MaxMem (optional)
Octets:	1	1	1	6	4	2	1	1

Figure 8-401bj—ECPAC Policy element format

The Element ID field is equal to the value for the ECPAC Policy, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

The ECPAC Policy Detail field is defined in Figure 8-401bk.

	B0	B1	B2	B3 B7
	BHI Enforced	TXSS CBAP Enforced	Protected Period Enforced	Reserved
Bits:	1	1	1	5

Figure 8-401bk—ECPAC Policy Detail field format

The BHI Enforced field set to 1 indicates that a PCP/AP within a centralized PCP/AP cluster completes the BHI for the current beacon interval before TBTT + 8/1024×Beacon SP duration, as described in 9.34.3.4. The BHI Enforced field set to 0 indicates that a PCP/AP within a cluster does not have to complete the BHI for the current beacon interval before TBTT + 8/1024×Beacon SP duration.

The TXSS CBAP Enforced field set to 1 indicates that a STA within a centralized PCP/AP cluster performs each of its TXSSs in the DTI within one or more TXSS CBAPs, as described in 9.34.3.4. The TXSS CBAP Enforced field set to 0 indicates that a STA within a centralized PCP/AP cluster does not have to perform each of its TXSSs in the DTI within one or more TXSS CBAPs.

The Protected Period Enforced field indicates that every scheduled SP in the BSS is a DMG Protected Period as specified in 9.33.6.6. The Protected Period Enforced field set to 0 indicates that a scheduled SP in the BSS does not have to be a DMG Protected Period.

The CCSR ID field is set to the MAC address of the CCSR within the ECPAC that the PCP/AP belongs to. The PCP/AP is the transmitter of the frame containing the ECPAC Policy element except when the ECPAC Policy element is transmitted in a Cluster Report element, where the PCP/AP is the transmitter that triggered the Cluster Report.

The Available Time Cluster Offset Bitmap field is a bitmap where the bit n-1, n = 1 to 32, indicates the availability of the n^{th} Beacon SP. Values of n = 1 and greater than ClusterMaxMem are reserved (i.e., bit 0 and bits ClusterMaxMem+1 to 31 inclusive). Bit n-1 set to 0 indicates that $ClusterTimeOffset_{n-1}$ is determined to be already in use by a neighboring PCP/AP, excluding the recipient if sent within an individually addressed frame, in the ECPAC. Bit n-1 set to 1 indicates that $ClusterTimeOffset_{n-1}$ is not determined to be already in use by a neighboring PCP/AP, excluding the recipient if sent within an individually addressed frame, in the ECPAC.

If TXSS CBAP Enforced field is set to 0, then the TXSS CBAP Offset field, the TXSS CBAP Duration field, and the TXSS CBAP MaxMem field are not present in the element; otherwise, they are present in the element.

The TXSS CBAP Offset field is the delay of the first TXSS CBAP in a beacon interval from the TBTT, in units of 8 µs.

The TXSS CBAP Duration field indicates the duration, in units of 8 µs, of each TXSS CBAP, in units of 8 µs.

The TXSS CBAP MaxMem field is the number of TXSS CBAPs per beacon interval.

8.4.2.158 Cluster Time Offset element

The format of the Cluster Time Offset element is shown in Figure 8-401bl.

	Element ID	Length	Cluster Time Offset Index
Octets:	1	1	1

Figure 8-401bl—Cluster Time Offset element format

The Element ID field is equal to the value for the Cluster Time Offset, specified in Table 8-54.

The Length field is set to 1.

The Cluster Time Offset Index field is set to the value n-1 for a member PCP/AP of a centralized PCP/AP cluster that adopted the n^{th} Beacon SP (see 9.34). Values equal to 0 and greater than ClusterMaxMem are reserved.

8.4.2.159 Antenna Sector ID Pattern element

The format of the Antenna Sector ID Pattern element is shown in Figure 8-401bm.

	B0 B7	B8 B15	B16 B19	B20 B25	B26 B31	B32 B39	B40 B47
	Element ID	Length	Type	Tap 1	State 1	Tap 2	State 2
Bits:	8	8	4	6	6	8	8

Figure 8-401bm—Antenna Sector ID Pattern element format

The Element ID field is equal to the value for the Antenna Sector ID Pattern, specified in Table 8-54.

The Length field is set to 4.

The Type field is set to 0 for Random Sequence Generator. Values 1 to 3 are reserved.

The Tap 1 field indicates the taps for Sequence Generator 1.

The State 1 field indicates the state for Sequence Generator 1.

The Tap 2 field indicates the taps for Sequence Generator 2.

The State 2 field indicates the state for Sequence Generator 2.

Sequence Generator 1 is shown in Figure 8-401bn and is defined as follows:

— Generate the sector IDs for subsequent DMG Beacons by advancing the Sequence Generator 1, which is initialized using Tap 1 and State 1 contained in the Antenna Sector ID Pattern element received from the PCP/AP.
— Advance the Sequence Generator 1 by one shift for each anticipated DMG Beacon transmission thereafter.
— After advancing the Sequence Generator 1, if the next state equals the initial state for the second time, overwrite the state with an all-zero state. The next state following the state following all zero-state uses the first 6 bits of the state of Sequence Generator 2 as the initial state.
— If the STA's total number of transmit sectors is not equal to the period of the Sequence Generator 1, ignore state(s) greater than or equal total number of transmit sectors and continue advancing Sequence Generator 1 until the state is less than the total number of transmit sectors.

NOTE—The taps are selected from the set of sequences with maximal length property.

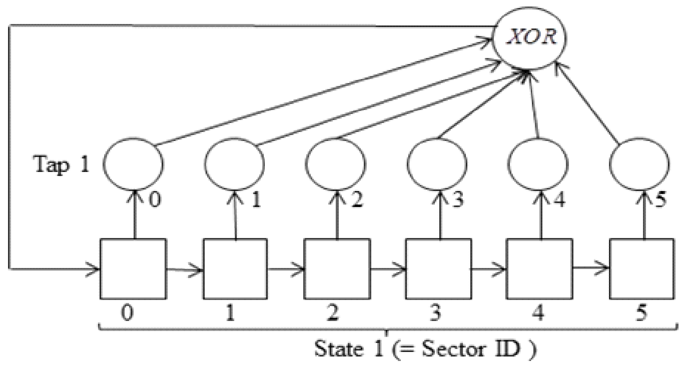


Figure 8-401bn—Sequence Generator 1

Sequence Generator 2 is shown in Figure 8-401bo and is defined as follows:

— Sequence Generator 2 is initiated with the value of the Tap 2 and State 2 fields contained in the Antenna Sector ID Pattern element received from the PCP/AP.
— Sequence Generator 2 is advanced by one shift when a new initial state is needed from Sequence Generator 1.

NOTE—The taps are selected from the set of the sequences with maximal length property.

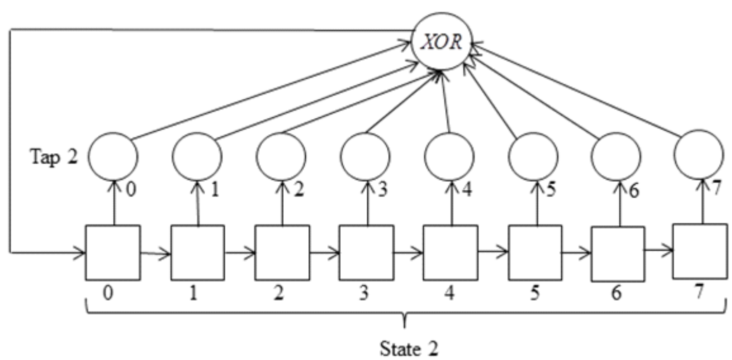


Figure 8-401bo—Sequence Generator 2

Insert the following subclauses, 8.4a to 8.4a.6 (including Figure 8-431a to Figure 8-431h, Table 8-190a, and Table 8-190b), after 8.4.4.19:

8.4a Fields used in Management and Extension frame bodies and Control frames

8.4a.1 Sector Sweep field

The format of the sector sweep (SSW) field is shown in Figure 8-431a.

	B0	B1 B9	B10 B15	B16 B17	B18 B23
	Direction	CDOWN	Sector ID	DMG Antenna ID	RXSS Length
Bits:	1	9	6	2	6

Figure 8-431a—SSW field format

The Direction field is set to 0 to indicate that the frame is transmitted by the beamforming initiator and set to 1 to indicate that the frame is transmitted by the beamforming responder.

The CDOWN field is a down-counter indicating the number of remaining DMG Beacon frame transmissions to the end of the TXSS, or the number of remaining SSW frame transmissions to the end of the TXSS/RXSS. This field is set to 0 in the last frame DMG Beacon and SSW frame transmission. Possible values range from 0 to 511.

The Sector ID field is set to indicate the sector number through which the frame containing this SSW field is transmitted.

The DMG Antenna ID field indicates the DMG antenna the transmitter is currently using for this transmission.

The RXSS Length field is valid only when transmitted in a CBAP and is reserved otherwise. The RXSS Length field specifies the length of a receive sector sweep as required by the transmitting STA, and is defined in units of a SSW frame. The value of this field is in the range of 0 to 62, with odd values being reserved.

NOTE—In a CBAP, a transmitting STA with multiple DMG antennas might not know the capabilities of the receiving STA; hence the size of the RXSS Length field is defined to cover for a single DMG antenna of the receiving STA.

8.4a.2 Dynamic Allocation Info field

The format of the Dynamic Allocation Info field is shown in Figure 8-431b.

	B0 B3	B4 B6	B7 B14	B15 B22	B23 B38	B39
	TID	AllocationType	Source AID	Destination AID	Allocation Duration	Reserved
Bits:	4	3	8	8	16	1

Figure 8-431b—Dynamic Allocation Info field format

The TID field identifies the TC or TS for the allocation request or grant.

NOTE—Unlike pseudo-static allocations, nonpseudo-static allocations are not labeled with an Allocation ID, and are associated to a TID.

The AllocationType field is defined in 8.4.2.134.

The Source AID field identifies the STA that is the source of the allocation.

The Destination AID field identifies the STA that is the destination of the allocation.

When the Dynamic Allocation Info field is transmitted within an SPR frame, the Allocation Duration field contains the requested duration in microseconds. When the Dynamic Allocation Info field is transmitted within a Grant frame, the Allocation Duration field contains the granted duration of the SP or CBAP allocation in microseconds (see 9.33.7, 9.33.8, and 9.33.9). Possible values range from 0 to 32 767 for an SP allocation and 0 to 65 535 for a CBAP allocation. A value of 0 in the Allocation Duration field transmitted within a Grant frame means that the STA can transmit one PPDU followed by any relevant acknowledgment plus one RTS/DMG CTS handshake.

8.4a.3 Sector Sweep Feedback field

When the SSW Feedback field is transmitted as part of an ISS, the format of the field is as shown in Figure 8-431c. Otherwise, the format of the SSW Feedback field is as shown in Figure 8-431d.

	B0 B8	B9 B10	B11 B15	B16	B17 B23
	Total Sectors in ISS	Number of RX DMG Antennas	Reserved	Poll Required	Reserved
Bits:	9	2	5	1	7

Figure 8-431c—SSW Feedback field format when transmitted as part of an ISS

	B0 B5	B6 B7	B8 B15	B16	B17 B23
	Sector Select	DMG Antenna Select	SNR Report	Poll Required	Reserved
Bits:	6	2	8	1	7

Figure 8-431d—SSW Feedback field format when not transmitted as part of an ISS

The Total Sectors in ISS field indicates the total number of sectors that the initiator uses in the ISS, including any repetition performed as part of multi-antenna beamforming. Possible values range from 0 to 511, representing 1 to 512 sectors.

The Number of RX DMG Antennas subfield indicates the number of receive DMG antennas the initiator uses during the following RSS.

The Sector Select field contains the value of the Sector ID subfield of the SSW field within the frame that was received with best quality in the immediately preceding sector sweep. The determination of which packet was received with best quality is implementation dependent. Possible values of this field range from 0 to 63.

The DMG Antenna Select field indicates the value of the DMG Antenna ID subfield of the SSW field within the frame that was received with best quality in the immediately preceding sector sweep. The determination of which frame was received with best quality is implementation dependent.

The SNR Report field is set to the value of the SNR from the frame that was received with best quality during the immediately preceding sector sweep, and which is indicated in the sector select field. This field is encoded as 8-bit twos complement value of 4×(SNR-19), where SNR is measured in dB. This covers from –13 dB to 50.75 dB in 0.25 dB steps.

The Poll Required field is set to 1 by a non-PCP/non-AP STA to indicate that it requires the PCP/AP to initiate communication with the non-PCP/non-AP. This field is set to 0 to indicate that the non-PCP/non-AP has no preference about whether the PCP/AP initiates the communication. This field is reserved when transmitted by a PCP/AP.

8.4a.4 BRP Request field

The BRP Request field is defined in Figure 8-431e.

	B0 B4	B5	B6	B7	B8	B9	B10	B11 B16	B17 B24	B25 B26	B27 B31
	L-RX	TX-TRN-REQ	MID-REQ	BC-REQ	MID-Grant	BC-Grant	Chan-FBCK-CAP	TX Sector ID	Other_AID	TX Antenna ID	Reserved
Bits:	5	1	1	1	1	1	1	6	8	2	5

Figure 8-431e—BRP Request field format

If the MID-REQ field is set to 0, the L-RX field indicates the compressed number of TRN-R subfields requested by the transmitting STA as part of beam refinement. To obtain the desired number of TRN-R subfields, the value of the L-RX field is multiplied by 4. Possible values range from 0 to 16, corresponding to 0 to 64 TRN-R fields. Other values are reserved. If the field is set to 0, the transmitting STA does not need receiver training as part of beam refinement. If the MID-REQ field is set to 1, the L-RX field indicates the compressed number of AWV settings that the STA uses during the MID phase. To obtain the number of AWVs that is used, the value of the L-RX field is multiplied by 4.

The TX-TRN-REQ field is set to 1 to indicate that the STA needs transmit training as part of beam refinement. Otherwise, it is set to 0.

A STA sets the MID-REQ field to 1 in SSW-Feedback or BRP frames to indicate a request for an I/R-MID subphase; otherwise, the STA sets the field to 0 to indicate it is not requesting an I/R-MID subphase. In case an R-MID subphase is requested, the STA can include information on the TX sector IDs to be used by the STA receiving this request. The STA receiving this request sets the MID-grant field in SSW-ACK or BRP frames to 1 to grant this request or otherwise sets it to 0.

A STA sets the BC-REQ field to 1 in SSW-Feedback or BRP frames to indicate a request for an I/R-BC subphase; otherwise, the STA sets the field to 0 to indicate it is not requesting an I/R-BC subphase. In case an R-BC subphase is requested, the STA can include information on the TX sector IDs to be used by the STA receiving this request. The STA receiving this request sets the BC-grant field in SSW-ACK or BRP frames to 1 to grant this request; otherwise, the STA sets it to 0 to reject the request.

The Chan-FBCK-CAP field is set to 1 to indicate the STA is capable to return channel measurement during beam refinement. The Chan-FBCK-CAP field is set to 0 to indicate the STA is able to return only BS-FBCK during beam refinement.

The TX sector ID field indicates the Sector ID that is used when transmitting the packet. If the packet is transmitted using a pattern that is not a sector that has been used in the sector sweep, the value of this field is set to 0x63.

The Other_AID field is set to the AID of an additional STA referenced in the BRP procedure as described in 9.35.6.4.4 and 21.10.2.2.6. Otherwise, if the additional STA is not used, this field is set to 0.

The TX Antenna ID field indicates the DMG antenna ID that is used when transmitting the packet.

8.4a.5 Beamforming Control field

The Beamforming Control field is formatted as shown in Figure 8-431f when both the IsInitiatorTXSS and IsResponderTXSS subfields are equal to 1, and the Beamforming Control field is transmitted in either a Grant or Grant ACK frames. In all other cases, the Beamforming Control field is formatted as shown in Figure 8-431g.

	B0	B1	B2	B3-B9	B10-B11	B12-B15
	Beamforming Training	IsInitiatorTXSS	IsResponderTXSS	Total Number of Sectors	Number of RX DMG Antennas	Reserved
Bit:	1	1	1	7	2	4

Figure 8-431f—BF Control field format when both IsInitiatorTXSS and IsResponderTXSS subfields are equal to 1 and the BF Control field is transmitted in Grant or Grant ACK frames

	B0	B1	B2	B3 B8	B9	B10 B15
	Beamforming Training	IsInitiatorTXSS	IsResponderTXSS	RXSS Length	RXSSTxRate	Reserved
Bit:	1	1	1	6	1	6

Figure 8-431g—BF Control field format in all other cases

The Beamforming Training subfield is set to 1 to indicate that the source DMG STA intends to initiate beamforming training with the destination DMG STA at the start of the allocation and is set to 0 otherwise. If the Beamforming Training subfield is set to 0, the IsInitiatorTXSS, IsResponderTXSS, and RXSS Length subfields are reserved.

The IsInitiatorTXSS subfield is set to 1 to indicate that the source DMG STA starts the beamforming training with an initiator TXSS. This subfield is set to 0 to indicate that the source DMG STA starts the BF training with an initiator RXSS.

The IsResponderTXSS subfield is set to 1 to indicate that the destination DMG STA starts the RSS with a responder TXSS. This subfield is set to 0 to indicate that the destination DMG STA is to initiate the RSS with a responder RXSS.

The RXSS Length subfield is valid only if at least one of IsInitiatorTXSS subfield or IsResponderTXSS subfield is equal to 0 and is reserved otherwise. The value represented by the RXSS Length subfield specifies the total number of receive sectors combined over all receive DMG antennas of the STA. The value represented by this subfield is in the range of 2 to 128 and is given by (RXSS Length+1)×2. The maximum number of SSW frames transmitted during an RXSS is equal to the value of (RXSS Length+1)×2 times the total number of transmit DMG antennas of the peer device.

The RXSSTxRate subfield is valid only if the RXSS Length subfield is valid and the value of the RXSS Length subfield is greater than 0. Otherwise, the RXSSTxRate subfield is reserved. The RXSSTxRate subfield is set to 0 to indicate that all frames transmitted as part of the RXSS use the DMG Control modulation class (9.7.5a.1). The RXSSTxRate subfield is set to 1 to indicate that only the first frame transmitted as part of the RXSS use the DMG Control modulation class and the remaining frames use MCS 1 of the DMG SC modulation class. If both IsInitiatorTXSS and IsResponderTXSS are set to 0 and the BF Control field is sent within a Grant frame, the RXSSTxRate subfield refers to the RSS only. If both IsInitiatorTXSS and IsResponderTXSS are set to 0 and the BF Control field is sent within a Grant ACK frame, the RXSSTxRate subfield refers to the ISS only.

When the BF Control field is transmitted in a Grant frame, the Total Number of Sectors subfield indicates the total number of sectors the initiator uses during the ISS. When the BF Control field is transmitted in a Grant ACK frame, the Total Number of Sectors subfield indicates the total number of sectors the responder uses during the RSS.

When the BF Control field is transmitted in a Grant frame, the Number of RX DMG Antennas subfield indicates the number of receive DMG antennas the initiator uses during the RSS. When the BF Control field is transmitted in a Grant ACK frame, the Number of RX DMG Antennas subfield indicates the number of receive DMG antennas the responder uses during the ISS.

8.4a.6 Beamformed Link Maintenance field

The Beamformed Link Maintenance field is shown in Figure 8-431h and provides the DMG STA with the value of dot11BeamLinkMaintenanceTime.

	B0	B1 B6	B7
	BeamLink Maintenance Unit Index	BeamLink Maintenance Value	BeamLink isMaster
Bits:	1	6	1

Figure 8-431h—Beamformed Link Maintenance field format

The encoding of the BeamLink Maintenance Unit Index field is specified in Table 8-190a.

Table 8-190a—Encoding of BeamLink Maintenance Unit Index

BeamLink Maintenance Unit Index	BeamLink Maintenance Unit (us)
0	32
1	2000

If the content of the BeamLink Maintenance value field is greater than 0, it is used to calculate the value of dot11BeamLinkMaintenanceTime as follows:

$$dot11BeamLinkMaintenanceTime = BLMU \times BLMV$$

where

BLMU is the value of the BeamLink Maintenance Unit corresponding to the value of the BeamLink Maintenance Unit Index field (see Table 8-190a)

BLMV is the value of the BeamLink Maintenance Value field

Otherwise, if the value of the BeamLink Maintenance value field is 0, the dot11BeamLinkMaintenanceTime is left undefined. An undefined value of the dot11BeamLinkMaintenanceTime indicates that the STA does not participate in beamformed link maintenance.

The BeamLink isMaster field is set to 1 to indicate that the DMG STA is the master of the data transfer and set to 0 if the DMG STA is a slave of the data transfer. The DMG STAs use the BeamLink isMaster field to negotiate the dot11BeamLinkMaintenanceTime as specified in Table 8-190b.

NOTE—In Table 8-190b, DMG STA-A and DMG STA-B refer to any of the STAs performing the Beamformed Link Maintenance negotiation procedure in no particular order.

Table 8-190b—The Beamformed Link Maintenance negotiation

BeamLink isMaster (DMG STA-A)	BeamLink isMaster (DMG STA-B)	dot11BeamLinkMaintenance Time (DMG STA-A) vs. dot11BeamLinkMaintenance Time (DMG STA-B)	Result
0	0	>=	dot11BeamLinkMaintenanceTime (DMG STA-A)
1	0	>, <, =	dot11BeamLinkMaintenanceTime (DMG STA-A)
1	1	=	dot11BeamLinkMaintenanceTime (DMG STA-A)
1	1	If either value equals 0	Undefined

8.5 Action frame format details

8.5.3 QoS Action frame details

8.5.3.1 General

Insert the following paragraph (including Table 8-192a and Table 8-192b) at the end of 8.5.3.1:

Two variants are defined for the ADDTS frames: a Basic ADDTS frame variant and a DMG ADDTS frame variant. These variants use different TSPEC formats. The variant of the frame is indicated by the Element ID in the fourth field of the ADDTS Request frame Action field format (Table 8-193) and sixth field of the ADDTS Response frame Action field format (Table 8-194). The Element ID is the first octet of each of these fields. The encoding of the ADDTS frame variants is shown in Table 8-192a and Table 8-192b.

Table 8-192a—Encoding of the ADDTS Request frame variant

Element ID of fourth field of ADDTS Request frame	ADDTS Request frame variant
13 (TSPEC)	Basic ADDTS Request frame
146 (DMG TSPEC)	DMG ADDTS Request frame

Table 8-192b—Encoding of the ADDTS Response frame variant

Element ID of sixth field of ADDTS Response frame	ADDTS Response frame variant
13 (TSPEC)	Basic ADDTS Response frame
146 (DMG TSPEC)	DMG ADDTS Response frame

Change the title of 8.5.3.2 as follows:

8.5.3.2 Basic and DMG ADDTS Request frame formats

Insert the following subclause title immediately after the title of 8.5.3.2:

8.5.3.2.1 Basic ADDTS Request frame variant

Change the title of Table 8-193, and insert the new rows at the end of the table:

Table 8-193—Basic ADDTS Request frame variant Action field format

Order	Information	Notes
n+6	Multi-band	Optional
n+7	Upper Layer Protocol Identification	Optional
n+8	Multiple MAC Sublayers	Optional

Change the sixth paragraph of now 8.5.3.2.1 as follows:

The TSPEC element, defined in 8.4.2.32, and the optional TCLAS element, defined in 8.4.2.33, contain the QoS parameters that define the TS. The TS is identified by the TSID and Direction fields within the TSPEC element. The TCLAS element is optional at the discretion of the STA that sends the ADDTS Request frame, regardless of the setting of the access policy (EDCA, SPCA, or HCCA). There may be one or more TCLAS elements in the ADDTS frame. The TCLAS Processing element is present when there are more than one TCLAS element and is defined in 8.4.2.35. There may be one Expedited Bandwidth Request element, which is defined in 8.4.2.96.

Insert the following paragraphs at the end of now 8.5.3.2.1:

When present in an ADDTS Request frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the ADDTS Request frame applies and contains band-specific information.

When present in the ADDTS Request frame, the Upper Layer Protocol Identification (U-PID) element indicates the upper layer protocol associated with the TID/TSID specified within the TSPEC element contained in this frame. If a TSPEC element is not present in the frame, the U-PID element is not included in the frame.

When present in the ADDTS Request frame, the Multiple MAC Sublayers element is used to establish an MMSL cluster.

Insert the following subclause, 8.5.3.2.2 (including Table 8-193a), after 8.5.3.2.1:

8.5.3.2.2 DMG ADDTS Request frame variant

The DMG ADDTS Request frame is used by DMG STAs in a PBSS and in an infrastructure BSS. The frame body of the DMG ADDTS Request frame contains the information shown in Table 8-193a.

Table 8-193a—DMG ADDTS Request frame variant Action field format

Order	Information	Notes
1	Category	
2	Action	
3	Dialog Token	

Table 8-193a—DMG ADDTS Request frame variant Action field format *(continued)*

Order	Information	Notes
4	DMG TSPEC	
5	TSPEC	Optional
6–n	TCLAS	Optional
n+1	TCLAS Processing	Optional
n+2	Multi-band	Optional
n+3	Upper Layer Protocol Identification	Optional
n+4	Multiple MAC Sublayers	Optional
n+5	Higher Layer Stream ID	Optional

The Dialog Token, DMG TSPEC, TSPEC, TCLAS, and TCLAS Processing fields of this frame are contained in an MLME-ADDTS.request primitive that causes the frame to be sent.

The DMG TSPEC element contains the parameters that define an allocation. The allocation uniquely identified by the source DMG STA MAC Address, Allocation ID, and destination AID within the DMG TSPEC element.

The optional TSPEC element defines a TS that can use the allocation should the allocation be created successfully.

The TCLAS element is optional and can be present only when a TSPEC element is present; it is used to identify the destination non-PCP/non-AP DMG STA of the ADDTS Request frame. There can be one or more TCLAS elements in the DMG ADDTS Request frame. The TCLAS Processing element is present if there is more than one TCLAS element.

When present in a DMG ADDTS Request frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the TS identified by the optional TSPEC element applies.

When present in the DMG ADDTS Request frame, the Upper Layer Protocol Identification (U-PID) element indicates the upper layer protocol associated with the TS identified by the optional TSPEC element contained in this frame.

When present in the DMG ADDTS Request frame, the Multiple MAC Sublayers element is used to establish an MMSL cluster.

Change the title of 8.5.3.3 as follows:

8.5.3.3 Basic and DMG ADDTS Response frame format

Insert the following subclause title immediately after the title of 8.5.3.3:

8.5.3.3.1 Basic ADDTS Response frame variant

Change the title of Table 8-194, and insert the new rows at the end of the table:

Table 8-194—Basic ADDTS Response frame variant Action field format

Order	Information	Notes
n+5	Multi-band	Optional
n+6	Upper Layer Protocol Identification	Optional
n+7	Multiple MAC Sublayers	Optional

Insert the following paragraphs at the end of now 8.5.3.3.1:

When present in an ADDTS Response frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the ADDTS Response frame applies and contains band-specific information.

When present in the ADDTS Response frame, the Upper Layer Protocol Identification (U-PID) element indicates the upper layer protocol associated with the TID/TSID specified within the TSPEC contained in this frame. If a TSPEC element is not present in the frame, the U-PID element is not included in the frame.

When present in the ADDTS Response frame, the Multiple MAC Sublayers element is used to establish an MMSL cluster (see 10.33).

Insert the following subclause, 8.5.3.3.2 (including Table 8-194a), after 8.5.3.3.1:

8.5.3.3.2 DMG ADDTS Response frame variant

The DMG ADDTS Response frame is used by DMG STAs in a PBSS and in an infrastructure BSS. The frame body of the DMG ADDTS Response contains the information shown in Table 8-194a.

Table 8-194a—DMG ADDTS Response frame variant Action field format

Order	Information	Notes
1	Category	
2	Action	
3	Dialog Token	
4	Status code	
5	TS Delay	
6	DMG TSPEC	
7	TSPEC	Optional
8–n	TCLAS	Optional
n+1	TCLAS Processing	Optional
n+2	Multi-band	Optional

Table 8-194a—DMG ADDTS Response frame variant Action field format *(continued)*

Order	Information	Notes
n+3	Upper Layer Protocol Identification	Optional
n+4	Multiple MAC Sublayers	Optional
n+5	Higher Layer Stream ID	Optional

The Dialog Token, TS Delay, DMG TSPEC, and optional TCLAS, TCLAS Processing, Multi-band, and U-PID fields in this frame are contained in an MLME-ADDTS.response primitive that causes the frame to be sent. The TS Delay element is present in a DMG ADDTS Response frame only if the status code is set to REJECTED_FOR_DELAY_PERIOD (8.4.1.9).

When present in a DMG ADDTS Response frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the TS identified by the optional TSPEC element applies.

When present in the DMG ADDTS Response frame, the Upper Layer Protocol Identification (U-PID) element indicates the upper layer protocol associated with the TS identified by the optional TSPEC contained in this frame.

When present in the DMG ADDTS Response frame, the Multiple MAC Sublayers element is used to establish an MMSL cluster (see 10.33).

8.5.3.4 DELTS frame format

Change the first paragraph of 8.5.3.4 as follows:

The DELTS frame is used to delete a TS or an allocation using the procedures defined in 10.4.9.

Change Table 8-195 as indicated below:

Table 8-195—DELTS frame Action field format

Order	Information
1	Category
2	QoS Action
3	TS Info
4	Reason code
5	DMG Allocation Info (optional)
6	Multi-band (optional)

Change the fifth paragraph in 8.5.3.4 as follows:

The TS Info field is defined in 8.4.2.32. Either the field identifies an existing TS created using the TSPEC element, or all its subfields are set to 0. The DMG Allocation Info field, defined in 8.4.2.136, is present when an existing DMG allocation is being deleted. When a DMG allocation is being deleted, the DMG

Allocation Info field identifies an existing allocation created using the DMG TSPEC element. When a DMG allocation is not being deleted, all subfields in the DMG Allocation Info field are set to 0.

Change the seventh paragraph in 8.5.3.4, and insert a new eighth paragraph as follows:

A DELTS frame is used to delete a TS characterized by the TS Info field or to delete a DMG allocation identified by the DMG Allocation Info field in the frame. A DELTS frame ~~may~~ can be sent from the HC or PCP to the source STA of that TS, or vice versa, to indicate an imperative request to which no response is required from the recipient STA.

When present in an DELTS frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the DELTS frame applies.

8.5.5 Block Ack Action frame details

8.5.5.2 ADDBA Request frame format

Insert the following rows at the end of Table 8-203:

Table 8-203—ADDBA Request frame Action field format

Order	Information
8	Multi-band (optional)
9	TCLAS (optional)
10	ADDBA Extension (optional)

Insert the following paragraphs at the end of 8.5.5.2:

When present in an ADDBA Request frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the ADDBA Request frame applies and contains band-specific information.

The ADDBA Extension element is defined in 8.4.2.141.

8.5.5.3 ADDBA Response frame format

Insert the following rows at the end of Table 8-204:

Table 8-204—ADDBA Response frame Action field format

Order	Information
8	Multi-band (optional)
9	TCLAS (optional)
10	ADDBA Extension (optional)

Insert the following paragraphs at the end of 8.5.5.3:

When present in an ADDBA Response frame, the Multi-band element indicates the frequency band ID, operating class, and channel number to which the ADDBA Response frame applies and contains band-specific information.

The ADDBA Extension element is defined in 8.4.2.141.

8.5.5.4 DELBA frame format

Insert the following rows at the end of Table 8-205:

Table 8-205—DELBA frame Action field format

Order	Information
6	Multi-band (optional)
7	TCLAS (optional)

Insert the following paragraph at the end of 8.5.5.4:

When present in an DELBA frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the DELBA Request frame applies.

8.5.7 Radio Measurement action details

8.5.7.5 Link Measurement Report frame format

Insert the following rows into Table 8-208 in numeric order:

Table 8-208—Optional Subelement IDs for Link Measurement Report frame

Subelement ID	Name	Length field (octets)	Extensible
162	DMG Link Margin	8	
172	DMG Link Adaptation Acknowledgment	5	Extensible

Insert the following paragraph after the eleventh paragraph ("The Subelement ID field ….") in 8.5.7.5:

The DMG Link Margin (8.4.2.144) and the DMG Link Adaptation Acknowledgment (8.4.2.145) subelements are present in the Optional Subelements field if the link measurements are performed with the DMG PHY (Clause 21) as defined in 9.37.

8.5.8 Public Action details

8.5.8.1 Public Action frames

Insert the following rows into Table 8-210 in numeric order, and update the Reserved row accordingly:

Table 8-210—Public Action field values

Public Action field value	Description
16	QAB Request frame
17	QAB Response frame

8.5.8.12 GAS Initial Request frame format

Change Table 8-216 as follows:

Table 8-216—GAS Initial Request frame body format

Order	Information
0	Category
1	Action
2	Dialog Token
3	Advertisement Protocol element
4	Query Request Length
5	Query Request
<u>6</u>	<u>Multi-band (optional)</u>

Insert the following paragraph at the end of 8.5.8.12:

When present in a GAS Initial Request frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the GAS Initial Request frame applies.

8.5.8.13 GAS Initial Response frame format

Change Table 8-217 as follows:

Table 8-217—GAS Initial Response frame body format

Order	Information
0	Category
1	Action
2	Dialog Token
3	Status Code
4	GAS Comeback Delay
5	Advertisement Protocol element
6	Query Response Length
7	Query Response (optional)
8	Multi-band (optional)

Insert the following paragraph at the end of 8.5.8.13:

When present in a GAS Initial Response frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the GAS Initial Response frame applies.

8.5.8.14 GAS Comeback Request frame format

Change Table 8-218 as follows:

Table 8-218—GAS Comeback Request frame body format

Order	Information
0	Category
1	Action
2	Dialog Token
3	Multi-band (optional)

Insert the following paragraph at the end of 8.5.8.14:

When present in a GAS Comeback Request frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the GAS Comeback Request frame applies.

8.5.8.15 GAS Comeback Response frame format

Change Table 8-219 as follows:

Table 8-219—GAS Comeback Response frame body format

Order	Information
0	Category
1	Action
2	Dialog Token
3	Status Code
4	GAS Query Response Fragment ID
5	GAS Comeback Delay
6	Advertisement Protocol element
7	Query Response Length
8	Query Response (optional)
<u>9</u>	<u>Multi-band (optional)</u>

Insert the following paragraph at the end of 8.5.8.15:

When present in a GAS Comeback Response frame, the Multi-band element indicates the frequency band, operating class, and channel number to which the GAS Comeback Response frame applies.

8.5.8.16 TDLS Discovery Response frame format

Insert the following row at the end of Table 8-220:

Table 8-220—Information for TDLS Discovery Response frame

Order	Information	Notes
16	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.

Insert the following subclauses, 8.5.8.25 and 8.5.8.26 (including Table 8-221d and Table 8-221e), after 8.5.8.24:

8.5.8.25 QAB Request frame format

The QAB Request Action frame is transmitted by an AP to another AP to schedule quiet periods that facilitate the detection of other system operating in the same band. The format of the QAB Request frame Action field is shown in Table 8-221d.

Table 8-221d—QAB Request frame Action field format

Order	Information
1	Category
2	Action
3	Dialog Token
4	RequesterAP Address
5	ResponderAP Address
6	Quiet Period Request element

The Category field is set to the value indicating the Public category, as specified in Table 8-38.

The Action field is set to the value indicating QAB Request frame, as specified in 8.5.8.1.

The Dialog Token field is set to a nonzero value chosen by the AP.

The RequesterAP Address field is the MAC address of the AP that initiates the process. The length of this field is 6 octets.

The ResponderAP Address field is the MAC address of the responding AP. The length of this field is 6 octets. This field can be set to the broadcast address if the request is sent to multiple APs.

The Quiet Period Request element is defined in 8.4.2.152.

8.5.8.26 QAB Response frame format

A QAB Response frame is sent in response to a QAB Request frame. The format of a QAB Response frame Action field contains the information shown in Table 8-221e.

Table 8-221e—QAB Response frame Action field format

Order	Information
1	Category
2	Action
3	Dialog Token
4	RequesterAP Address
5	ResponderAP Address
6	Quiet Period Response element

The Category field is set to the value indicating the Public category, as specified in Table 8-38.

The Action field is set to the value indicating QAB Response frame, as specified in 8.5.8.1.

The Dialog Token field value is copied from the corresponding received QAB Request frame.

The RequesterAP Address field is the MAC address of the AP that initiates the process. The length of this field is 6 octets.

The ResponderAP Address field is the MAC address of the responding AP. The length of this field is 6 octets.

The Quiet Period Response element is defined in 8.4.2.153.

8.5.11 Protected Dual of Public Action frames

Insert the following rows into Table 8-228 in numeric order, and update the Reserved row accordingly:

Table 8-228—Public Action field values defined for Protected Dual of Public Action frames

Public Action field value	Description
16	QAB Request
17	QAB Response

8.5.13 TDLS Action field formats

8.5.13.2 TDLS Setup Request Action field format

Insert the following row at the end of Table 8-239:

Table 8-239—Information for TDLS Setup Request Action field

Order	Information	Notes
18	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.

8.5.13.3 TDLS Setup Response Action field format

Insert the following row at the end of Table 8-240:

Table 8-240—Information for TDLS Setup Response Action field

Order	Information	Notes
19	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.

8.5.13.12 TDLS Discovery Request Action field format

Insert the following row at the end of Table 8-249:

Table 8-249—Information for TDLS Discovery Request Action field

Order	Information	Notes
5	Multi-band	The Multi-band element is optionally present if dot11MultibandImplemented is true.

8.5.19 Robust AV Streaming Action frame details

Insert the following subclauses, 8.5.20 to 8.5.22.3 (including Figure 8-502f to Figure 8-502j and Table 8-281b to Table 8-281ag), after 8.5.19.5:

8.5.20 DMG Action frame details

8.5.20.1 DMG Action field

Several Action frame formats are defined to support DMG features. A DMG Action field, in the octet immediately after the Category field, differentiates the DMG Action frame formats. The DMG Action field values associated with each frame format within the DMG category are defined in Table 8-281b.

Table 8-281b—DMG Action field values

DMG Action field value	Meaning
0	Power Save Configuration Request
1	Power Save Configuration Response
2	Information Request
3	Information Response
4	Handover Request
5	Handover Response
6	DTP Request
7	DTP Response
8	Relay Search Request
9	Relay Search Response
10	Multi-Relay Channel Measurement Request
11	Multi-Relay Channel Measurement Report
12	RLS Request
13	RLS Response
14	RLS Announcement
15	RLS Teardown

Table 8-281b—DMG Action field values *(continued)*

DMG Action field value	Meaning
16	Relay ACK Request
17	Relay ACK Response
18	TPA Request
19	TPA Response
20	TPA Report
21	ROC Request
22	ROC Response

8.5.20.2 Power Save Configuration Request frame format

The format of the Power Save Configuration Request (PSC-REQ) frame Action field is shown in Table 8-281c.

Table 8-281c—Power Save Configuration Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	DMG Power Management
5	Wakeup Schedule element (optional)

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Power Save Configuration Request specified in Table 8-281b.

The Dialog Token field is set to a value chosen by the STA sending the frame to uniquely identify the transaction.

The length of the DMG Power Management (DPM) field is one octet. Setting the DPM field to 0 indicates a transition from power save mode to active mode. Setting the DPM field to 1 indicates a transition from active mode to power save mode. All other values are reserved.

The Wakeup Schedule is defined in 8.4.2.133 (10.2.5.2).

8.5.20.3 Power Save Configuration Response frame format

The format of the Power Save Configuration Response (PSC-RSP) frame Action field is shown in Table 8-281d.

Table 8-281d—Power Save Configuration Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Status Code
5	Wakeup Schedule element (optional)
6	Antenna Sector ID Pattern element (optional)

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Power Save Configuration Response specified in Table 8-281b.

The Dialog Token field is set to the Dialog Token value in the corresponding PSC-REQ frame.

The Status Code field is defined in 8.4.1.9.

The Wakeup Schedule is defined in 8.4.2.133.

The Antenna Sector ID Pattern is defined in 8.4.2.159.

8.5.20.4 Information Request frame format

The Information Request frame is an Action frame of category DMG. The format of an Information Request frame Action field is shown in Table 8-281e.

Table 8-281e—Information Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Subject Address
4	Request information
5	DMG Capabilities 1 (optional)
…	…
N+4	DMG Capabilities N (optional)
N+5	IE Provided 1 (optional)
…	…
4+N+M	IE Provided M (optional)
Last	Vendor specific

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value for Information Request, specified in Table 8-281b.

The Subject Address field contains the MAC address of the STA whose information is being requested. If this frame is sent to the PCP and the value of the Subject Address field is the broadcast address, then the STA is requesting information regarding all associated STAs.

The Request element field is described in 8.4.2.13.

The DMG Capabilities element carries information about the transmitter STA and other STAs known to the transmitter STA. The format of this element is defined in 8.4.2.130.

Each IE Provided field contains an element as specified in 8.4.2, that the transmitter of this frame is providing to the destination of the frame.

One or more vendor-specific elements can appear in this frame. These elements follow all other elements.

8.5.20.5 Information Response frame format

The Information Response frame is an Action frame of category DMG. The format of an Information Response frame Action field is shown in Table 8-281f.

This frame is individually addressed to a STA in response to an Information Request or it is sent unsolicited and individually addressed to a STA or broadcast to all STAs in the PBSS/infrastructure BSS. If this frame is sent as a broadcast, then this frame is an Action No Ack frame.

Table 8-281f—Information Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	Subject Address
4	DMG Capabilities 1
…	…
N+3	DMG Capabilities N (optional)
N+4	Request information
N+5	IE Provided 1 (optional)
…	…
4+N+M	IE Provided M (optional)
Last	Vendor specific

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value for Information Response, specified in Table 8-281b.

The Subject Address field contains the MAC address of the STA whose information is being provided. If this field is set to the broadcast address, then the STA is providing information regarding all associated STAs.

The DMG Capabilities element carries information about the transmitter STA and other STAs known to the transmitter STA. The DMG Capabilities element is described in 8.4.2.130.

The Request element field is described in 8.4.2.13.

The IE Provided field contains the element, as described in 8.4.2, that the transmitter of this frame is providing to the destination of the frame.

One or more vendor-specific elements can appear in this frame. These elements follow all other elements.

8.5.20.6 Handover Request frame format

The Handover Request frame is an Action frame of category DMG. The format of the Handover Request frame Action field is shown in Table 8-281g.

Table 8-281g—Handover Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Handover Reason
4	Handover Remaining BI

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value for Handover Request, specified in Table 8-281b.

Handover Reason is 1 octet in length and indicates the reason that the current PCP intends to do the PCP handover. The Handover Reason field is set to 0 to indicate the PCP is leaving the PBSS, it is set to 1 to indicate low power in the PCP, is set to 2 to indicate that a more qualified PCP handover capable STA is available, and is set to 3 to indicate that the PCP handover capable STA wishes to become a PCP. All the other values are reserved.

Handover Remaining BI is 1 octet in length and indicates the number of beacon intervals, excluding the beacon interval in which this frame is transmitted, remaining until the handover takes effect.

8.5.20.7 Handover Response frame format

The Handover Response frame is an Action frame of category DMG. The format of the Handover Response frame Action field is shown in Table 8-281h.

Table 8-281h—Handover Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	Handover Result
4	Handover Reject Reason

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value for Handover Response, specified in Table 8-281b.

Handover Result is 1 octet in length and indicates whether the STA accepted the handover request. A value of 0 indicates that the STA accepts the handover request. A value of 1 indicates that the STA does not accept the handover request.

If the Handover Result field is set to 0, the Handover Reject Reason field is reserved and set to 0. If the Handover Result field is set to 1, the Handover Reject Reason indicates the reason the STA rejected the handover request and can be one of the following: 0 for low power, 1 for handover in progress with another STA, 2 for invalid value for Handover Remaining BI field, and 3 for unspecified reason. The length of Handover Reject Reason field is 1 octet.

8.5.20.8 DTP Request frame format

The DTP Request frame is transmitted to request DTP information. The format of the DTP Request frame Action field is shown in Figure 8-502f.

	Category	DMG Action	Dialog Token
Octets:	1	1	1

Figure 8-502f—DTP Request frame Action field format

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value representing a DTP Request frame, specified in Table 8-281b.

The Dialog Token field is set to a nonzero value chosen by the STA sending the request to identify the transaction.

8.5.20.9 DTP Report frame format

The DTP Report frame is transmitted in response to a DTP Request frame. A DTP Report frame can also be sent unsolicited. The format of the DTP Report frame Action field is shown in Figure 8-502g.

	Category	DMG Action	Dialog Token	DTP Report
Octets:	1	1	1	34

Figure 8-502g—DTP Report frame Action field format

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value representing a DTP Report frame, specified in Table 8-281b.

The Dialog Token field is set to the Dialog Token value in the corresponding DTP Request frame. If the DTP Report frame is not being transmitted in response to a DTP Request frame, the Dialog Token is set to 0.

The DTP Report element is defined in 8.4.2.148.

8.5.20.10 Relay Search Request frame format

The Relay Search Request frame is transmitted by a non-PCP/non-AP STA to the PCP/AP to request a list of RDSs in the BSS. The format of the Relay Search Request frame Action field is shown in Table 8-281i.

Table 8-281i—Relay Search Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Destination REDS AID

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Relay Search Request, specified in Table 8-281b.

The Dialog Token field is set to a nonzero value chosen by the STA sending the Relay Search Request frame to identify the request/response transaction.

The Destination REDS AID field is set to the AID of the target destination REDS.

8.5.20.11 Relay Search Response frame format

The Relay Search Response frame is sent by a PCP/AP in response to a Relay Search Request frame. The format of a Relay Search Response frame Action field is shown in Table 8-281j.

Table 8-281j—Relay Search Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Status Code
5	Relay Capable STA 1 Info

Table 8-281j—Relay Search Response frame Action field format *(continued)*

Order	Information
…	…
N+4	Relay Capable STA N Info

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Relay Search Response, specified in Table 8-281b.

The Dialog Token field is set to the value in the corresponding Relay Search Request frame that generated this response.

The Status Code field is defined in 8.4.1.9.

The Relay Capable STA Info field is defined in 8.4.1.44. This information is included only if the status code indicates successful.

8.5.20.12 Multi-relay Channel Measurement Request frame format

The Multi-Relay Channel Measurement Request frame is transmitted by a STA initiating relay operation to the recipient STA in order to obtain Channel Measurements between the recipient STA and the other STA participating in the relay operation. The format of the Multi-Relay Channel Measurement Request frame Action field is shown in Table 8-281k.

Table 8-281k—Multi-relay Channel Measurement Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Multi-Relay Channel Measurement Request, specified in Table 8-281b.

The Dialog Token field is set to a nonzero value chosen by the STA sending the Multi-Relay Channel Measurement Request frame to identify the request/report transaction.

8.5.20.13 Multi-relay Channel Measurement Report frame format

The Multi-Relay Channel Measurement Report frame is sent in response to a Multi-Relay Channel Measurement Request. The format of the Multi-Relay Channel Measurement Report frame Action field is shown in Table 8-281l.

Table 8-281l—Multi-relay Channel Measurement Report frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Channel Measurement Info 1
…	…
N+3	Channel Measurement Info N

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Multi-Relay Channel Measurement Report, specified in Table 8-281b.

The Dialog Token field is set to the value in any corresponding Multi-Relay Channel Measurement Request frame. If the Multi-Relay Channel Measurement Report frame is not being transmitted in response to a Multi-Relay Channel Measurement Request frame, then the Dialog token is set to 0.

The format of the Channel Measurement Info field is defined in Figure 8-502h. Multiple Channel Measurement Info fields can be included in case that the reporting STA measures the channel for multiple RDSs.

	B0 B7	B8 B15	B16 B22	B23	B24 B31
	Peer STA AID	SNR	Internal Angle	Recommend	Reserved
Bits:	8	8	7	1	8

Figure 8-502h—Channel Measurement Info field format

The Peer STA AID subfield contains the AID of the STA toward which the reporting STA measures link.

The SNR subfield indicates the SNR measured in the link toward the STA corresponding to Peer STA AID. This field is encoded as 8-bit twos complement value of 4x(SNR-19), where SNR is measured in dB. This covers from –13 dB to 50.75 dB in 0.25 dB steps.

The Internal Angle subfield indicates the angle between directions toward the other STAs involved in the relay operation. This covers from 0 degree to 180 degree in 2 degree steps. This subfield uses the degree of the direction from the sector that the feedbacks indicates has highest quality during TXSS if SLS phase of BF is performed and RXSS is not included.

The Recommend subfield indicates whether the responding STA recommends the relay operation based on the channel measurement with the Peer STA. This subfield is set to 1 when the relay operation is recommended and otherwise is set to 0.

8.5.20.14 RLS Request frame format

The RLS Request frame is used to set up a relay link. The format of the RLS Request frame Action field is shown in Table 8-281m.

Table 8-281m—RLS Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Destination AID
5	Relay AID
6	Source AID
7	Destination Capability Information
8	Relay Capability Information
9	Source Capability Information
10	Relay Transfer Parameter Set

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to RLS Request, specified in Table 8-281b.

The Dialog Token field is set to a nonzero value chosen by the STA sending the RLS Request frame to identify the request/response transaction.

The Destination AID field value is the AID of the target destination.

The Relay AID field value is the AID of the selected RDS.

The Source AID field value is the AID of the initiating STA.

The Destination Capability Information field indicates the Relay capabilities info field within the Relay capabilities element of the target destination REDS as defined in 8.4.2.150.

The Relay Capability Information field indicates the Relay capabilities info field within the Relay capabilities element of the selected RDS as defined in 8.4.2.150.

The Source Capability Information field indicates the Relay capabilities info field within the Relay capabilities element of the originator of the request as defined in 8.4.2.150.

The Relay Transfer Parameter Set element is defined in 8.4.2.151.

8.5.20.15 RLS Response frame format

The RLS Response frame is sent in response to an RLS Request frame. The format of an RLS Response frame Action field is shown in Table 8-281n.

Table 8-281n—RLS Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Destination Status Code
5	Relay Status Code (optional)

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to RLS Response, specified in Table 8-281b.

The Dialog Token field is set to the value in any corresponding RLS Request frame.

The Destination Status Code field is included when the destination REDS transmits this RLS Response frame as a result of RLS Request. It is defined in 8.4.1.9.

The Relay Status Code field is included when the relay REDS transmits this RLS Response frame as a result of RLS Request. It is defined in 8.4.1.9.

8.5.20.16 RLS Announcement frame format

The RLS Announcement frame is sent to announce the successful RLS. The format of an RLS Announcement frame Action field is shown in Table 8-281o.

Table 8-281o—RLS Announcement frame Action field format

Order	Information
1	Category
2	DMG Action
3	Status Code
4	Destination AID
5	Relay AID
6	Source AID

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to RLS Announcement, specified in Table 8-281b.

The Status Code field is defined in 8.4.1.9.

The Destination AID field value is the AID of the target destination.

The Relay AID field value is the AID of the RDS.

The Source AID field value is the AID of the initiating STA.

8.5.20.17 RLS Teardown frame format

The RLS Teardown frame is sent to terminate a relay operation. The format of the RLS Teardown frame Action field is shown in Table 8-281p.

Table 8-281p—RLS Teardown frame Action field format

Order	Information
1	Category
2	DMG Action
3	Destination AID
4	Relay AID
5	Source AID
6	Reason Code

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to RLS Teardown, specified in Table 8-281b.

The Destination AID field value is the AID of the destination REDS.

The Relay AID field value is the AID of the RDS.

The Source AID field value is the AID of the source REDS.

The Reason Code field is defined in 8.4.1.7.

8.5.20.18 Relay ACK Request frame format

The Relay ACK Request frame is sent by a source REDS to an RDS participating in a relay operation in order to determine whether all frames forwarded through the RDS were successfully received by the destination REDS also participating in the relay operation. This frame is used only when the RDS is operated in HD-DF mode and relay operation is link switching type. The format of the Relay ACK Request frame Action field is shown in Table 8-281q.

Table 8-281q—Relay ACK Request frame Action field format

Order	Information
1	Category
2	DMG Action

Table 8-281q—Relay ACK Request frame Action field format *(continued)*

Order	Information
3	BAR Control
4	BlockAck Starting Sequence Control

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Relay ACK Request, specified in Table 8-281b.

The BAR Control field and BlockAck Starting Sequence Control fields are defined in 8.3.1.8.

8.5.20.19 Relay ACK Response frame format

The Relay ACK Response frame is sent by an RDS to a source REDS participating in a relay operation in order to report which frames have been received by the destination REDS also participating in the relay operation. This frame is used only when the RDS is operated in HD-DF mode and relay operation is link switching type. The format of the Relay ACK Response frame Action field is shown in Table 8-281r.

Table 8-281r—Relay ACK Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	BA Control
4	BlockAck Starting Sequence Control
5	BlockAck Bitmap

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to Relay ACK Response, specified in Table 8-281b.

The BA Control field is defined in 8.3.1.9.

The BlockAck Starting Sequence Control field is defined in 8.3.1.9 and is set to the corresponding value within the immediately previously received Relay ACK Request frame.

The BlockAck Bitmap field is defined in 8.3.1.9.

8.5.20.20 TPA Request frame format

The TPA Request frame is sent by a destination REDS participating in operation based on link cooperating type to both the RDS and source REDS that belong to the same group as the destination REDS in order for them to send back their own TPA Response frames at the separately pre-defined times. Also, a source REDS sends a TPA Request frame to the RDS that is selected by the source REDS in order for the RDS to feedback its own TPA Response frame at the pre-defined time.

The format of the TPA Request frame Action field is shown in Table 8-281s.

Table 8-281s—TPA Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Timing Offset
5	Sampling Frequency Offset

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to TPA Request, specified in Table 8-281b.

The Dialog Token field is set to a nonzero value chosen by the STA sending the TPA Request frame to identify the request/response transaction.

The Timing Offset is 2 octets in length and indicates the amount of time, in nanoseconds, that the STA identified in the RA of the frame is required to change the timing offset of its transmissions so that they arrive at the expected time at the transmitting STA.

The Sampling Frequency Offset is 2 octets in length and indicates the amount by which to change the sampling frequency offset of the burst transmission so that bursts arrive at the destination DMG STA with no sampling frequency offset. The unit is 0.01 ppm. The Sampling Frequency Offset field is reserved when set to 0.

8.5.20.21 TPA Response frame format

The TPA Response frame is sent by an RDS or a source REDS participating in relay operation in response to a TPA Request frame from a destination REDS or a source REDS. The RDS or the source REDS that receives a TPA Request frame responds to the destination REDS or the source REDS, as appropriate, with a TPA Response frame at a pre-determined time from the end of the TPA Request frame (see 10.35). The format of the TPA Response frame Action field is shown in Table 8-281t.

Table 8-281t—TPA Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to TPA Response, specified in Table 8-281b.

The Dialog Token field is set to the value received in the corresponding TPA Request frame that generated this response.

8.5.20.22 TPA Report frame format

The TPA Report frame is sent to announce whether a TPA procedure is successful. The format of the TPA Report frame Action field is shown in Table 8-281u.

Table 8-281u—TPA Report frame Action field format

Order	Information
1	Category
2	DMG Action
3	Status code

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to TPA Report, specified in Table 8-281b.

The Status Code field indicates the result of the current TPA procedure and is defined in 8.4.1.9.

8.5.20.23 ROC Request frame format

The ROC Request frame is sent by the source REDS participating in a relay operation in order to request a change in the current relay operation type. The format of the ROC Request frame Action field is shown in Table 8-281v.

Table 8-281v—ROC Request frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Relay Operation Type

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to ROC Request, specified in Table 8-281b.

The Dialog Token field is set to a nonzero value chosen by the STA sending the ROC Request frame to identify the request/response transaction.

The format of the Relay Operation Type field is defined in Figure 8-502i.

	B0	B1	B2 B7
	Link Cooperating	Relay-link	Reserved
Bits:	1	1	6

Figure 8-502i—Relay Operation Type field format

The Link Cooperating subfield is set to 0 to request the operation to be changed to link switching and is set to 1 to request the operation to be changed to link cooperating.

The Relay-link subfield is set to 0 to indicate that the link switching operation starts at the direct link between the source REDS and destination REDS and set to 1 to indicate that the link switching operation starts with the RDS. If the Link cooperating subfield is set to 1, the relay-link subfield is reserved.

8.5.20.24 ROC Response frame format

The ROC Response frame is sent by the RDS or the destination DMG STA participating in a relay operation in response to a ROC Request frame from the source DMG STA. The format of the ROC Response frame Action field is shown in Table 8-281w.

Table 8-281w—ROC Response frame Action field format

Order	Information
1	Category
2	DMG Action
3	Dialog Token
4	Status Code

The Category field is set to the category for DMG, specified in Table 8-38.

The DMG Action field is set to the value corresponding to ROC Response, specified in Table 8-281b.

The Dialog Token field is set to the value received in the corresponding ROC Request frame that generated this response.

The Status Code field is defined in 8.4.1.9.

8.5.21 FST Action frame details

8.5.21.1 FST Action field

The FST Action field values are defined in Table 8-281x.

Table 8-281x—FST Action field values

FST Action field value	Meaning
0	FST Setup Request
1	FST Setup Response
2	FST Tear Down
3	FST Ack Request
4	FST Ack Response
5	On-channel Tunnel Request

8.5.21.2 FST Setup Request frame format

The FST Setup Request frame is an Action frame of category FST. The FST Setup Request frame allows an initiating STA to announce to a peer STA whether the initiating STA intends to enable FST for the session between the initiating STA and the peer STA (10.32). The format of the FST Setup Request frame Action field is shown in Table 8-281y.

Table 8-281y—FST Setup Request frame Action field format

Order	Information
1	Category
2	FST Action
3	Dialog Token
4	LLT
5	Session Transition
6	Multi-band (optional)
7	Wakeup Schedule (optional)
8	Awake Window (optional)
9	Switching Stream (optional)
Last – n	One or more elements can appear in this frame (see 10.32). These elements follow all other elements that are not vendor-specific elements and precede all other elements that are vendor-specific elements that are part of the Last field in the Action frame. An element can be included only once in the frame.
Last	Vendor Specific (optional)

The Category field is set to the category for FST.

The FST Action field is set to the value for FST Setup Request.

The Dialog Token field is set to a nonzero value chosen by the STA.

The Link loss timeout (LLT) field is 32 bits and indicates the compressed maximum duration counted from the last time an MPDU was received by the initiating STA from the peer STA until the initiating STA decides to initiate FST. The use of this field is described in 10.32.

The Session Transition field contains the Session Transition element as defined in 8.4.2.147.

The Multi-band field contains the Multi-Band element as defined in 8.4.2.140. The regulatory information contained in the Multi-band element is applicable to all the fields and elements contained in the frame.

The Wakeup Schedule element is defined in 8.4.2.133.

The Awake Window element is defined in 8.4.2.139.

The Switching Stream element is defined in 8.4.2.146.

8.5.21.3 FST Setup Response frame format

The FST Setup Response frame is an Action frame of category FST. This frame is transmitted in response to the reception of an FST Setup Request frame. The format of the frame Action field is shown in Table 8-281z.

Table 8-281z—FST Setup Response frame Action field format

Order	Information	Notes
1	Category	
2	FST Action	
3	Dialog Token	
4	Status Code	The Status Code is defined in 8.4.1.9
5	Session Transition	
6	Multi-band (optional)	
7	Wakeup Schedule (optional)	
8	Awake Window (optional)	
9	Switching Stream (optional)	
10	Timeout Interval (optional)	
Last – n	One or more elements can appear in this frame (see 10.32). These elements follow all other elements that are not vendor-specific elements and precede all other elements that are vendor-specific elements that are part of the Last field in the Action frame. An element can be included only once in the frame.	
Last	Vendor Specific	One or more vendor-specific elements are optionally present. These elements follow all other elements.

The Category field is set to the category for FST.

The FST Action field is set to the value for FST Setup Response.

The Dialog Token field value is copied from the corresponding received FST Setup Request frame.

The Session Transition field contains the Session Transition element as defined in 8.4.2.147.

The Multi-band element is defined in 8.4.2.140.

The Wakeup Schedule element is defined in 8.4.2.133.

The Awake Window element is defined in 8.4.2.139

The Switching Stream element is defined in 8.4.2.146.

The Timeout Interval element is defined in 8.4.2.51.

8.5.21.4 FST Tear Down frame format

The FST Tear Down frame is an Action frame of category FST. This frame is transmitted to delete an established FST session between STAs. The format of the frame Action field is shown in Table 8-281aa.

Table 8-281aa—FST Tear Down frame Action field format

Order	Information
1	Category
2	FST Action
3	FSTS ID

The Category field is set to the category for FST.

The FST Action field is set to the value for FST teardown.

The FSTS ID field contains the identification of the FST session established between the STAs identified by the TA and RA fields of this frame (8.4.2.147).

8.5.21.5 FST Ack Request frame format

The FST Ack Request frame is an Action frame of category FST. This frame is transmitted in the frequency band an FST session is transferred to and confirms the FST session transfer. The format of the frame Action field is shown in Table 8-281ab.

Table 8-281ab—FST Ack Request frame Action field format

Order	Information
1	Category
2	FST Action

Table 8-281ab—FST Ack Request frame Action field format *(continued)*

Order	Information
3	Dialog Token
4	FSTS ID

The Category field is set to the category for FST.

The FST Action field is set to the value for FST Ack Request.

The Dialog Token field is set to a nonzero value chosen by the STA sending the FST ACK request to identify the request/report transaction.

The FSTS ID field contains the identification of the FST session established between the STAs identified by the TA and RA fields of this frame (8.4.2.147).

8.5.21.6 FST Ack Response frame format

The FST Ack Response frame is an Action frame of category FST. This frame is transmitted in response to the reception of an FST Ack Request frame. The format of the frame Action field is shown in Table 8-281ac.

Table 8-281ac—FST Ack Response frame Action field format

Order	Information
1	Category
2	FST Action
3	Dialog Token
4	FSTS ID

The Category field is set to the category for FST.

The FST Action field is set to the value for FST Ack Response.

The Dialog Token field is set to the value in any corresponding FST Ack Request frame. If the FST Ack Response frame is not being transmitted in response to an FST Ack Request frame, then the Dialog token is set to 0.

The FSTS ID field contains the identification of the FST session established between the STAs identified in the TA and RA fields of this frame (8.4.2.147).

8.5.21.7 On-channel Tunnel Request frame format

The On-channel Tunnel Request frame is an Action frame of category FST. The On-channel Tunnel Request frame allows a STA of a multi-band device to encapsulate an MMPDU for transmission to an MLME of a peer STA within the same multi-band device (10.32), which can be used to perform multi-band association and multi-band authentication.

The format of the On-channel Tunnel Request frame Action field is shown in Table 8-281ad.

Table 8-281ad—On-channel Tunnel Request frame Action field format

Order	Information
1	Category
2	FST Action
3	OCT MMPDU
4	Multi-band

The Category field is set to the category for FST.

The FST Action field is set to the value for On-channel Tunnel Request.

The OCT MMPDU field is defined in Figure 8-502j.

	MMPDU Length	MMPDU Frame Control	MMPDU Frame Body
Octets:	2	2	Variable

Figure 8-502j—Definition of OCT MMPDU

The MMPDU Length field contains the length in octets of the MMPDU Frame Body field.

The MMPDU Frame Control field carries the content of the Frame Control field of an MMPDU that would be constructed if the MMPDU for the corresponding management frame type were transmitted over the air.

The MMPDU Frame Body field carries the content of the Frame Body field of an MMPDU that would be constructed if the MMPDU for the corresponding management frame type were transmitted over the air (i.e., all the octets after the MAC header and up to, but not including, the FCS).

The Multi-band field contains the Multi-band element (see 8.4.2.140) of the peer MLME to which the OCT MMPDU is destined to. The channel, frequency band and MAC address contained in this element are used to deliver the OCT MMPDU to the correct MLME within the peer STA.

8.5.22 Unprotected DMG Action frame details

8.5.22.1 Unprotected DMG Action field

Unprotected DMG Action frames are not encapsulated using mechanisms defined for robust management frames. An Action field, in the octet field immediately after the Category field, differentiates the formats. The Action field values associated with each frame format are defined in Table 8-281ae.

Table 8-281ae—Unprotected DMG Action field values

Unprotected DMG Action field value	Meaning
0	Announce
1	BRP

8.5.22.2 Announce frame format

The Announce frame is an Action or an Action No Ack frame of category Unprotected DMG. The format of an Announce frame Action field is shown in Table 8-281af.

Announce frames can be transmitted during the ATI of a beacon interval and can perform functions including of a DMG Beacon frame, but since this frame does not have to be transmitted as a sector sweep to a STA, it can provide much more spectrally efficient access than using a DMG Beacon frame.

Table 8-281af—Announce frame Action field format

Order	Information
1	Category
2	Unprotected DMG Action
3	Timestamp
4	Beacon Interval
5	SSID (optional)
6	Extended Schedule (optional)
7	DMG Capabilities (optional)
8	RSN (optional)
9	Multiple BSSID (optional)
10	DMG Operation (optional)
11	Next DMG ATI (optional)
12	Multi-band (optional)
Last – n	Multiple elements can appear in this frame. These elements follow all other elements that are not vendor-specific elements and precede all other elements that are vendor-specific elements.
Last	Vendor Specific (optional)

The Category field is set to the category for Unprotected DMG, specified in Table 8-38.

The Unprotected DMG Action field is set to the value corresponding to Announce specified in Table 8-281ae.

Any number of elements can be included within an Announce frame.

8.5.22.3 BRP frame format

The BRP frame is an Action No Ack frame. The format of a BRP frame Action field is shown in Table 8-281ag.

Table 8-281ag—BRP frame Action field format

Order	Information
1	Category
2	Unprotected DMG Action
3	Dialog Token
4	BRP Request field
5	DMG Beam Refinement element
6	Channel Measurement Feedback element 1 (optional)
…	…
6+N-1	Channel Measurement Feedback element N (optional)

The Category field is set to the category for Unprotected DMG, specified in Table 8-38.

The Unprotected DMG Action field is set to the value corresponding to BRP, specified in Table 8-281ae.

The Dialog Token field is set to a value chosen by the STA sending the frame to uniquely identify the transaction.

The BRP Request field is defined in 8.4a.4.

The DMG Beam Refinement element is defined in 8.4.2.132.

The Channel Measurement Feedback element is defined in 8.4.2.138.

The BRP frame contains more than one Channel Measurement Feedback element if the measurement information exceeds 255 bytes. The content of each Channel Measurement Feedback element that follows the first one in a single BRP frame is a continuation of the content in the previous element. The Channel Measurement, Tap Delay, and Sector ID Order subfields can be split between several elements. Each Channel Measurement Feedback element that is not the last Channel Measurement Feedback element in the frame is 257 bytes long. Channel measurement information for a single channel measurement is always contained within a single BRP frame.

NOTE—The length of a BRP frame can limit the choice of channel measurement parameters such as the number of measurements and the number of taps.

8.6 Aggregate MPDU (A-MPDU)

8.6.1 A-MPDU format

Change the second, third, and fourth paragraphs in 8.6.1 as follows:

The structure of the A-MPDU subframe is shown in Figure 8-504. Each A-MPDU subframe consists of an MPDU delimiter followed by an MPDU. Except when an A-MPDU subframe is the last one in an A-MPDU, padding octets are appended to make each A-MPDU subframe a multiple of 4 octets in length. The A-MPDU maximum length for a non-DMG STA is 65 535 octets. The A-MPDU maximum length for a DMG STA is 262 143 octets. The length of an A-MPDU addressed to a particular STA may be further constrained as described in 9.12.2.

Figure 8-504 remains unchanged.

The MPDU delimiter is 4 octets in length. The structure of the MPDU delimiter when transmitted by a non-DMG STA is defined in Figure 8-505. The structure of the MPDU Delimiter field when transmitted by a DMG STA is shown in Figure 8-505a.

Change the title of Figure 8-505 as follows:

Figure 8-505—MPDU delimiter (non-DMG)

Insert the following figure, Figure 8-505a, after Figure 8-505:

	B0 B2	B3 B15	B16 B23	B24 B31
	Reserved	MPDU Length	CRC	Delimiter Signature
Bits:	3	13	8	8

Figure 8-505a—MPDU delimiter (DMG)

The fields of the MPDU delimiter when transmitted by a non-DMG STA are defined in Table 8-282. The fields of the MPDU delimiter when transmitted by a DMG STA are defined in Table 8-282a.

Change the title of Table 8-282 as follows:

Table 8-282—MPDU delimiter fields (non-DMG)

Insert the following table, Table 8-282a, after Table 8-282:

Table 8-282a—MPDU delimiter fields (DMG)

MPDU Delimiter field	Size (bits)	Description
Reserved	3	
MPDU length	13	Length of MPDU in octets
CRC	8	8-bit CRC on preceding 16 bits
Delimiter Signature	8	Pattern that can be used to detect an MPDU delimiter when scanning for a delimiter. The unique pattern is set to the value 0x4E.

8.6.3 A-MPDU contents

Change Table 8-284 as follows:

Table 8-284—A-MPDU contents in the data enabled immediate response context

<table>
<tr><th>MPDU description</th><th colspan="2">Conditions</th></tr>
<tr><td>ACK MPDU</td><td>If the preceding PPDU contains an MPDU that requires an ACK response, a single ACK MPDU at the start of the A-MPDU.</td><td rowspan="2">In a non-DMG STA: a~~A~~t most one of these MPDUs is present.

In a DMG STA: at most one ACK MPDU is present, and zero or more HT-immediate BlockAck MPDUs are present.</td></tr>
<tr><td>HT-immediate BlockAck</td><td>In a non-DMG STA: ~~I~~if the preceding PPDU contains an implicit or explicit Block Ack request for a TID for which an HT-immediate Block Ack agreement exists, at most one BlockAck for this TID, in which case it occurs at the start of the A-MPDU.

In a DMG STA: if the preceding PPDU contains an implicit or explicit Block Ack request for a TID for which an HT-immediate Block Ack agreement exists, one or more copies of the same BlockAck for this TID.</td></tr>
<tr><td>Delayed BlockAcks</td><td colspan="2">BlockAck frames with the BA Ack Policy subfield equal to No Acknowledgment with a TID for which an HT-delayed Block Ack agreement exists.</td></tr>
<tr><td>Delayed Block Ack data</td><td colspan="2">QoS Data MPDUs with a TID that corresponds to a Delayed or HT-delayed Block Ack agreement.
These have the Ack Policy field equal to Block Ack.</td></tr>
<tr><td>Action No Ack</td><td colspan="2">Management frames of subtype Action No Ack.</td></tr>
<tr><td>Delayed BlockAckReqs</td><td colspan="2">BlockAckReq MPDUs with a TID that corresponds to an HT-delayed Block Ack agreement in which the BA Ack Policy subfield is equal to No Acknowledgment.</td></tr>
<tr><td>Data MPDUs sent under an HT-immediate Block Ack agreement</td><td>QoS Data MPDUs with the same TID, which corresponds to an HT-immediate Block Ack agreement, or in a DMG BSS QoS Null MPDUs with Ack Policy set to No Acknowledgment.
These MPDUs all have the Ack Policy field equal to the same value, which is either Implicit Block Ack Request or Block Ack.</td><td rowspan="2">Of these, at most one of the following is present:
— QoS Null MPDU (in DMG BSS only) with Ack Policy set to No Acknowledgment
— One or more QoS Data MPDUs with the Ack Policy field equal to Implicit Block Ack Request
— BlockAckReq</td></tr>
<tr><td>Immediate BlockAckReq</td><td>At most one BlockAckReq frame with a TID that corresponds to an HT-immediate Block Ack agreement.
This is the last MPDU in the A-MPDU. It is not present if any QoS data frames for that TID are present.</td></tr>
</table>

Change Table 8-287 as follows:

Table 8-287—A-MPDU contents MPDUs in the control response context

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

9. MAC sublayer functional description

9.2 MAC architecture

9.2.1 General

Change 9.2.1 (including Figure 9-1) as follows:

~~A representation of t~~The MAC architecture is shown in Figure 9-1. ~~in which the PCF and HCF services are provided using~~ When operating with any of the Clause 14 through Clause 20 PHYs, the MAC provides the HCF, including the PCF, through the services of the DCF. ~~Note that in a non-Qos STA, HCF is not present.~~ In a non-DMG QoS STA implementation, both DCF and HCF are present. In a non-DMG non-QoS STA implementation, only DCF is present. PCF is optional in all non-DMG STAs.

Due to the distributed nature of the MBSS, only the MCF is present in a mesh STA.

When operating with a DMG PHY (Clause 21), the MAC provides services using the DMG channel access mechanisms. Specific rules apply for access during scheduled periods, which include the association beamforming training (A-BFT) period, announcement transmission interval (ATI), contention-based access period (CBAP), and service period (SP). The DCF is used during contention-based access periods. Dynamic allocation (9.33.7) is built on service period and contention-based access period.

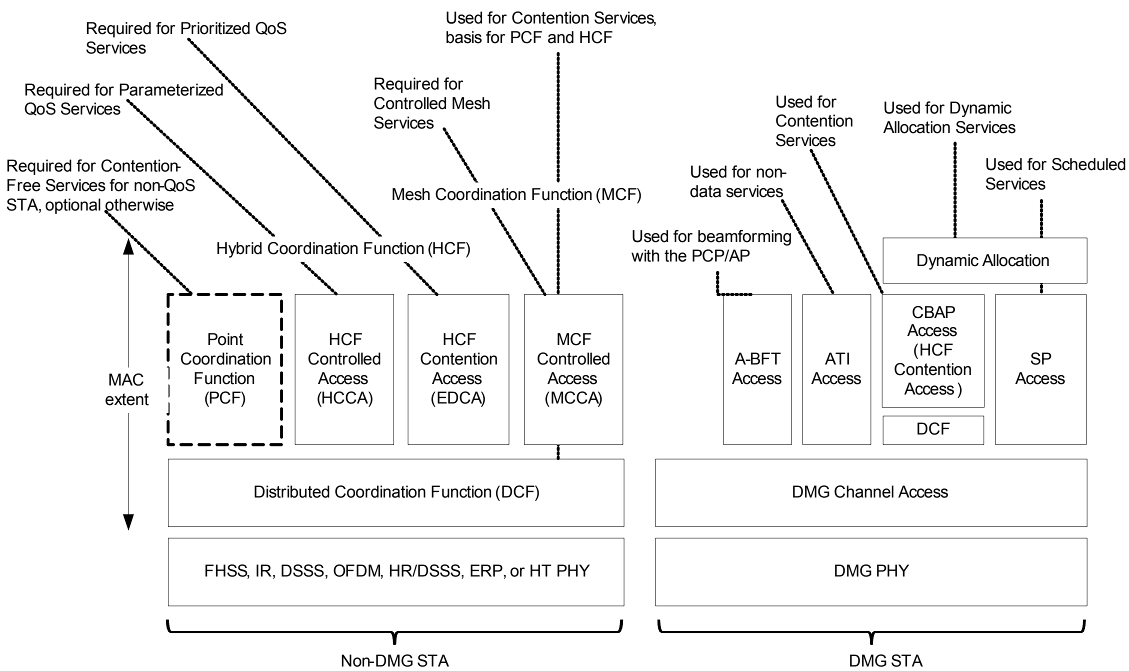


Figure 9-1—MAC architecture

9.2.2 DCF

Change 9.2.2 as follows:

The fundamental access method of the IEEE 802.11 MAC used by non-DMG STAs is a DCF known as *carrier sense multiple access with collision avoidance* (CSMA/CA). The DCF shall be implemented in all STAs.

For a STA to transmit, it shall sense the medium to determine if another STA is transmitting. If the medium is not determined to be busy (see 9.3.2.1), the transmission may proceed. The CSMA/CA distributed algorithm mandates that a gap of a minimum specified duration exist between contiguous frame sequences. A transmitting STA shall ensure that the medium is idle for this required duration before attempting to transmit. If the medium is determined to be busy, the non-DMG STA shall defer until the end of the current transmission, and a DMG STA may defer until the end of the current transmission. After deferral, or prior to attempting to transmit again immediately after a successful transmission, the STA shall select a random backoff interval and shall decrement the backoff interval counter while the medium is idle. A transmission is successful either when an ACK frame is received from the STA addressed by the RA field of the transmitted frame or when a frame with a group address in the RA field is transmitted completely. A refinement of the method may be used under various circumstances to further minimize collisions—here the transmitting and receiving STAs exchange short control frames (RTS and CTS frames for non-DMG STAs and RTS and DMG CTS frames for DMG STAs) after determining that the medium is idle and after any deferrals or backoffs, prior to data transmission. The details of CSMA/CA, deferrals, and backoffs are described in 9.3. RTS/CTS and RTS/DMG CTS exchanges are also presented in 9.3.

9.2.4 Hybrid coordination function (HCF)

9.2.4.2 HCF contention-based channel access (EDCA)

Insert the following note after Table 9-1 (UP-to-AC mappings):

NOTE—A DMG STA that implements a single AC (see 9.19.2.1) has all of its UP values in Table 9-1 mapped to AC_BE.

Change the sixth paragraph of 9.2.4.2 as indicated below:

The AP and PCP may use a different set of EDCA parameters from what it advertises to the STAs in its BSS.

9.2.7 Fragmentation/defragmentation overview

Insert the following paragraphs at the end of 9.2.7:

A QoS Data MPDU with a TID matching an existing BA agreement may be transmitted outside an A-MPDU with its Ack Policy subfield set to Normal Ack.

Transmission of fragmented MPDUs by a DMG STA outside of an A-MPDU depends on setting of the No-Fragmentation field in the ADDBA Extension element within the ADDBA Response frame transmitted during the BA agreement handshake. The MSDU shall not be fragmented if the No-Fragmentation field in the ADDBA Extension element within the ADDBA Response frame transmitted during the BA agreement handshake is 1. If the No-Fragmentation field in the ADDBA Extension element within the ADDBA Response frame is 0, the originator may send fragmented nonaggregated MSDU with Normal ACK policy under BA agreement.

9.3 DCF

9.3.1 General

Insert the following paragraphs after the second paragraph ("The CSMA/CA protocol is ….") of 9.3.1:

The DCF is modified for use by DMG STAs to allow sharing of the medium between compatible DMG PHYs (see 9.3.4). A DMG STA has no direct knowledge of when it might interfere (collide with the transmission of) another STA.

The CS function of a DMG STA might not indicate the medium busy condition due to the predominant nature of directional transmissions and receptions. The transmission of a STA might interfere (collide) with the transmission of another STA even though the CS function at the first STA does not indicate medium busy. The interference (collision) is identified when the expected response frame is not received. SPSH is achieved by the proper combination of the STA antenna configuration during the media access and data transfer phases.

Change the now twelfth paragraph in 9.3.1 as follows:

All STAs that are members of a BSS are able to receive and transmit at all the data rates in the BSSBasicRateSet parameter of the MLME-START.request primitive or BSSBasicRateSet parameter of the BSSDescription representing the SelectedBSS parameter of the MLME-JOIN.request primitive; see 6.3.4.2.4 and 6.3.11.2.4. All HT STAs and DMG STAs that are members of a BSS are able to receive and transmit using all the MCSs in the BSSBasicMCSSet parameter of the MLME-START.request primitive or BSSBasicMCSSet parameter of the BSSDescription representing the SelectedBSS parameter of the MLME-JOIN.request primitive; see 6.3.4.2.4 and 6.3.11.2.4. To support the proper operation of the RTS/CTS by non-DMG STAs, RTS/DMG CTS by DMG STAs, and the virtual CS mechanism, all non-DMG STAs shall be able to interpret control frames with the Subtype field set to RTS or CTS, and all DMG STAs shall be able to interpret control frames with the Subtype field set to RTS or DMG CTS.

Insert the following paragraph at the end of 9.3.1:

While in the WAKE state and operating under DCF but not transmitting, a DMG STA can configure its receive antenna to a quasi-omni pattern in order to receive frames transmitted by any STA that is covered by this antenna pattern.

9.3.2 Procedures common to the DCF and EDCAF

9.3.2.1 CS mechanism

Change the third and fourth paragraphs of 9.3.2.1 as follows:

A virtual CS mechanism shall be provided by the MAC. This mechanism is referred to as the NAV. The NAV maintains a prediction of future traffic on the medium based on duration information that is announced in RTS/CTS frames by non-DMG STAs and RTS/DMG CTS frames by DMG STAs prior to the actual exchange of data. The duration information is also available in the MAC headers of all frames sent during the CP, other than PS-Poll frames, and during the BTI, the A-BFT, the ATI, the CBAP, and the SP. The mechanism for setting the NAV using RTS/CTS or RTS/DMG CTS in the DCF is described in 9.3.2.4, use of the NAV in PCF is described in 9.4.3.3, and the use of the NAV in HCF is described in 9.19.2.2 and 9.19.3.4. Additional details regarding NAV usage and update appear in 9.3.2.5, 9.3.2.11, 9.33.10, and 9.23.

The CS mechanism combines the NAV state and the STA's transmitter status with physical CS to determine the busy/idle state of the medium. The NAV may be thought of as a counter, which counts down to 0 at a uniform rate. When the counter is 0, the virtual CS indication is that the medium is idle; when the counter is nonzero, the indication is busy. If a DMG STA supports multiple NAV timers as defined in 9.33.10 and all counters are 0, the virtual CS indication is that the medium is idle; when at least one of the counters is nonzero, the indication is busy. The medium shall be determined to be busy when the STA is transmitting.

9.3.2.3 IFS

9.3.2.3.1 General

Change the first paragraph of 9.3.2.3.1 as follows:

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

Insert the following list items into the lettered list of the first paragraph of 9.3.2.3.1:

g) SBIFS Short Beamforming Interframe Spacing
h) BRPIFS Beam Refinement Protocol Interframe Spacing
i) MBIFS Medium Beamforming Interframe Spacing
j) LBIFS Long Beamforming Interframe Spacing

9.3.2.3.2 RIFS

Change the second paragraph (including adding the dashed list and creating a new third paragraph) of 9.3.2.3.2 as follows:

RIFS may be used in place of SIFS to separate multiple transmissions from a single transmitter when no SIFS-separated response transmission is expected~~.~~ and at least one of the following is true:

— The transmitter is not a DMG STA.
— The transmitter is a DMG STA, and each transmission occurs with the same transmit antenna configuration.

RIFS shall not be used between frames with different RA values. The duration of RIFS is defined by the aRIFS PHY characteristic (see Table 20-25 and Table 21-31). The RIFS is the time from the end of the last symbol of the previous frame to the beginning of the first symbol of the preamble of the subsequent frame as seen at the air interface. A STA shall not allow the space between frames that are defined to be separated by a RIFS time, as measured on the medium, to vary from the nominal RIFS value (aRIFSTime) by more than ± 10% of aRIFSTime. Two frames separated by a RIFS shall both be HT PPDUs or shall both be DMG PPDUs.

9.3.2.3.3 SIFS

Change 9.3.2.3.3 as follows:

The SIFS shall be used prior to transmission of an ACK frame, a CTS frame, a PPDU containing a BlockAck frame that is an immediate response to either a BlockAckReq frame or an A-MPDU, a DMG CTS frame, a DMG DTS frame, an SSW-ACK frame, a Grant ACK frame, a response frame transmitted in the ATI, and the second or subsequent MPDU of a fragment burst and by a STA responding to any polling by the PCF. The SIFS may also be used by a PC for any type of frame during the CFP (see 9.4). The SIFS is the time from the end of the last symbol, or signal extension if present, of the previous frame to the beginning of the first symbol of the preamble of the subsequent frame as seen at the air interface.

The SIFS timing shall be achieved when the transmission of the subsequent frame is started at the TxSIFS Slot boundary as specified in 9.3.7. An IEEE 802.11 implementation of a non-DMG STA shall not allow the space between frames that are defined to be separated by a SIFS time, as measured on the medium, to vary from the nominal SIFS value by more than ± 10% of aSlotTime for the PHY in use. An implementation of a DMG STA shall not allow the space between frames that are defined to be separated by a SIFS time, as measured on the medium, to vary from the nominal SIFS value by more than –0% or +10% of aSlotTime.

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

When transmitting a response frame immediately following a SIFS period, a DMG STA shall set the TXVECTOR parameter LAST_RSSI of the response frame to the power that was measured on the received packet, as reported in the RCPI field of the frame that elicited the response frame. The encoding of the value is as follows:

- Power values less than or equal to –68 dBm are represented as the value of 1.
- Power values between –68 dBm and –42 dBm are represented as round((power – (–71 dBm))/2).
- Power values equal to or above –42 dBm are represented as the value 15.
- For all other cases, the DMG STA shall set the TXVECTOR parameter LAST_RSSI of the transmitted frame to 0.

A DMG STA that transmits a PPDU containing at least one individually addressed MPDU shall set the TXVECTOR parameter Turnaround to 1 if the DMG STA is required to listen for an incoming PPDU immediately following the transmission of the PPDU; otherwise, the DMG STA shall set the TXVECTOR parameter Turnaround to 0. The DMG STA shall set the TXVECTOR parameter Turnaround to 0 when it transmits an RTS frame.

9.3.2.3.4 PIFS

Insert the following items at the end of the dashed list after the second paragraph of 9.3.2.3.4:

- A PCP/AP continuing to transmit in the ATI after a transmission failure during the ATI (9.33.3)
- A source DMG STA of an SP continuing to transmit after a transmission failure as described in 9.33.6.2
- A DMG STA performing EDCA access during an allocated CBAP as described in 9.33.5

9.3.2.3.6 AIFS

Change 9.3.2.3.6 as follows:

The AIFS shall be used by QoS STAs that access the medium using the EDCAF to transmit all data frames (MPDUs) except during the ATI or an SP, all management frames (MMPDUs) except during the ATI or an SP, all extension frames except for the DMG Beacon frame, and the following control frames:

- PS-Poll~~,~~
- SSW (if first transmission by initiator in a CBAP)
- Poll (if first transmission and when in a CBAP)

- Grant (if first transmission and when in a CBAP and not transmitted in response to a SPR)
- SPR (when in a CBAP and not transmitted as a response to a Poll)
- RTS~~,~~
- CTS (when not transmitted as a response to the RTS)~~,~~
- DMG CTS (when not transmitted as a response to the RTS)
- BlockAckReq~~, and~~
- BlockAck (when not transmitted as a response to the BlockAckReq)~~.~~

A STA using the EDCAF shall obtain a TXOP for an AC if the STA's CS mechanism (see 9.3.2.1) determines that the medium is idle at the AIFS[AC] slot boundary (see 9.19.2.3), after a correctly received frame, and the backoff time for that AC has expired.

A non-PCP/non-AP QoS STA computes the time periods for each AIFS[AC] from the dot11EDCATableAIFSN attributes in the MIB. In an infrastructure BSS, QoS STAs update their dot11EDCATableAIFSN values using information in the most recent EDCA Parameter Set element of Beacon frames received from the AP of the BSS (see 8.4.2.31) if the STA is a non-DMG STA or the most recent EDCA Parameter Set element of DMG Beacon and Announce frames received from the PCP/AP of the BSS if the STA is a DMG STA. A QoS PCP/AP computes the time periods for each AIFS[AC] from the dot11QAPEDCATableAIFSN attributes in its MIB.

Insert the following subclauses, 9.3.2.3.8 to 9.3.2.3.11, after 9.3.2.3.7:

9.3.2.3.8 SBIFS

SBIFS shall be used to separate multiple transmissions from a single transmitter during a receive sector sweep or when each transmission occurs with a different transmit antenna configuration and no SIFS-separated response transmission is expected. The duration of SBIFS is determined by the aSBIFS PHY characteristic. The SBIFS is the time from the end of the last symbol of the previous frame to the beginning of the first symbol of the preamble of the subsequent frame as seen at the air interface. A STA shall not allow the space between frames that are defined to be separated by a SBIFS time, as measured on the medium, to vary from the nominal SBIFS value (aSBIFSTime) by more than aSBIFSAccuracy. Two frames separated by a SBIFS shall both be DMG PPDUs.

9.3.2.3.9 BRPIFS

BRPIFS shall be used by STAs between any combination of transmissions of BRP-TX and BRP-RX packets. The BRPIFS is the maximum time from the end of the last symbol of the previous PPDU, or training field if present in the PPDU, to the beginning of the first symbol of the preamble of the subsequent PPDU as seen at the air interface. The corresponding minimum time is SIFS. BRPIFS is defined to be equal to aBRPIFS+10%.

9.3.2.3.10 MBIFS

MBIFS shall be used between the BTI and the A-BFT and between the ISS, RSS, SSW Feedback, and SSW ACK. MBIFS is equal to 3×aSIFStime. An implementation of a DMG STA shall not allow the space between frames that are separated by MBIFS time, as measured on the medium, to vary from the nominal MBIFS value by more than –0% or +10 of aSlotTime.

9.3.2.3.11 LBIFS

LBIFS shall be used between transmissions employing different DMG antennas and when the recipient STA is expected to switch DMG antennas. LBIFS is equal to 6×aSIFStime. An implementation of a DMG STA shall not allow the space between frames that are separated by LBIFS time, as measured on the medium, to vary from the nominal LBIFS value by more than –0% or +10 of aSlotTime.

9.3.2.4 Setting and resetting the NAV

Insert the following paragraph as the new first paragraph of 9.3.2.4:

This subclause describes the setting and resetting of the NAV timer for non-DMG STAs and DMG STAs that support a single NAV timer. DMG STAs that support multiple NAV timers shall update their NAV timers according to the procedures described in 9.33.10.

Change the title of 9.3.2.6 as follows:

9.3.2.6 CTS and DMG CTS procedure

Insert the following paragraph at the end of 9.3.2.6:

A DMG STA follows the procedure defined in this subclause, except that it uses a DMG CTS frame instead of a CTS frame. A non-DMG STA does not transmit DMG CTS frames.

9.3.2.10 Duplicate detection and recovery

Change the second paragraph of 9.3.2.10 as follows:

Duplicate frame filtering is facilitated through the inclusion of a Sequence Control field (consisting of a sequence number and fragment number) within data, extension, and management frames, a TID subfield in the QoS Control field within QoS data frames, and an ACI subfield in the Sequence Number field within QMFs. MPDUs that are part of the same MSDU or A-MSDU shall have the same sequence number, and different MSDUs or A-MSDUs have (with a high probability) a different sequence number.

Change the fourth paragraph of 9.3.2.10 as follows:

A STA operating as a QoS STA shall maintain one modulo-4096 counter, per <Address 1, TID> tuple, for individually addressed QoS Data frames. Sequence numbers for these frames are assigned using the counter identified by the Address 1 field and the TID subfield of the QoS Control field of the frame, and that counter is incremented by 1 for each MSDU or A-MSDU corresponding to that <Address 1, TID> tuple. Sequence numbers for management frames, extension frames (when this field is present), QoS data frames with a group address in the Address 1 field, and all non-QoS data frames transmitted by QoS STAs with dot11QMFActivated false or not present shall be assigned using an additional single modulo-4096 counter, starting at 0 and incrementing by 1 for each such MSDU, A-MSDU, or MMPDU, except that a QoS STA may use values from additional modulo-4096 counters per <Address 1, TID> for sequence numbers assigned to time priority management frames. A transmitting STA should cache the last used sequence number per RA for frames that are assigned sequence numbers from this counter and should ensure that the successively assigned sequence numbers for frames transmitted to a single RA do not have the same value by incrementing the counter by 2, if incrementing by 1 would have produced the same sequence number as is found in the cache for that RA.

Change the first bullet in the dashed list in the fifth paragraph of 9.3.2.10 as follows:

— Management and extension frames that are not QMFs

9.3.2.11 NAV distribution

Change the first paragraph of 9.3.2.11 as follows:

When a node needs to distribute NAV information, for instance, to reserve the medium for a transmission of a nonbasic rate frame (that may not be heard by other nodes in the BSS), the node may ~~first~~ transmit a CTS frame with the RA field equal to its own MAC address (CTS-to-self) if the node is a non-DMG STA, or it may transmit a DMG CTS with the RA field equal to its own MAC address and the TA field equal to the MAC address of the peer DMG STA for which the forthcoming transmission of the node is intended (DMG CTS-to-self) if the node is a DMG STA. A~~and with a~~ duration value in the frame~~that~~ protects the pending transmission, plus possibly an ACK frame.

Insert the following paragraph at the end of 9.3.2.11:

A DMG STA shall not transmit a DMG DTS frame outside an SP.

9.3.3 Random backoff time

Change the last sentence in the first paragraph of 9.3.3 as follows:

This process minimizes collisions during contention between multiple STAS that have been deferring to the same event in a non-DMG network.

9.3.4 DCF access procedure

9.3.4.2 Basic access

Insert the following paragraphs and note after the second paragraph ("In general, a STA may ….) of 9.3.4.2:

A DMG STA operating under the DCF access method should transmit frames with its transmit antenna pattern directed towards the intended receiver.

A DMG STA operating under the DCF access method that does not operate in a TXOP exchange may configure its receiving antenna array to a quasi-omni antenna pattern to be ready to receive frames from any DMG STA.

NOTE—The steady state of the antenna configuration might depend on the actual applications in which the DMG STA is involved. For example, a DMG STA that expects transactions with several DMG STAs during a CBAP configures the receiving antenna to a quasi-omni pattern to be ready to receive transmission from any of the DMG STA. A DMG STA that expects transactions with a single DMG STA (e.g., PCP/AP) might keep its receiving antenna directed to the peer DMG STA.

A DMG STA operating under the DCF access method that is participating in a TXOP exchange should configure its receiving antenna array to be directed toward the other transmitter involved in the TXOP.

9.3.4.3 Backoff procedure for DCF

Insert the following figures, Figure 9-12a and Figure 9-12b, after Figure 9-12:

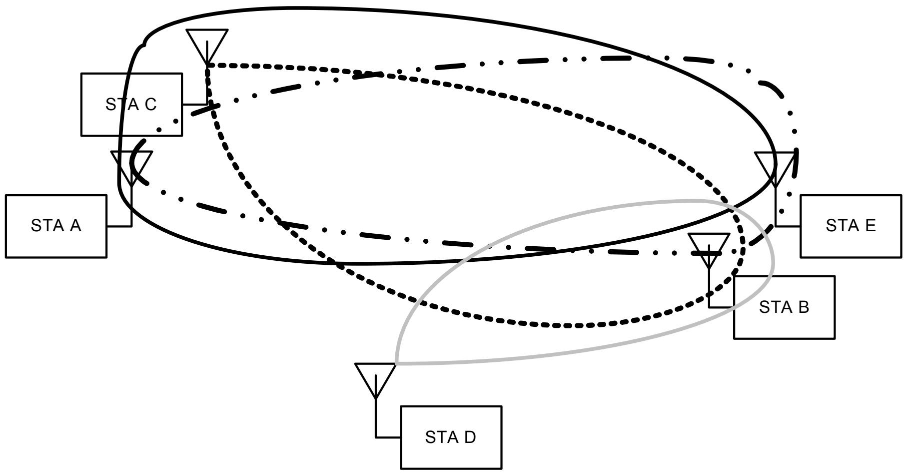


Figure 9-12a—Example topology of NAV setting in DMG STAs

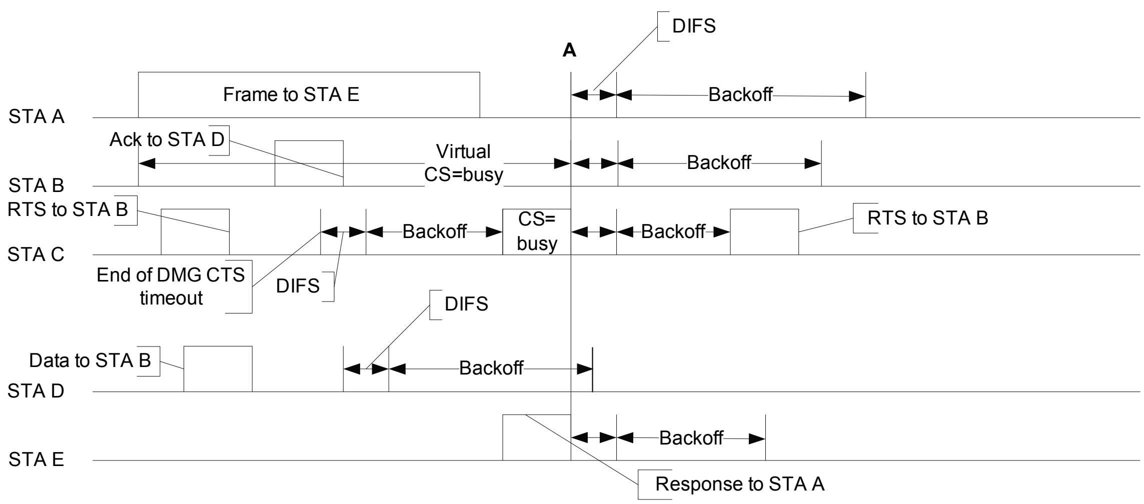


Figure 9-12b—Backoff procedure for DMG STAs

Change the third paragraph of 9.3.4.3 as shown:

To begin the backoff procedure, the STA shall set its Backoff Timer to a random backoff time using the equation in 9.3.3. All backoff slots occur following a DIFS period during which the medium is determined to be idle for the duration of the DIFS period or following an EIFS period during which the medium is determined to be idle for the duration of the EIFS period, as appropriate (see 9.3.2.3)<u>, except that no backoff slots for DCF occur during the BTI, the A-BFT, the ATI, and non-CBAP portions of the DTI</u>.

Change the seventh paragraph of 9.3.4.3 as follows:

The effect of this procedure is that when multiple STAs are deferring and go into random backoff, then the STA selecting the smallest backoff time using the random function wins the contention (assuming all of the contending STAs detect the same instances of WM activity at their respective receivers, a situation that is not always true, due to hidden node effects and interference events). The number of DMG STAs that are able to detect each WM transmission is reduced even further due to SPSH.

Insert the following text at the end of 9.3.4.3:

Figure 9-12b describes the backoff procedure for DMG STAs for the example topology shown in Figure 9-12a.

At the time that STA A starts transmitting a frame to STA E and STA E starts receiving the frame, the antennas of both stations are directed to the peer, i.e., the transmitting antennas of STA A are directed to STA E and the receiving antennas of STA E are directed to STA A. At this point, STA B, STA C, and STA D are not involved in any frame exchange; therefore, they are in receiving state and happen to have the configuration of their receiving antenna arrays set to a quasi-omni antenna pattern to be ready to receive frames from any STA.

STA B receives the frame transmitted by STA A (to STA E), and CS (physical and virtual) in STA B indicates a busy medium during the exchange between STA A and STA E.

STA D is not able to receive the frame transmitted by STA A or the response transmitted by STA E; hence CS in STA D indicates IDLE for the duration of the exchange between STA A and STA E.

The physical CS function of STA C indicates a medium busy condition when it receives the response sent by STA E, but indicates an idle medium condition during the transmission from STA A.

STA A and STA E (which are directly involved in the frame exchange), STA B (which received the frame sent by STA A), and STA C (which received the response sent by STA E) are synchronized at point A, where the transaction between STA A and STA E completes.

Since STA D cannot hear the directional transmissions from either STA A or STA C, its physical CS indicates an idle medium condition for the duration of the frame exchange, enabling a frame exchange with STA B at the same time as the frame exchange between STA A and STA E. This is an example of SPSH.

Because STA C is unaware of the transmission of the frame from STA A to STA E, STA C transmits an RTS to STA B. But STA C does not receive a DMG CTS from STA B since the CS at STA B is busy when STA B receives the RTS from the STA C. This causes STA C to retry the RTS transmission following the expiration of a backoff count, which occurs after the completion of the exchange between STA A and STA E.

9.3.4.4 Recovery procedures and retransmit limits

Change the fifth paragraph of 9.3.4.4 as follows:

Retries for failed transmission attempts shall continue until the SRC for the MPDU of type Data or MMPDU is equal to dot11ShortRetryLimit or until the LRC for the MPDU of type Data or MMPDU is equal to dot11LongRetryLimit. When either of these limits is reached, retry attempts shall cease, and the MPDU of type Data (and any MSDU of which it is a part) or MMPDU shall be discarded. A DMG STA, in addition to using random access within a CBAP, may transmit retries in available scheduled SPs.

9.3.6 Group addressed MPDU transfer procedure

Change the first paragraph of 9.3.6 as follows:

In the absence of a PCF or use of the group addressed transmission service (GATS), when group addressed MPDUs in which the To DS field is 0 are transferred from a STA, only the basic access procedure shall be used. When group addressed MPDUs are not delivered using GATS, no RTS/CTS or RTS/DMG CTS exchange shall be used, regardless of the length of the frame. In addition, no ACK shall be transmitted by any of the recipients of the frame. Any group addressed MPDUs in which the To DS field is 1 transferred from a STA shall, in addition to conforming to the basic access procedure of CSMA/CA, obey the rules for RTS/CTS exchange and the ACK procedure because the MPDU is directed to the AP. For DMG STAs, the MPDU transmission shall also conform to the access procedures defined in 9.33. When dot11SSPNInterfaceActivated is true, an AP shall distribute the group addressed message into the BSS only if dot11NonAPStationAuthSourceMulticast in the dot11InterworkingEntry identified by the source MAC address in the received message is true. When dot11SSPNInterfaceActivated is false, the group addressed message shall be distributed into the BSS. Unless the MPDU is delivered via DMS, the STA originating the message receives the message as a group addressed message (prior to any filtering). Therefore, all STAs shall filter out group addressed messages that contain their address as the source address. When dot11SSPNInterfaceActivated is false, group addressed MSDUs shall be propagated throughout the ESS. When dot11SSPNInterfaceActivated is true, group addressed MSDUs shall be propagated throughout the ESS only if dot11NonAPStationAuthSourceMulticast in the dot11InterworkingEntry identified by the source MAC address in the received message is true.

Insert the following paragraph after the third paragraph ("As a result, the reliability ….") of 9.3.6:

A DMG STA may transmit a copy of the same group addressed MPDU using different antenna configurations. This might be needed to provide a quasi-omni coverage or to enable transmission by an MCS that is higher than MCS 0. If multiple copies of a group addressed MPDU with a To DS field equal to 0 are transferred, the DMG STA shall not transmit a different frame before the completion of the transmission of all copies of the group addressed MPDU.

9.5 Fragmentation

Insert the following paragraph at the end of 9.5:

Except when using Block Ack, a STA that supports the DMG PHY shall complete the transmission of a fragmented MSDU before starting transmission of another MSDU with the same TID of the fragmented MSDU.

9.7 Multirate support

9.7.1 Overview

Change the fourth paragraph of 9.7.1 as follows:

Otherwise, a non-DMG STA ~~the frame~~ shall ~~be~~ transmit~~ted~~ the frame using a rate that is in accordance with rules defined in 9.7.5 and 9.7.6. A DMG STA shall transmit the frame using a rate that is in accordance with rules defined in 9.7.5a.

Change the last paragraph of 9.7.1 as follows:

For the Clause 18, Clause 17, Clause 19, Clause 21, and Clause 20 PHYs, the time required to transmit a frame for use in calculating the value for the Duration/ID field is determined using the

PLME-TXTIME.request primitive (see 6.5.7) and the PLME-TXTIME.confirm primitive (see 6.5.8), both defined in 18.4.3, 17.3.4, 19.8.3.2, 19.8.3.3, 19.8.3.4, 21.12.3, or 20.4.3 depending on the PHY options. In QoS STAs, the Duration/ID field may cover multiple frames and may involve using the PLME-TXTIME.request primitive several times.

Insert the following subclauses, 9.7.5a to 9.7.5a.5, after 9.7.5.6:

9.7.5a Multirate support for DMG STAs

9.7.5a.1 Usage of DMG Control modulation class

The DMG Control modulation class has only one MCS, which is DMG MCS 0 defined in Clause 21. The DMG Beacon, SSW-Feedback, SSW-ACK, RTS, DMG CTS, DMG CTS-To-Self, DMG DTS, and first BRP packet in beam refinement shall be transmitted using the DMG Control modulation class. In the case of an RXSS that was specified through the Beamforming Control field with the value of the RXSSTxRate subfield equal to 1 and the RXSSTxRate Supported field in the DMG Capabilities element of the STA performing the RXSS is 1, the first SSW frame of the RXSS shall be transmitted using the DMG Control modulation class, and the remaining frames of the RXSS shall be transmitted using MCS 1 of the DMG SC modulation class. In all other cases, the SSW frames shall be transmitted using the DMG Control modulation class. Other DMG beamforming training frames may be transmitted using the DMG Control modulation class or the DMG SC modulation class.

9.7.5a.2 Rate selection rules for control frames transmitted by DMG STAs

This subclause describes the rate selection rules for control frames transmitted by DMG STAs. The rate selection rules apply only for MCSs defined in Clause 21.

A control frame that does not have an MCS defined in 9.7.5a.1 and that is not a control response frame shall be transmitted using an MCS from the mandatory MCS set of the DMG SC modulation class or DMG Control modulation class.

A STA transmitting an ACK or a BA frame that is a response to a frame sent using the DMG low-power SC modulation class shall use the same modulation class and an MCS chosen from the DMG low-power SC Supported MCS set of the STA that transmitted the frame that elicited the response. The MCS index shall be the same as or lower than the MCS of the frame that elicited the response.

A STA transmitting a Grant ACK frame shall use the DMG Control modulation class or any MCS from the mandatory MCS set of the DMG SC modulation class.

A STA transmitting an ACK or a BA frame that is a response to a frame sent using the DMG Control modulation class shall use the DMG Control modulation class.

A STA transmitting an ACK frame or a BA frame in response to a frame sent using the DMG SC modulation class or DMG OFDM modulation class shall use an MCS from the mandatory MCS set of the DMG SC modulation class and shall use the highest MCS index for which the Data Rate is the same as or lower than that of the frame that elicited the response.

NOTE—A control response frame is a control frame that is transmitted within an MPDU as a response to a reception SIFS time after the PPDU containing the frame that elicits the response, e.g., a DMG CTS in response to an RTS reception, an ACK in response to a DATA reception, a BA in response to a BAR reception. In some situations, the transmission of some of these control frames is not a control response transmission, such as when a DMG CTS is used to initiate a TXOP.

The rules in this subclause do not apply to control frames that are contained in A-MPDUs that also include at least one MPDU of type Data or Management. Exception is an A-MPDU consisting of one of the following combinations:

— An ACK frame and a QoS Null frame
— A BA frame and a QoS Null frame
— A BAR frame and a QoS Null frame
— A BA frame, a BAR frame, and a QoS Null frame

In these exceptions, the rate selection rules are the same as those for a standalone ACK or BA frame.

9.7.5a.3 Rate selection for group addressed data and management frames transmitted by DMG STAs

This subclause describes the rate selection rules for group addressed data and management frames transmitted by DMG STAs. The rate selection rules apply only for MCSs defined in Clause 21.

If the transmit antenna pattern of a single transmission of a group addressed frame covers more than one receiver and the supported MCS set of each of the receivers is known to the sender, then the MCS used for the transmission shall be an MCS common to the supported MCS sets of all the receivers. If such an MCS is not known, the frame shall be transmitted using an MCS from the mandatory MCS set of the DMG Control or SC PHY.

If the transmit antenna pattern of a single transmission of a group addressed frame covers only one receiver, the frame shall be transmitted following the rate selection rules of individually addressed frames as described in 9.7.5a.4.

9.7.5a.4 Rate selection for individually addressed data and management frames transmitted by DMG STAs

This subclause describes the rate selection rules for individually addressed data and management frames as transmitted by DMG STAs. The rate selection rules apply only for MCSs defined in Clause 21.

An individually addressed data or management frame shall be sent using any MCS subject to the following constraints:

— A STA shall not transmit a frame using an MCS that is not supported by the receiver STA, as reported in the maximum receive MCS subfields in the Supported MCS Set field in management frames transmitted by the receiver STA.
— A STA shall not initiate transmission of a frame at an MCS index higher than the highest Transmission MCS in the OperationalRateSet, which is a parameter of the MLME-JOIN.request primitive.

When the Supported MCS set of the receiving STA is not known, the transmitting STA shall transmit using an MCS from the mandatory MCS set of the DMG Control or SC PHY.

The rules in this subclause also apply to A-MPDUs that contain at least one control type of MPDU and at least one MPDU of type Data or Management.

9.7.5a.5 Rate selection for BRP packets

The first BRP packet transmitted from the initiator to the responder after the SLS phase shall use MCS 0.

The first BRP packet transmitted from the responder to the initiator after the SLS phase shall use MCS 0.

BRP packets transmitted during beam refinement should use MCS 1 and shall not use any MCS greater than MCS 12. BRP packets transmitted during beam refinement should use MCS 0 if the BRP packet is sent at start of an SP as defined in 9.33.6.2.

BRP packets transmitted during the BRP setup subphase, the MID subphase, and the BC subphase shall use MCS 0.

BRP packets transmitted during a BC subphase, as part of a BC subphase only training, may use MCS 0-MCS 12.

BRP packets transmitted during beam tracking may use any MCS.

9.7.8 Modulation classes

Change the column title as indicated, and insert the following rows into Table 9-4 in numeric order:

Table 9-4—Modulation classes

Modulation class	Description of modulation	Condition that selects this modulation	
		Clause 14 to Clause 19 <u>or Clause 21</u> PHYs	Clause 20 PHY
9	DMG Control	21.4 transmission	NA
10	DMG SC	21.6 transmission	NA
11	DMG OFDM	21.5 transmission	NA
12	DMG low-power SC	21.7 transmission	NA

9.11 A-MSDU operation

Insert the following paragraphs at the start of 9.11:

The transmitter of frames for a TID established using a PTP TSPEC shall use an A-MSDU subframe format that is the result of the PTP TSPEC negotiation for that TID. The A-MSDU subframe format is negotiated using the PTP TSPEC (8.4.2.32): the Short A-MSDU subframe format shall not be used for frames of the corresponding TID if the A-MSDU subframe field of the PTP TSPEC element is 0 either in the ADDTS Request frame or in the ADDTS Response frame used to set up the TID. Prior to PTP TSPEC negotiation, a STA shall use the Basic A-MSDU subframe format if the STA employs MSDU aggregation.

A non-PCP DMG STA in a PBSS may use an A-MSDU to forward frames to another non-PCP STA in the PBSS via the PCP of the PBSS if the PCP Forwarding field within the PCP’s DMG Capabilities element is 1. A non-PCP DMG STA in a PBSS shall not use the PCP to do the forwarding if the PCP Forwarding field within the PCP’s DMG Capabilities element is 0.

The Short A-MSDU subframe structure is used only between a pair of STAs that communicate directly (see 8.3.2.1). The Short A-MSDU subframe structure cannot be used for frame forwarding.

Change the now fourth paragraph of 9.11 as follows:

An A-MSDU shall contain only MSDUs whose DA and SA parameter values map to the same RA and TA values. For the Short A-MSDU case, an A-MSDU shall contain only MSDUs whose SA and DA parameter values are the same.

Change the now tenth paragraph of 9.11 as follows:

The following rules apply to the transmission of an A-MSDU in a non-DMG network:

— A STA that has a value of false for dot11HighthroughputOptionImplemented shall not transmit an A-MSDU.
— A STA shall not transmit an A-MSDU to a STA from which it has not received a frame containing an HT Capabilities element.

9.12 A-MPDU operation

9.12.1 A-MPDU contents

Insert the following paragraphs at the end of 9.12.1:

A DMG STA that transmits an A-MPDU shall do so only in the Data Enabled Immediate Response context or the Control Response context specified in Table 8-284 and Table 8-287, respectively.

The contents of an A-MPDU transmitted by a DMG STA in the data enabled immediate response context are the ACK MPDU, or the HT-immediate BlockAck, or the Action No Ack as specified in Table 8-284.

9.12.2 A-MPDU length limit rules

Change 9.12.2 as follows:

An HT STA or a DMG STA indicates a value in the Maximum A-MPDU Length Exponent field in its HT Capabilities element or DMG Capabilities element, respectively, that defines the maximum A-MPDU length that it can receive. The encoding of this field is defined in Table 8-125 for an HT STA and in Table 8-183f for a DMG STA. Using this field, the STA establishes at association the maximum length of A-MPDUs that can be sent to it. The STA shall be capable of receiving A-MPDUs of length up to the value indicated by this field.

An HT STA or a DMG STA shall not transmit an A-MPDU that is longer than the value indicated by the Maximum A-MPDU Length Exponent field declared by the intended receiver.

NOTE—The A-MPDU length limit applies to the maximum length of the PSDU that might be received. If the A-MPDU includes any padding delimiters (i.e., delimiters with the Length field equal to 0) in order to meet the MPDU start spacing requirement, this padding is included in this length limit.

9.12.3 Minimum MPDU Start Spacing

Change 9.12.3 as follows:

An HT STA or a DMG STA shall not start the transmission of more than one MPDU within the time limit described in the Minimum MPDU Start Spacing field declared by the intended receiver. To satisfy this requirement, the number of octets between the start of two consecutive MPDUs in an A-MPDU, measured at the PHY SAP, shall be equal or greater than

$t_{MMSS} \times r/8$

where

t_{MMSS} is the time (in microseconds) defined in the “Encoding” column of Table 8-125 for an HT STA and of Table 8-183f for a DMG STA for the value of the Minimum MPDU Start Spacing field

r is the value of the PHY Data Rate (in megabits per second) defined in Clause 21 for a DMG STA and defined in 20.6 for an HT STA based on the TXVECTOR parameters: MCS, GI_TYPE, and CH_BANDWIDTH

If necessary, in order to satisfy this requirement, a STA shall add padding between MPDUs in an A-MPDU. Any such padding shall be in the form of one or more MPDU delimiters with the MPDU Length field set to 0.

QoS Null frames transmitted by DMG STAs are not subject to this spacing, i.e., no MPDU delimiters with zero length need to be inserted after the MPDU immediately preceding the QoS Null frame in an A-MPDU.

9.12.4 A-MPDU aggregation of group addressed data frames

Change 9.12.4 as follows:

An HT STA that is neither an AP nor a mesh STA shall not transmit an A-MPDU containing an PDU with a group addressed RA.

NOTE—An HT AP and an HT mesh STA can transmit an A-MPDU containing MPDUs with a group addressed RA.

An HT AP and an HT mesh STA shall not transmit an A-MPDU containing group addressed MPDUs if the HT Protection field is equal to non-HT mixed mode.

A DMG STA may transmit an A-MPDU containing MPDUs with a group addressed RA.

When a~~n HT AP or an HT mesh~~ STA transmits a PPDU containing at least one ~~an~~ A-MPDU that contains ~~containing~~ MPDUs with a group addressed RA, ~~both of~~ the following rules shall apply:

— If the PPDU is an HT PPDU, t~~T~~he value of maximum A-MPDU length exponent that applies is the minimum value in the Maximum A-MPDU Length Exponent subfield of the A-MPDU Parameters field of the HT Capabilities element across all HT STAs associated with the transmitting AP or across all peer HT mesh STAs of the transmitting mesh STA.

— If the PPDU is an HT PPDU, t~~T~~he value of minimum MPDU start spacing that applies is the maximum value in the Minimum MPDU Start Spacing subfield of the A-MPDU Parameters field of the HT Capabilities element across all HT STAs associated with the transmitting AP or across all peer HT mesh STAs of the transmitting mesh STA.

— If the PPDU is a DMG PPDU, the value of maximum A-MPDU length exponent that applies is the minimum value in the Maximum A-MPDU Length Exponent subfield of the A-MPDU Parameters field of the DMG Capabilities element across all DMG STAs associated with the PCP/AP.

— If the PPDU is a DMG PPDU, the value of minimum MPDU start spacing that applies is the maximum value in the Minimum MPDU Start Spacing subfield of the A-MPDU Parameters field of the DMG Capabilities element across all DMG STAs associated with the PCP/AP.

9.13 PPDU duration constraint

Insert the following paragraph at the end of 9.13:

A DMG STA shall not transmit a PPDU that has a duration (as determined by the PHY-TXTIME.confirm primitive defined in 6.5.8) that is greater than aPPDUMaxTime.

Insert the following subclause, 9.13a, after 9.13:

9.13a DMG A-PPDU operation

A DMG STA is aggregate PPDU (A-PPDU) capable if the A-PPDU supported field within the DMG STA's DMG Capabilities element is 1. Otherwise, the DMG STA is A-PPDU incapable.

A DMG STA shall not transmit an A-PPDU aggregate to a STA that is not A-PPDU capable.

An A-PPDU is a sequence of two or more PPDUs transmitted without IFS, preamble, and separation between PPDU transmissions. All PPDUs within an A-PPDU shall have the ADD-PPDU parameter of the TXVECTOR set to ADD-PPDU, except for the last PPDU in the A-PPDU that shall have this parameter set to NO-ADD-PPDU. The value of fields within the PLCP header of a PPDU belonging to an A-PPDU might differ from other PPDUs in the same A-PPDU, including the MCS field.

A PPDU within an A-PPDU shall contain an A-MPDU. All MPDUs within A-MPDUs within an A-PPDU shall have the same values for the TA and RA fields. All QoS Data MPDUs within A-MPDUs within an A-PPDU shall have the same value of the Ack Policy subfield of the QoS Control field. If a frame that requires an immediate response is present within an A-PPDU, it shall be transmitted in the last A-MPDU of the A-PPDU.

The transmission duration of an A-PPDU shall be no greater than aPPDUMaxTime.

NOTE—An A-PPDU capable DMG STA that receives an A-PPDU responds with an acknowledgment frame, if appropriate, only after it receives the last PPDU in the A-PPDU. The last PPDU in an A-PPDU has the ADD-PPDU parameter of the TXVECTOR set to NO-ADD-PPDU.

9.18 Operation across regulatory domains

9.18.2 Operation upon entering a regulatory domain

Change the second paragraph of 9.18.2 as follows:

When a STA with dot11MultiDomainCapabilityActivated true enters a regulatory domain, before transmitting, it shall passively scan to learn at least one valid channel, i.e., a channel upon which it detects IEEE 802.11 frames. The Beacon frame transmitted by non-DMG STAs and DMG Beacon/Announce frame transmitted by DMG STAs contain~~s~~ information on the country code, the maximum allowable transmit power, and the channels that may be used for the regulatory domain. Optionally, these ~~Beacon~~ frames may also include in the Country element, on a periodic basis, the regulatory information that would be returned in a Probe Response frame. When DSE-dependent STA operation is required in a regulatory domain, a dependent STA may be required to receive a Beacon frame or a DMG Beacon/Announce frame signaling dependent enablement (10.12.5), and until ~~this Beacon~~ at least one of these frames is received, the STA may continue passive scanning to receive one such ~~a Beacon~~ frame directly from an enabling STA. Once the STA has acquired the information so that it is able to meet the transmit requirements of the regulatory domain, it shall transmit a Probe Request to a~~n~~ PCP/AP to gain the additional necessary regulatory domain information contained in the Probe Response frame, unless the information was previously received in a

Beacon, DMG Beacon, or Announce frame. The STA then has sufficient information available to configure its PHY for operation in the regulatory domain.

9.18.6 Operation with coverage classes

Change 9.18.6 as follows:

The default PHY parameters are based on aAirPropagationTime having a value of 1 µs or less, and aSlotTime and other MAC timing are based on the PHY timing parameters, as specified in 9.3.2.3 and 9.3.7. When dot11OperatingClassesRequired is true, it is possible to manage the MAC timing of STAs that can receive Beacon frames, DMG Beacon frames, or Probe Response frames that contain the Country element (8.4.2.10), to increase fairness in contending for the medium. Radio waves propagate at 300 m/µs in free space, and, for example, 3 µs would be the ceiling for BSS maximum one-way distance of ~450 m (~900 m round trip). The Coverage Class field of the Country element indicates the new value of aAirPropagationTime (see Table 8-56), and the MAC can use the new value to calculate aSlotTime (see 9.3.7). When dot11OperatingClassesRequired and dot11ExtendedChannelSwitchActivated are true and Country elements have been received in Beacon frames, DMG Beacon frames, or Probe Response frames, associated STAs and dependent STAs shall use MAC timing that corresponds to the new value of aAirPropagationTime (see 9.3.7).

Using the Country element, a~~n~~ PCP/AP can change coverage class and maximum transmit power level to enhance operation. When dot11OperatingClassesRequired and dot11ExtendedChannelSwitchActivated are true and the maximum transmit power level is different from the transmit power limit indicated by the operating class, the associated STA or dependent STA shall operate at a transmit power at or below that indicated by the lesser of the two limits.

9.19 HCF

9.19.1 General

Change 9.19.1 as follows:

Under HCF, the basic unit of allocation of the right to transmit onto the WM is the TXOP. Each TXOP is defined by a starting time and a defined maximum length. In a non-DMG network, t~~T~~he TXOP may be obtained by a STA winning an instance of EDCA contention (see 9.19.2) during the CP or by a STA receiving a QoS (+)CF-Poll frame (see 9.19.3) during the CP or CFP. The former is called *EDCA TXOP*, while the latter is called *HCCA TXOP* or *polled TXOP*. An HCCA TXOP shall not extend across a TBTT. A TXOP shall not exceed dot11MaxDwellTime (if using an FH PHY). The occurrence of a TBTT implies the end of the HCCA TXOP, after which the regular channel access procedure (EDCA or HCCA) is resumed. It is possible that no frame was transmitted during the TXOP. The shortened termination of the HCCA TXOP does not imply an error condition.

In a DMG BSS, the EDCAF operates only during CBAPs. Operation of the EDCAF is suspended at the end of a CBAP and is resumed at the beginning of the following CBAP. When the EDCAF is being suspended, the values of the backoff and NAV timers shall remain unchanged until the start of the following CBAP. A TXOP may be obtained only within a CBAP. A TXOP may be obtained by a DMG STA winning an instance of EDCA contention (see 9.19.2) or by a DMG STA receiving a Grant frame with the AllocationType field equal to 1. See 9.33.5 and 9.33.6.3 for additional rules regarding contention-based access in DMG BSSs.

HCCA is not used by DMG STAs.

9.19.2 HCF contention-based channel access (EDCA)

9.19.2.1 Reference implementation

Insert the following paragraph and note at the end of 9.19.2.1:

A DMG STA may implement a single AC. If the DMG STA implements a single AC, all UP and frame types shall be mapped to AC_BE.

NOTE—A DMG STA that implements a single AC has only one queue in Figure 9-19.

9.19.2.5 EDCA backoff procedure

Insert the following list item at the end of the lettered list of the third paragraph of 9.19.2.5:

e) The transmission attempt of a STA coordinated by an MM-SME collides internally with another STA coordinated by the same MM-SME (see 10.33), which is indicated to the first MAC entity with a PHY-TxBusy.indication (BUSY) as response to the PHY-TXSTART.request primitive.

Change the first sentence in the eighth paragraph of 9.19.2.5 as follows:

If the backoff procedure is invoked because of a failure event [reason c) or d) or e) above or the transmission failure of a non-initial frame by the TXOP holder], the value of CW[AC] shall be updated as follows before invoking the backoff procedure:

9.19.2.7 Truncation of TXOP

Change 9.19.2.7 as follows:

When a STA gains access to the channel using EDCA and empties its transmission queue, it may transmit a CF-End frame provided that the remaining duration is long enough to transmit this frame. By transmitting the CF-End frame, the STA is explicitly indicating the completion of its TXOP. In a DMG BSS, the STA shall not send a CF-End with a nonzero value in the Duration/ID field if the remaining duration is shorter than $2 \times$ TXTIME(CF-End) + $2 \times$ SIFS.

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

A non-AP STA that is not the TXOP holder shall not transmit a CF-End frame.

In a non-DMG network, a~~A~~ STA shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the PPDU containing this frame. After receiving a CF-End frame with a matching BSSID, an AP may respond by transmitting a CF-End frame after SIFS.

NOTE—The transmission of a single CF-End frame by the TXOP holder resets the NAV of STAs hearing the TXOP holder. There may be STAs that could hear the TXOP responder that had set their NAV that do not hear this NAV reset. Those STAs are prevented from contending for the medium until the original NAV reservation expires.

In a DMG BSS, a STA that is not in the Listening Mode (9.33.6.6) shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the time interval indicated in the value of the Duration/ID field of the received frame. The interval starts at PHY-RXEND.indication of the frame reception. The STA shall not transmit during the interval if the RA field of the frame is not equal to the STA MAC address. The STA may transmit a CF-End frame if the RA field of the received frame is equal to the STA MAC address and the value of the Duration/ID field in the received frame is not equal to 0.

Figure 9-21 shows an example of TXOP truncation. In this example, the STA accesses the medium using EDCA channel access and then transmits a nav-set sequence (e.g., RTS/CTS for non-DMG STAs or RTS/DMG CTS for DMG STAs) (using the terminology of Annex G). After a SIFS, it then transmits an initiator-sequence, which may involve the exchange of multiple PPDUs between the TXOP holder and a TXOP responder. At the end of the second sequence, the TXOP holder has no more data that it can ~~available to~~ send that fits within the TXOP; therefore, it truncates the TXOP by transmitting a CF-End frame.

Figure 9-21 remains unchanged.

Non-DMG STAs that receive a CF-End frame reset their NAV and can start contending for the medium without further delay. DMG STAs that receive a CF-End frame can start contending for the medium at the end of the time interval equal to the value in Duration/ID field of the frame if none of its NAV timers has a nonzero value (9.33.10).

TXOP truncation shall not be used in combination with L-SIG TXOP protection when the HT Protection field of the HT Operation element is equal to nonmember protection mode or non-HT mixed mode.

9.21 Block Acknowledgment (Block Ack)

9.21.1 Introduction

Change the second and third paragraphs of 9.21.1 as follows:

The Block Ack mechanism is initialized by an exchange of ADDBA Request/Response frames. After initialization, blocks of QoS data frames may be transmitted from the originator to the recipient. A block may be started within a polled TXOP, within an SP, or by winning EDCA contention. The number of frames in the block is limited, and the amount of state that is to be kept by the recipient is bounded. The MPDUs within the block of frames are acknowledged by a BlockAck control frame, which is requested by a BlockAckReq frame.

The Block Ack mechanism does not require the setting up of a TS; however, QoS STAs using the TS facility may choose to signal their intention to use Block Ack mechanism for the scheduler's consideration in assigning TXOPs. The Block Ack mechanism is also used by the GCR service. Acknowledgments of frames belonging to the same TID, but transmitted during multiple TXOPs/SPs, may also be combined into a single BlockAck frame. This mechanism allows the originator to have flexibility regarding the transmission of data MPDUs. The originator may split the block of frames across TXOPs/SPs, separate the data transfer and the Block Ack exchange, and interleave blocks of MPDUs carrying all or part of MSDUs or A-MSDUs for different TIDs or RAs.

Insert the following paragraph after the third paragraph of 9.21.1:

A DMG STA shall support the HT-Immediate Block Ack extension. A DMG STA shall not use the HT-Delayed Block Ack extension.

9.21.2 Setup and modification of the Block Ack parameters

Change the fifth paragraph of 9.21.2 as follows:

When a Block Ack agreement is established between two HT/DMG STAs, the originator may change the size of its transmission window if the value in the Buffer Size field of the ADDBA Response frame is larger than the value in the ADDBA Request frame. If the value in the Buffer Size field of the ADDBA Response frame is smaller than the value in the ADDBA Request frame, the originator shall change the size of its transmission window (WinSizeO) so that it is not greater than the value in the Buffer Size field of the ADDBA Response frame and is not greater than the value 64.

9.21.3 Data and acknowledgment transfer using immediate Block Ack policy and delayed Block Ack policy

Change the second and third paragraphs of 9.21.3 as follows:

Subject to any constraints in this subclause about permitted use of TXOP or SP according to the channel access mechanism used, the originator may

— Separate the Block and Basic BlockAckReq frames into separate TXOPs or SPs
— Split a Block frame across multiple TXOPs or SPs
— Split transmission of data MPDUs sent under Block Ack policy across multiple TXOPs or SPs
— Interleave MPDUs with different TIDs within the same TXOP or SP
— Sequence or interleave MPDUs for different RAs within a TXOP or SP

A protective mechanism (such as transmitting using HCCA, RTS/CTS, RTS/DMG CTS, SP, Protected Period, or the mechanism described in 9.23) should be used to reduce the probability of other STAs transmitting during the TXOP or SP. If no protective mechanism is used, then the first frame that is sent as a block shall have a response frame and shall have the Duration field set so that the NAVs are set to appropriate values at all STAs in the BSS.

Change the 13th paragraph in 9.21.3 as follows:

If there is no response (i.e., neither a Basic BlockAck nor an ACK frame) to the Basic BlockAckReq frame, the originator may retransmit the Basic BlockAckReq frame within the current TXOP or SP (if time permits) or within a subsequent TXOP or SP. MSDUs that are sent using the Block Ack mechanism are not subject to retry limits but only to MSDU lifetime. Non-DMG ~~The~~ originators need not set the retry bit to 1 for any possible retransmissions of the MPDUs. DMG originators shall set the retry bit to 1 for any possible retransmissions of the MPDUs.

9.21.6 Selection of BlockAck and BlockAckReq variants

Insert the following paragraphs after the second paragraph ("The Multi-TID subfield ….") of 9.21.6:

In a DMG BSS, if the Compressed Bitmap subfield of the BAR Control field within a BlockAckReq frame related to an HT-immediate agreement is equal to 1, then all the following BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement shall have the Compressed Bitmap subfield of the BA Control and BAR Control fields set to 1. In this case, the Multi-TID subfield of the BA Control field and BAR Control field shall be set to 0 in all BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement.

In a DMG BSS, if the Compressed Bitmap subfield of the BAR Control field within a BlockAckReq frame related to an HT-immediate agreement is equal to 0, then all the following BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement shall have the Compressed Bitmap subfield of the BA Control and BAR Control fields set to 0. In this case, the Multi-TID subfield of the BA Control field and BAR Control field shall be set to 1 in all BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement.

9.21.7 HT-immediate Block Ack extensions

9.21.7.2 HT-immediate Block Ack architecture

Insert the following subclause title immediately after the title of 9.21.7.2 for all the existing subclause text ("The HT-immediate Block Ack rules … the HT-immediate Block Ack agreement is still active.") (including Figure 9-28):

9.21.7.2.1 Introduction

Insert the following subclause, 9.21.7.2.2, after 9.21.7.2.1:

9.21.7.2.2 Data and acknowledgment transfer

Under a BA agreement, the Normal ACK policy may be used in order to improve efficiency. STAs shall respond with an ACK to the reception of frames that are covered by a BA agreement, but that are not part of an A-MPDU and that are received with their Ack Policy subfield in the QoS Control field equal to Normal Ack.

The Block Ack record shall be updated irrespective of the acknowledgment type (Normal or Block ACK) for the TID/TSID with a Block Ack agreement.

The reception of QoS data frames using Normal Ack policy shall not be used by the recipient as an indication to reset the timer employed in detecting a Block Ack timeout (see 10.5). The Block Ack timeout allows the recipient to delete the Block Ack if the originator does not switch back to using Block Ack.

Change the title of 9.21.7.5 as follows:

9.21.7.5 Generation and transmission of BlockAck by an HT or DMG STA

9.21.7.6 Receive reordering buffer control operation

9.21.7.6.2 Operation for each received data MPDU

Change list item a) 2) of the first paragraph in 9.21.7.6.2 as follows:

a) If $WinStart_B \le SN \le WinEnd_B$,
   2) Pass MSDUs or A-MSDUs up to the next MAC process if they ~~that~~ are stored in the buffer in order of increasing value of the Sequence Number subfield starting with the MSDU or A-MSDU that has $SN=WinStart_B$ or one of the following conditions is met for a DMG STA if $SN>WinStart_B$:
      i) The MPDU is received as non-first frame in the A-MPDU; the bit at position SN=WinStartR – 1 is set to 1; and all delimiters between the received MPDU and the preceding MPDU (SN=WinStartR – 1) are valid.
      ii) The MPDU is received as first frame in the A-MPDU; the A-MPDU is received in SIFS or RIFS time after an A-MPDU or in SIFS time after transmission of a BA frame; the bit at position SN=WinStartR – 1 is set to 1; and all delimiters after the MPDU(SN=WinStartR – 1) in the preceding A-MPDU are valid.
      iii) The MPDU is received in SIFS or RIFS time after an A-MPDU or in SIFS time after transmission of a BA frame; the bit at position SN=WinStartR – 1 is set to 1; and all delimiters after the MPDU (SN=WinStartR – 1) in the preceding A-MPDU are valid.

iv) The MPDU is received as first frame in the A-MPDU; the A-MPDU is received in SIFS or RIFS time after an MPDU or in SIFS time after transmission of an Ack frame; and the bit at position SN=WinStartR – 1 is set to 1.

v) The MPDU is received in SIFS or RIFS time after the preceding MPDU or in SIFS time after transmission of an Ack frame; and the bit at position SN=WinStartR – 1 is set to 1.

This process is continued ~~and proceeding~~ sequentially until there is no buffered MSDU or A-MSDU for the next sequential value of the Sequence Number subfield.

Change list item b) 5) of the first paragraph of 9.21.7.6.2 as follows:

b) If $WinEnd_B < SN < WinStart_B+2^{11}$,

5) For a non-DMG STA, p~~P~~ass MSDUs or A-MSDUs stored in the buffer up to the next MAC process in order of increasing value of the Sequence Number subfield starting with $WinStart_B$ and proceeding sequentially until there is no buffered MSDU or A-MSDU for the next sequential Sequence Number subfield value. For a DMG STA, follow rules defined in item a) 2) above.

9.21.7.7 Originator's behavior

Insert the following paragraphs at the end of 9.21.7.7:

The Originator that is a DMG STA shall construct A-MPDUs that contain MPDUs in increasing order of SN. When responding to a Block Ack, the Originator shall first retransmit unacknowledged MPDUs in increasing order of SN.

The Originator that is a DMG STA shall not start a new TXOP or SP with an MPDU or A-MPDU that has an ACK policy other than Normal ACK if at least one frame transmitted by the Originator to the Recipient in the last PPDU did not require an immediate response.

9.24 MAC frame processing

9.24.3 Duration/ID field processing

Change the first paragraph of 9.24.3 as follows:

When the contents of a received Duration/ID field, treated as an unsigned integer and without regard for address values, type, and subtype (even when type or subtype contain reserved values), are less than 32 768, the duration value is used to update the network allocation vector (NAV) according to the procedures defined in 9.3.2.4, 9.33.10, or 9.19.3.4, as appropriate.

9.25 Reverse Direction protocol

Insert the following subclause, 9.25.0a, before 9.25.1:

9.25.0a General

The RD protocol may be supported by an HT STA and by a DMG STA. The normative behavior of the RD protocol defined in this subclause applies to both types of STAs. For an HT STA, the RDG/More PPDU subfield and the AC Constraint subfield are present in the HTC field, and for a DMG STA, the RDG/More PPDU subfield and the AC Constraint subfield are present in the QoS Control field.

9.25.1 Reverse Direction (RD) exchange sequence

Change item a) of the first paragraph of 9.25.1 as follows:

a) The transmission of a PPDU by a TXOP holder or SP source containing an RD grant (the *RDG PPDU*), which is indicated by the PPDU containing one or more +HTC/DMG MPDUs in which the RDG/More PPDU subfield is equal to 1. The STA that transmits this PPDU is known as the *RD initiator*. The rules for an RD initiator apply only during a single RD exchange sequence, i.e., after the transmission of an RDG PPDU and up to the end of the last PPDU in the RD exchange sequence.

Change the note after the first paragraph in 9.25.1 as follows:

NOTE—An RD initiator might include multiple RD exchange sequences within a single TXOP or SP. Each RD exchange sequence within a single TXOP or SP might be addressed to a different recipient, and any single recipient might be given more than one RDG within a single TXOP or SP.

9.25.2 Support for RD

Change 9.25.2 as follows:

Support of the RD feature is an option for an HT STA and a DMG STA. It is optional in the sense that a TXOP holder or SP source is never required to generate an RDG, and a STA receiving an RDG is never required to use the grant.

An HT STA indicates s~~S~~upport of the RD feature as an RD responder ~~is indicated~~ using the RD Responder subfield of the HT Extended Capabilities field of the HT Capabilities element. A STA shall set the RD Responder subfield to 1 in frames that it transmits containing the HT Capabilities element if dot11RDResponderOptionImplemented is true. Otherwise, the STA shall set the RD Responder subfield to 0.

A DMG STA indicates support of the RD feature using the Reverse Direction subfield of the DMG STA Capability Information field of the DMG Capabilities element. A STA shall set the Reverse Direction subfield to 1 in frames that it transmits containing the DMG Capabilities element if dot11RDResponderOptionImplemented is true. Otherwise, the STA shall set the Reverse Direction subfield to 0.

9.25.3 Rules for RD initiator

Change the third to sixth paragraphs in 9.25.3 as follows:

Transmission of a +HTC/DMG frame by an RD initiator with the RDG/More PPDU subfield equal to 1 (either transmitted as a non-A-MPDU frame or within an A-MPDU) indicates that the duration indicated by the Duration/ID field is available for the RD response burst and RD initiator final PPDU (if present).

An RD initiator that sets the RDG/More PPDU field to 1 in a +HTC/DMG frame shall set the AC Constraint subfield to 1 in that frame if the allocation is a TXOP and the TXOP was gained through the EDCA channel access mechanism and shall otherwise set it to 0.

An RD initiator shall not transmit a +HTC/DMG frame with the RDG/More PPDU subfield set to 1 that requires a response MPDU that is not one of the following:

— Ack
— Compressed BlockAck

Subject to TXOP or SP constraints, after transmitting an RDG PPDU, an RD initiator may transmit its next PPDU as follows:

a) *Normal continuation*: The RD initiator may transmit its next PPDU a minimum of a SIFS after receiving a response PPDU that meets one of the following conditions:
   1) Contains one or more correctly received +HTC/DMG frames with the RDG/More PPDU subfield equal to 0, or
   2) For an HT STA, c~~C~~ontains one or more correctly received frames that are capable of carrying the HT Control field but did not contain an HT Control field, or
   3) Contains a correctly received frame that requires an immediate response, or
   4) For a DMG STA, none of the correctly received frames in the PPDU carry the QoS Control field.
b) *Error recovery*: The RD initiator may transmit its next PPDU when the CS mechanism (see 9.3.2.2) indicates that the medium is idle at the TxPIFS slot boundary (defined in 9.3.7) (this transmission is a continuation of the current TXOP or SP).

Change and number the following note, and insert a new note at the end of 9.25.3:

NOTE 1—In a non-DMG network t~~T~~he RD initiator can transmit a CF-End frame according to the rules for TXOP truncation in 9.19.2.7 following a RD transmit sequence. An RD responder never transmits a CF-End.

NOTE 2—In a DMG network, the RD initiator can transmit a CF-End frame according to the rules for TXOP truncation in 9.19.2.7 or SP truncation in 9.33.8, as appropriate, following a RD transmit sequence. An RD responder never transmits a CF-End.

9.25.4 Rules for RD responder

Change 9.25.4 as follows:

An RD responder shall transmit the initial PPDU of the RD response burst a SIFS after the reception of the RDG PPDU. PPDUs in a response burst are separated by SIFS or RIFS. The RIFS rules in the RD are the same as in the forward direction; the use of RIFS is constrained as defined in 9.3.2.3.2 and 9.23.3.3.

NOTE—The transmission of a response by the RD responder does not constitute a new channel access but a continuation of the RD initiator's TXOP or SP. An RD responder ignores the NAV when responding to an RDG.

The recipient of an RDG may decline the RDG by

— Not transmitting any frames following the RDG PPDU when no response is otherwise required, or
— Transmitting a control response frame with the RDG/More PPDU subfield set to 0, or
— Transmitting a control response frame that contains no HT Control field

An RD responder that is a non-DMG STA may transmit a +CF-ACK non-A-MPDU frame in response to a non-A-MPDU QoS Data +HTC MPDU that has the Ack Policy field set to Normal Ack and the RDG/More PPDU subfield equal to 1.

The RD responder shall ensure ~~verify~~ that its PPDU transmission(s) and any expected responses fit entirely within the remaining TXOP or SP duration, as indicated in the Duration/ID field of MPDUs within the RDG PPDU.

An RD responder shall not transmit an MPDU (either individually or aggregated within an A-MPDU) that is not one of the following:

— ACK
— Compressed BlockAck

— Compressed BlockAckReq
— QoS data
— Management

If the AC Constraint subfield is equal to 1, the RD responder shall transmit data frames of only the same AC as the last frame received from the RD initiator. For a BlockAckReq or BlockAck frame, the AC is determined by examining the TID field. For a management frame, the AC is AC_VO. The RD initiator shall not transmit a +HTC/DMG MPDU with the RDG/More PPDU subfield set to 1 from which the AC cannot be determined. If the AC Constraint subfield is equal to 0, the RD responder may transmit data frames of any TID.

During an RDG, the RD responder shall not transmit any frames with an Address 1 field that does not match the MAC address of the RD initiator.

If an RDG PPDU also requires an immediate BlockAck response, the BlockAck response frame shall be included in the first PPDU of the response.

When a PPDU is not the final PPDU of a response burst, an HT Control field carrying the RDG/More PPDU subfield set to 1 shall be present in every MPDU within the PPDU capable of carrying the HT Control field, or if the PPDU is transmitted in a DMG BSS, the RDG/More PPDU subfield within the QoS Control field shall be set to 1 in every MPDU within the PPDU. The last PPDU of a response burst shall have the RDG/More PPDU subfield set to 0 in all +HTC/DMG MPDUs contained in that PPDU.

The RD responder shall not set the RDG/More PPDU subfield to 1 in any MPDU in a PPDU that contains an MPDU that requires an immediate response.

NOTE—If the RD responder transmits a PPDU that expects a transmission by the RD initiator after SIFS and no such transmission is detected, the RD responder has to wait for either another RDG or its own TXOP or SP before it can retry the exchange.

After transmitting a PPDU containing one or more +HTC/DMG MPDUs in which the RDG/More PPDU subfield is equal to 0, the RD responder shall not transmit any more PPDUs within the current response burst.

NOTE 1—If an RD-capable STA that is not the TXOP holder or SP source receives a PPDU that does not indicate an RDG, there is no difference in its response compared to a STA that is not RD-capable.

NOTE 2—The RD responder can set the RDG/More PPDU subfield to 1 in response to a frame sent by the RD initiator that has the RDG/More PPDU subfield equal to 0.

9.26 PSMP operation

Insert the following subclause, 9.26.0a, before 9.26.1:

9.26.0a General

A DMG STA shall not use PSMP.

9.32 Mesh forwarding framework

Insert the following subclauses, 9.33 through 9.39.4 (including Figure 9-43 through Figure 9-80 and Table 9-16), after 9.32.9:

9.33 DMG channel access

9.33.1 General

Channel access by a DMG STA occurs during beacon intervals and is coordinated using a schedule. A DMG STA operating as a PCP or AP generates the schedule and communicates it to STAs using DMG Beacon and Announce frames. A non-PCP STA that is a non-AP STA and that receives scheduling information accesses the medium during the scheduled periods using the access rules specific to that period. Medium access rules to establish a BSS are defined in 9.34 and 10.1.4.

In the ATI, a non-PCP/non-AP STA shall be ready to receive a transmission from the PCP/AP at least RxAdvanceTime before the expected transmission of a request frame. The destination STA of an SP shall be ready to receive a transmission from the source STA of the SP at least RxAdvanceTime before the start of the SP. A STA that participates in a CBAP shall be ready to receive a transmission within the CBAP at least RxAdvanceTime before the start of the CBAP plus DIFS. In the A-BFT, the PCP/AP should be ready to receive a transmission from a non-PCP/non-AP STA at least RxAdvanceTime before the start of an SSW slot. In all the preceding rules, RxAdvanceTime is defined as follows:

$$RxAdvanceTime = ceiling\ ([ClockAccuracy\ (\text{ppm}) \times 10^{-6}] \times DriftInterval + aAirPropagationTime, aTSFResolution)$$

where

DriftInterval is the time elapsed since a synchronizing reference event. The synchronizing event is the reception of the Timestamp field from the PCP/AP.

9.33.2 Access periods within a beacon interval

Medium time within a DMG BSS is divided into beacon intervals. Subdivisions within the beacon interval are called access periods. Different access periods within a beacon interval have different access rules. The access periods are described in a schedule that is communicated by the PCP or AP to the non-PCP and non-AP STAs within the BSS. The schedule communicated by the PCP or AP can include the following access periods:

— **BTI:** An access period during which one or more DMG Beacon frames is transmitted. Not all DMG Beacon frames are detectable by all non-PCP and non-AP STAs. Not all beacon intervals contain a BTI. A non-PCP STA that is a non-AP STA shall not transmit during the BTI of the BSS of which it is a member.
— **A-BFT:** An access period during which beamforming training is performed with the STA that transmitted a DMG Beacon frame during the preceding BTI. The presence of the A-BFT is optional and signaled in DMG Beacon frames.
— **ATI:** A request-response based management access period between PCP/AP and non-PCP/non-AP STAs. The presence of the ATI is optional and signaled in DMG Beacon frames.
— **DTI:** An access period during which frame exchanges are performed between STAs. There is a single DTI per beacon interval.

The DTI, in turn, comprises contention-based access periods (CBAPs) and scheduled service periods (SPs).

Figure 9-43 illustrates an example of access periods within a beacon interval comprising a BTI, an A-BFT, an ATI, and two CBAPs and SPs within the DTI. Any combination in the number and order of SPs and CBAPs can be present in the DTI.

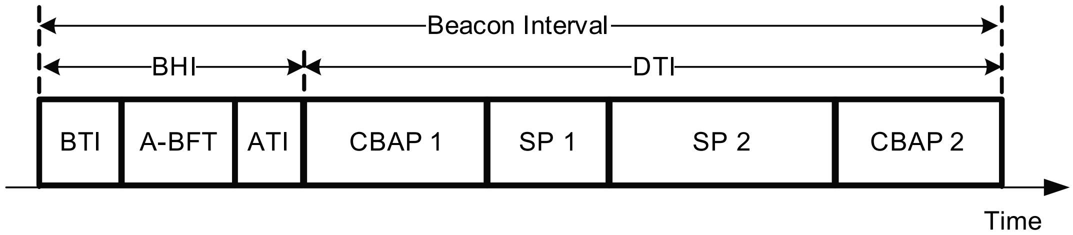


Figure 9-43—Example of access periods within a beacon interval

The details of the access protocol within each of the access periods are described in the remaining subclauses of 9.33 and within 9.35.

9.33.3 ATI transmission rules

The presence of an ATI in the current beacon interval is signaled by the ATI Present field set to 1 in the current DMG Beacon (8.3.4.1). The Next DMG ATI element (8.4.2.137) transmitted in the Announce frame or in the DMG Beacon frame indicates the earliest start time for the next ATI in a subsequent beacon interval and ATI duration.

An example of an ATI is shown in Figure 9-44.

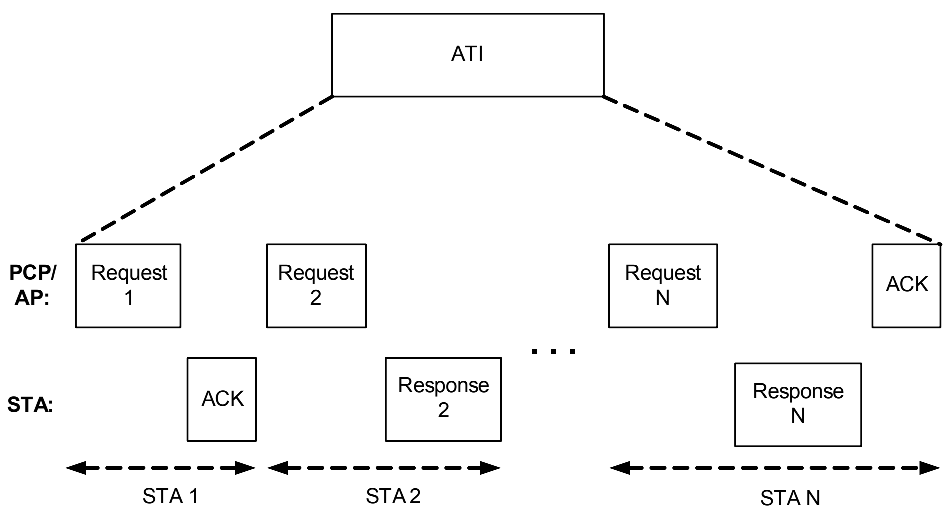


Figure 9-44—Example of frame exchanges during the ATI

During an ATI, request and response frames are exchanged between the PCP/AP and any subset of STAs. The PCP/AP initiates all frame exchanges that occur during the ATI. The ATI shall not start sooner than Max(guard time, MBIFS) following the end of the previous A-BFT when an A-BFT is present in the beacon interval or following the end of the previous BTI when an A-BFT is not present but a BTI is present in the beacon interval. The ATI shall not start before TBTT if the ATI is the first period in the beacon interval (the ATI is never the first period in the beacon interval in an infrastructure BSS; see 10.1.2.1). Once the ATI starts, the PCP/AP may start transmission of a request frame immediately or it may delay the transmission of the request frame if the medium is determined by the CCA mechanism to be busy.

During each ATI the PCP/AP shall schedule transmissions to a non-PCP/non-AP STA if the non-PCP/non-AP STA Heartbeat field in the STA's DMG Capabilities element within the Association Request frame of the last successful association attempt is 1 and the non-PCP/non-AP STA is in the Awake state. If the non-PCP/non-AP STA does not respond to the frame transmitted by the PCP/AP, the PCP/AP shall use the DMG Control modulation class (9.7.5a.1) at its next transmission attempt to the non-PCP/non-AP STA. The PCP/AP shall use the DMG Control modulation class for all subsequent transmissions to the non-PCP/non-AP STA until it receives a valid frame from the non-PCP/non-AP STA.

A non-PCP/non-AP STA shall not transmit during the ATI except in response to a received individually addressed frame whose TA field contains the PCP/AP's MAC address and whose RA field contains the STA's MAC address.

During the ATI STAs shall not transmit frames that are not request or response frames. Request and response frames transmitted during the ATI shall be one of the following:

— A frame of type Management
— An ACK frame
— A Grant, Poll, RTS or DMG CTS frame when transmitted as a request frame
— An SPR or DMG CTS frame when transmitted as a response frame
— A frame of type Data only as part of an authentication exchange to reach a RSNA security association

NOTE—The Announce frame is designed to be used primarily during the ATI and can perform functions of a DMG Beacon frame.

The transmission of Poll frames during the ATI follows the rules described in 9.33.7. The Response Offset field within a Poll frame transmitted during the ATI shall be set to 0.

Individually addressed request frames transmitted during the ATI shall not be sent using management frames of subtype action no ACK.

During the ATI, after a PCP/AP transmits an individually addressed request frame (such as an Announce frame) to a non-PCP/non-AP STA, and the STA receives that frame, the STA shall transmit a response frame addressed to the PCP/AP. The transmission of the response frame shall commence one SIFS period after the successful reception of the request frame. The PCP/AP shall interpret the receipt of the response frame as an acknowledgment of the request frame. Response frames transmitted by non-PCP/non-AP STAs during the ATI shall be individually addressed to the PCP/AP.

NOTE—STAs do not transmit a response frame to the PCP/AP when they receive a request frame from the PCP/AP with the RA equal to a group address (see 9.3.2.9 and 9.3.6).

The Duration field of a request frame transmitted during the ATI shall be set to cover the remaining duration of the ATI at the end of the request frame transmission. The Duration field of a response frame transmitted during the ATI shall be set to the value of the Duration field within the previously received request frame minus SIFS and minus the duration of the response frame transmission.

When a transmission by a STA is expected by a PCP/AP and a SIFS period elapses without its receipt, the PCP/AP may either repeat its individually addressed transmission to that STA or, as early as one PIFS after the end of its previous transmission, transmit a frame to any other STA.

NOTE—If acknowledgment is required, the PCP/AP transmits an ACK frame to acknowledge the reception of a response frame during the ATI (see Figure 9-44).

Multiple request and response frame exchanges between the PCP/AP and a STA might occur during a single ATI.

During the ATI the PCP/AP should schedule transmissions to non-PCP/non-AP STAs in power save mode before transmissions to non-PCP/non-AP STAs that are not in power save mode.

9.33.4 DTI transmission rules

During the DTI, a STA may transmit frames (following the DMG channel access rules) if any of the following conditions are met:

a) During a CBAP for which the STA is identified or included as source or destination (9.33.6.3, 9.33.7, and 9.33.8)
b) During an SP for which the STA is identified as source or destination (9.33.6.2 and 9.33.7)

and shall not transmit if none of these conditions are met. A STA initiating data transfer shall check that the transaction, including acknowledgments, completes before the end of the CBAP or SP in which it was initiated.

When the entire DTI is allocated to CBAP (that is, the CBAP Only field is 1 in the DMG Parameters field), the ATI Present field within the DMG Beacon containing the DMG Parameters field shall be set to 0.

Non-PCP/non-AP DMG STAs shall be capable of processing the Poll and Grant frames and the Extended Schedule element. A PCP/AP shall be capable of processing the SPR frame transmitted by a non-PCP/non-AP STA and responding to a SPR frame with a Grant frame.

The DMG low-power SC PHY (21.7) may be used only within SPs that have the LP SC Used subfield within the Extended Schedule element equal to 1 and shall not be used otherwise. A STA supports the DMG low-power SC PHY if the Low-Power SC PHY Supported subfield within its DMG Capabilities element is 1. A STA that supports the DMG low-power SC PHY shall not transmit a PPDU using the DMG low-power SC PHY unless the STAs identified in the RA field of all MPDUs contained within the PPDU support the DMG low-power SC PHY. A STA can use the procedure described in 10.29.1 to discover the capabilities of another STA.

9.33.5 Contention-based access period (CBAP) transmission rules

The definition of contention-based transmission rules used within a CBAP is provided in 9.3 and in 9.19. This subclause specifies additional rules applicable to the CBAP.

A STA shall not transmit within a CBAP unless at least one of the following conditions is met:

— The value of the CBAP Only field is equal to 1 and the value of the CBAP Source field is equal to 0 within the DMG Parameters field of the DMG Beacon that allocates the CBAP
— The STA is a PCP/AP and the value of the CBAP Only field is equal to 1 and the value of the CBAP Source field is equal to 1 within the DMG Parameters field of the DMG Beacon that allocates the CBAP
— The value of the Source AID field of the CBAP is equal to the broadcast AID
— The STA's AID is equal to the value of the Source AID field of the CBAP
— The STA's AID is equal to the value of the Destination AID field of the CBAP

If a STA's AID is equal to the value of the Source AID field of a CBAP allocation or if a STA performs in the role of PCP/AP and both the CBAP Only and CBAP Source fields are equal to 1 in the DMG Beacon that allocates a CBAP, the STA may initiate a frame transmission within the CBAP immediately after the medium is determined to be idle for one PIFS period.

A BF initiator (9.35) should not initiate an SLS phase within a CBAP if there is not enough time within the CBAP to complete the SLS phase.

A STA shall not extend a transmission frame exchange sequence that started during a CBAP beyond the end of that CBAP. A STA that initiates a sequence shall check that the frame exchange sequence, including any control frame responses, completes before the end of the CBAP.

At the beginning of a TXOP with a TXOP responder that has the Heartbeat field in the TXOP responder's DMG Capabilities element equal to 1, the following rules apply:

— The TXOP holder shall transmit a frame to the TXOP responder using the DMG Control modulation class before it uses any other modulation class for transmission if the time elapsed since the last frame received from the TXOP responder is larger than or equal to the Heartbeat Elapsed Time value computed using the Heartbeat Elapsed Indication field within the TXOP responder's DMG Capabilities element.

— The TXOP holder may transmit a frame using a modulation class other than the DMG Control modulation class at the start of the TXOP if the time elapsed since the last frame received from the TXOP responder is shorter than the Heartbeat Elapsed Time value computed using the Heartbeat Elapsed Indication field within the TXOP responder's DMG Capabilities element.

The frame sent by the STA at the beginning of the TXOP may be an RTS or a DMG CTS-To-Self.

Within a CBAP a STA with multiple DMG antennas should use only one DMG antenna in its frame transmission, CCA and frame reception, except if it is the initiator or responder in an SLS (9.35). The algorithm to select a DMG antenna and switch the active DMG antenna is implementation dependent. Within CBAPs a STA that changed to a different DMG antenna in order to transmit should perform CCA on that DMG antenna until a frame sequence is detected by which it can correctly set its NAV, or until a period of time equal to the dot11DMGProbeDelay has transpired, whichever is earlier.

9.33.6 Channel access in scheduled DTI

9.33.6.1 General

The PCP/AP schedules each allocation with a specified start time from the TSF and with a fixed duration. An allocation can be an SP, where ownership of channel time is granted to a single STA, or a CBAP, where STAs can compete for channel access. The PCP/AP shall reference the start time of each allocation from the TSF.

The PCP/AP may schedule SPs or CBAPs only during the DTI of a beacon interval, following the end of an allocated BTI, A-BFT, and ATI when any of these periods are present in the beacon interval.

The schedule of the DTI of a beacon interval is communicated through the Extended Schedule element. The PCP/AP shall transmit the Extended Schedule element in either or both an Announce frame or a DMG Beacon frame. The Extended Schedule element shall contain the scheduling information of all allocations in the DTI. The same Allocation field shall not appear more than once in the Extended Schedule element transmitted in a beacon interval. The content of the Extended Schedule element communicated in a beacon interval shall not change if transmitted more than once in the beacon interval, except that if the STA transmitting the Extended Schedule element is a PCP with multiple DMG antennas then the value of the PCP Active field of CBAP allocations within the Extended Schedule element might change when this element is transmitted through different DMG antennas. The PCP/AP should schedule SPs for a STA such that the scheduled SPs do not overlap in time with the traffic scheduling constraints indicated by this STA in the TSCONST field of the associated DMG TSPEC element.

When scheduling a nonpseudo-static SP or changing the start time of an existing pseudo-static SP that has a non-PCP/non-AP STA as a source DMG STA or as a destination DMG STA of the SP, a PCP/AP shall set the start time of the SP to no less than aMinAllocationDeliveryTime after the last Extended Schedule element containing this SP is transmitted by the PCP/AP.

NOTE—This rule does not apply to the case when a PCP/AP schedules a new pseudo-static SP.

An SP or CBAP allocation within an Extended Schedule element may comprise one or more individual allocations. The start time of each individual allocation of an SP or CBAP is given by

$$(A\_start + (i - 1) \times A\_period)$$

where

A_start	is the value of the Allocation Start field for the SP or CBAP
A_period	is the value of the Allocation Block Period field for the SP or CBAP
i	is an integer greater than 0 and less than or equal to the value of the Number of Blocks field for the SP or CBAP

The end of the i^{th} individual SP or CBAP allocation is computed by adding the start time of the i^{th} individual allocation to the value of the Allocation Block Duration field for the corresponding SP or CBAP allocation.

If the PCP Active subfield in the Allocation field for an allocation within an Extended Schedule element is 1, the PCP shall be in the receive state for the duration of that allocation, except when transmitting during that allocation. The AP shall set the PCP Active field to one for every allocation within an Extended Schedule element transmitted by the AP.

9.33.6.2 Service period (SP) allocation

The PCP/AP shall set the AllocationType subfield to 0 in an Allocation field within an Extended Schedule element to indicate an SP allocation.

An SP is assigned to the source DMG STA identified in the Source AID subfield in an Allocation field within the Extended Schedule element. The source DMG STA shall initiate the frame exchange sequence that takes place during the SP at the start of the SP, except when the source DMG STA intends to establish a DMG Protected Period in which case the rules described in 9.33.6.6 shall be followed before the source DMG STA initiates the frame exchange in the SP. The SP allocation identifies the TC or TS for which the allocation is made; however, the type of traffic transmitted is not restricted to the specified TC or TS (10.4.1).

Except when transmitting a frame as part of the SP recovery procedure (9.33.6.7) or transmitting a response to the source DMG STA or transmitting a PPDU as part of a RD response burst (9.25), the STA identified by the Destination AID field in the Extended Schedule element should be in the receive state for the duration of the SP in order to receive transmissions from the source DMG STA. If the Destination AID field of the scheduled SP is equal to the broadcast AID and if the Source AID field of the scheduled SP is not equal to the broadcast AID, then all STAs on the PBSS/infrastructure BSS should be in the receive state in order to receive transmissions from the source DMG STA for the duration of the SP. Subclause 9.33.7 describes the rules for when the scheduled SP has both the Source and Destination AID fields equal to the broadcast AID.

Only a STA identified as the source DMG STA or destination DMG STA of an SP shall transmit during the SP, except when the rules in 9.33.7, 9.33.8, or 9.33.9 are used.

At the beginning of an SP, except when the source DMG STA intends to establish a DMG Protected Period in which case the rules described in 9.33.6.6 shall be followed before the source DMG STA initiates the frame exchange in the SP, a source DMG STA shall transmit a frame to the destination DMG STA using the DMG Control modulation class before it uses any other modulation class for transmission if the Heartbeat field in the destination DMG STA's DMG Capabilities element is 1. The frame sent by the STA may be an RTS or a DMG CTS-To-Self. The frame sent by the STA may be a SSW frame or a BRP packet if the STA is performing beamforming (9.7.5a.5).

At the beginning of an SP, a destination DMG STA shall transmit a frame to the source DMG STA using the DMG Control modulation class before it uses any other modulation for transmission if the Heartbeat field in the source DMG STA's DMG Capabilities element is 1 and the frame sent by the destination DMG STA is the unsolicited DMG DTS as first frame in the SP of the STA performing DMG Protected Period (9.33.6.6).

Any MAC entity coordinated by an MM-SME that belongs to an MMSL cluster identified by the Source AID and Destination AID that are equal to, respectively, the Source AID and Destination AID of the Allocation field in the Extended Schedule element that allocates the SP may transmit during the SP, if the STA sent an MMS element to the peer STA and the BeamLink Cluster field within the MMS element is 1.

The PCP/AP may create SPs in its beacon interval with the source and destination AID subfields within an Allocation field set to 255 to prevent transmissions during specific periods in the beacon interval.

The PCP/AP shall set the Beamforming Training subfield to one in the Allocation field for an SP within an Extended Schedule element to indicate that the source DMG STA of this SP initiates beamforming training with the destination DMG STA at the start of that SP. The source DMG STA and destination DMG STA of the SP shall perform beamforming training as described in 9.35.

If the PCP Active subfield is 0 in the Allocation field for an SP within an Extended Schedule element, neither the destination DMG STA of the SP nor the source DMG STA of the SP shall transmit to the PCP during the SP if none of the STAs are the PCP.

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

When scheduling two adjacent SPs, the PCP/AP should allocate the SPs separated by at least aDMGPPMinListeningTime if one or more of the source or destination DMG STAs participate in both SPs.

Except for frames used for beamforming as described in 9.35, the source of an SP may retransmit a frame PIFS after the end of the frame transmission in case a response frame is expected from the destination DMG STA and a SIFS period elapses without receipt of the expected transmission.

The source DMG STA can relinquish the remainder of an SP to the destination DMG STA by sending a Grant frame to the destination DMG STA (9.33.7.3).

9.33.6.3 Contention-based access period (CBAP) allocation

The PCP/AP shall set the AllocationType subfield to 1, the Source AID subfield to the broadcast AID or to the AID of the source of the CBAP, and the Destination AID subfield to the broadcast AID or to the AID of the destination of the CBAP in an Allocation field within an Extended Schedule element to indicate a CBAP allocation.

All CBAPs are allocated by the PCP/AP, except when allocated by a non-PCP/non-AP STA with the transmission of a Grant frame following an SP truncation (9.33.8). Multiple CBAPs may be present in a beacon interval, with the location and duration of each determined by the PCP/AP and announced in the

Extended Schedule element. When only one CBAP is present and no other allocations exist for the DTI, then the PCP/AP shall announce the presence of the CBAP by setting the CBAP Only field to 1 in the DMG Parameters field of the DMG Beacon. If at least one non-CBAP allocation is present, or more than one CBAP are present, or no allocations are present within a DTI, then the PCP/AP shall set the CBAP Only field to 0 in the DMG Parameters field in the DMG Beacon transmitted during the BTI. The PCP/AP shall set the CBAP Only field to 0 in the DMG Parameters field within a transmitted DMG Beacon if the DMG Beacon contains at least one Extended Schedule element.

When the entire DTI is allocated to CBAP through the CBAP Only field in the DMG Parameters field, then that CBAP is pseudo-static and exists for dot11MaxLostBeacons beacon intervals following the most recently transmitted DMG Beacon that contained the indication, except if the CBAP is canceled by the transmission by the PCP/AP of a DMG Beacon with the CBAP Only field of the DMG Parameters field equal to 0 or an Announce frame with an Extended Schedule element. A guard time (9.33.6.5) precedes a CBAP that is allocated through the CBAP Only field equal to 1.

Channel access during a CBAP shall follow the rules described in 9.33.5.

9.33.6.4 Pseudo-static allocations

An SP or CBAP allocation is pseudo-static if the Pseudo-static field in the Allocation control field for the SP or CBAP is 1, or when the Extended Schedule element is not used and the CBAP Only field within the DMG Parameters field of the DMG Beacon frame is 1 (9.33.6.3). A pseudo-static SP or CBAP recurs at the same relative offset to TBTT and with the same duration in up to dot11MaxLostBeacons beacon intervals following the last received Extended Schedule element containing the pseudo-static allocation or DMG Beacon with the CBAP Only field equal to 1.

A STA might fail to receive up to dot11MaxLostBeacons minus 1 Extended Schedule elements or DMG Beacon with the CBAP Only field equal to 1 in consecutive beacon intervals and still may access the channel during the pseudo-static SP or CBAP. The STA shall cease transmission during a pseudo-static allocation if it fails to receive an Extended Schedule element or DMG Beacon with the CBAP Only field equal to 1 for dot11MaxLostBeacons consecutive beacon intervals.

The PCP/AP may change the offset relative to TBTT or the duration of a pseudo-static allocation by transmitting a modified Allocation field in an Extended Schedule element before dot11MaxLostBeacons beacon intervals from the last transmitted Extended Schedule element. The PCP/AP may delete a pseudo-static allocation by transmitting an Extended Schedule element that does not include an allocation field containing that allocation’s TID, source AID, and destination AID before the completion of dot11MaxLostBeacons beacon intervals from the last transmitted Extended Schedule element. In either case, the PCP/AP should not schedule a new allocation that overlaps with the previous pseudo-static allocation for a minimum of dot11MaxLostBeacons beacon intervals unless both the new and previous allocation are for a CBAP or the new allocation identifies the same source DMG STA as the original pseudo-static allocation.

To maintain the same position of the allocation with respect to the start of a beacon interval, the value of the Allocation Block Period subfield within an Allocation field of the Extended Schedule element shall be set to be an integer multiple or submultiple of the beacon interval duration.

If the destination DMG STA of a pseudo-static allocation receives an Extended Schedule element with an Allocation field that indicates a change in the schedule of the pseudo-static allocation, the STA should enter receive state during the new pseudo-static allocation and may enter receive state during the previous allocation to account for the time it can take the source DMG STA of the allocation to receive the updated schedule.

9.33.6.5 Guard time

Guard time is the time between the end of one allocation and the start of the following allocation, provided these allocations are not under spatial sharing (10.31). For the purpose of guard time insertion, an allocation is defined as an SP, a CBAP, and a BTI or A-BFT or ATI that is immediately followed by a CBAP allocated through the CBAP Only field (9.33.6.3). Guard times are used to keep transmissions in adjacent allocations from colliding. Figure 9-45 shows an example of the insertion of the guard time such that the allocations are separated by at least the guard time, in case the STAs participating in the adjacent allocations drift towards each other's allocation.

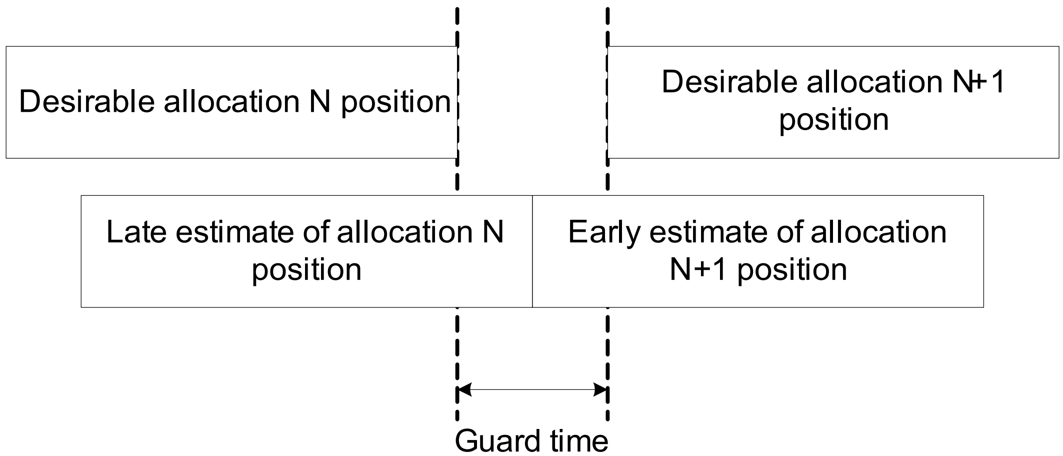


Figure 9-45—The guard time

The PCP/AP inserts a sufficient guard time between adjacent allocations to insure that transmissions in adjacent allocations do not overlap in time. For each of the adjacent allocations, guard times are calculated based on the worst case drift and the maximum allowed number of lost DMG Beacons. The PCP/AP shall insert a guard time between adjacent allocations that is not shorter than

$$GuardTime = ceiling((MLB_{Allocation\_i} + 1) \times ([ClockAccuracy \text{ (ppm)} \times 10^{-6}] \times DriftInterval_{Allocation\_i}) + (MLB_{Allocation\_i+1} + 1) \times ([ClockAccuracy \text{ (ppm)} \times 10^{-6}] \times DriftInterval_{Allocation\_i+1}) + SIFS + aAirPropagationTime, aTSFResolution)$$

where

The value of $MLB_{Allocation\_i}$ (and $MLB_{Allocation\_i+1}$) for each allocation depends on whether the allocation is pseudo-static. $MLB_{Allocation\_i}$ (and $MLB_{Allocation\_i+1}$) is 0 for a nonpseudo-static allocation and is equal to dot11MaxLostBeacons if the allocation is pseudo-static.

ClockAccuracy is equal to aClockAccuracy.

$DriftInterval_{Allocation\_i}$ (and $DriftInterval_{Allocation\_i+1}$) is the time elapsed since a synchronizing reference event and is not greater than the beacon interval. The synchronizing event is the reception of the Timestamp field from the PCP/AP. For a pseudo-static allocation, $DriftInterval_{Allocation\_i}$ (and $DriftInterval_{Allocation\_i+1}$) is equal to the beacon interval.

aAirPropagationTime accounts for the propagation delay between the STAs participating in the adjacent allocations.

aTSFResolution is the resolution of the TSF timer (10.38).

The function ceiling(x, y) shall return the value of x rounded towards positive infinity, with rounding to the nearest multiple of y.

9.33.6.6 DMG Protected Period

9.33.6.6.1 Introduction

Communicating STA pairs of neighboring PBSS/infrastructure BSS might be granted SPs that potentially create interference for neighbor PBSS/infrastructure BSS STA pairs. SPs within a PBSS/infrastructure BSS can also experience such interference when spatial diversity conditions change. The intent of DMG Protected Period is to minimize such interference by allowing any pair of STAs to protect their SP and thereby limit the transmission of frames during the DMG Protected period to not more than one pair of a set of potentially interfering pairs of communicating stations.

A DMG Protected Period can be created by the source DMG STA during an SP, and shall be created by the source DMG STA if at least one of the following conditions is met:

— The source DMG STA is the PCP/AP of the BSS, the ECPAC Policy Enforced subfield within the DMG Parameters field of the last DMG Beacon frame transmitted by the source DMG STA is equal to 1, and the Protected Period Enforced field within the ECPAC Policy Detail field of the last ECPAC Policy element transmitted by the source DMG STA is equal to 1.

— The source DMG STA is not the PCP/AP of the BSS, the ECPAC Policy Enforced subfield within the DMG Parameters field of the last DMG Beacon frame received by the source DMG STA from the PCP/AP of the BSS is equal to 1, and the Protected Period Enforced field within the ECPAC Policy Detail field of the last ECPAC Policy element received by the source DMG STA from the PCP/AP of the BSS is equal to 1.

Both the source DMG STA and destination DMG STA of an SP are owners of the DMG Protected Period. During any DMG Protected Period, both stations can receive frames from the other participant.

A DMG STA that creates a DMG Protected Period during an SP in which it is a source DMG STA or a destination DMG STA moves to and stays in Listening Mode during time interval that starts before the start of the SP and remains in the Listening mode until it is allowed to use the SP. The actual duration of the time the STA stays in the Listening Mode is limited by the aDMGPPMinListeningTime parameter. The intent of the Listening Mode is that the DMG STA listens to other DMG STAs that may have an SP that overlaps with the SP where the DMG STA is a source DMG STA or a destination DMG STA. The NAV mechanism is used to indicate the time occupancy and the DMG STA in the Listening Mode updates NAV timers. If the NAV timers are not equal to 0, the DMG STA does not use the time of the SP in which it is a source DMG STA or a destination DMG STA. If none of the NAV timers has a nonzero value at the start of the SP, the DMG STA is allowed to leave the Listening Mode and use the SP. If at least one of the NAV timers has a nonzero value at the start of the SP, the DMG STA is allowed to leave the Listening Mode and to use the time remaining in the SP after all NAV timers become or already have value zero.

Listening Mode is a mode of operation during which a DMG STA is in receiving state and meets at least one of the following conditions:

a) Its receiving antenna are in the quasi-omni mode.

b) Its receiving antenna are directed to the peer DMG STA for which this DMG STA is either the destination or source DMG STA.

A DMG Protected Period is established through an RTS/DMG CTS handshake. To create a DMG Protected Period, the source DMG STA of an SP sends an RTS, and the recipient STA responds with a DMG CTS. If the recipient STA responds with a DMG CTS, then a DMG Protected Period is established; otherwise, no DMG Protected Period has been established. In all cases of DMG Protected Period establishment, the same antenna configurations that are used by the STAs that establish the DMG Protected Period are used for the exchange of frames during the DMG Protected Period.

9.33.6.6.2 DMG Protected Period establishment and maintenance

A DMG STA that attempts to create a DMG Protected Period during an SP shall transition to Listening Mode not less than aDMGPPMinListeningTime before the attempt and shall remain in Listening Mode for at least aDMGPPMinListeningTime before making the attempt.

A STA shall not issue an RTS to establish a DMG Protected Period if any of its NAV timers is not equal to zero.

A DMG STA that transmits an RTS to establish a DMG Protected Period during an SP in which it is a source DMG STA shall not transmit the RTS outside of the SP and the value of the Duration field of the RTS shall not exceed the duration of the portion of the SP that remains following the RTS transmission.

In order to maintain STAs that are not aware of the establishment of the DMG Protected Period because they have begun listening to the medium after the establishment of a DMG Protected Period, a STA that established a DMG Protected period should transmit additional RTSs. An additional RTS should be sent at the end of every (aDMGPPMinListeningTime – aRTSTimeoutTime) interval during the DMG Protected Period if the duration of the RTS/DMG CTS exchange is less than the time remaining in the SP.

A DMG STA that transmitted an RTS that established a DMG Protected Period shall transmit data frames during the DMG Protected Period using the same antenna configuration as was used for the transmission of the RTS.

A DMG STA should transition to Listening Mode not less than aDMGPPMinListeningTime before the start of an SP in which it is the destination DMG STA.

During an SP in which it is the destination DMG STA, a DMG STA that receives a valid RTS with the RA equal to the recipient DMG STA MAC address and the TA corresponding to the source DMG STA of the SP shall respond with a DMG CTS if the recipient DMG STA has been in Listening Mode for aDMGPPMinListeningTime at the start of the reception of the RTS and none of its NAV timers has a nonzero value.

During an SP in which it is the destination DMG STA, a DMG STA that receives a valid RTS with the RA equal to the recipient DMG STA MAC address and the TA corresponding to the source DMG STA of the SP shall not respond with a DMG CTS if at the start of the reception of the RTS the recipient DMG STA has a nonzero value in at least one of its NAV timers or the recipient DMG STA has not been in Listening Mode for at least aDMGPPMinListeningTime.

During an SP in which it is the destination DMG STA, a DMG STA that receives a valid RTS with the RA equal to the recipient DMG STA MAC address and the TA corresponding to the source DMG STA of the SP may respond with a DMG DTS if at the start of the reception of the RTS the recipient DMG STA has a nonzero value in at least one of its NAV timers.

A DMG STA may transmit a DMG DTS after expiration of the aRTSTimeoutTime time following the start of an SP in which it is the destination DMG STA, if any of its NAV timers has a nonzero value at that time and no RTS has been received from the source DMG STA of the SP and the DMG STA has been in Listening Mode for aDMGPPMinListeningTime immediately preceding the start of transmission of the DMG DTS. The destination DMG STA shall not transmit a DMG DTS if any portion of the DMG DTS would be transmitted outside of the SP.

The value in the Duration field of a DMG DTS shall be calculated by subtracting the DMG DTS transmission time from the NAV timer in the destination DMG STA that has the largest value at the time of the start of the transmission of the DMG DTS. The NAV-DA and NAV-SA fields shall be set to the MAC addresses that identify the NAV timer in the destination DMG STA that was used to determine the Duration field value of the DMG DTS.

During an SP in which it is the destination DMG STA, a DMG STA that receives a valid RTS with the RA equal to the recipient DMG STA MAC address and the TA corresponding to the source DMG STA of the SP may respond with a DMG DTS if at the start of the reception of the RTS the recipient DMG STA has not been in Listening Mode for at least aDMGPPMinListeningTime. The value of the Duration field of the DMG DTS sent by the recipient DMG STA shall include the difference of aDMGPPMinListeningTime and the elapsed time since the recipient DMG STA has been in Listening Mode, and the NAV-SA and the NAV-DA fields of the DMG DTS shall contain the recipient DMG STA MAC address.

A destination DMG STA that responds to an RTS with a DMG CTS or DMG DTS shall transmit the response frame a SIFS interval after the end of the received RTS. A destination DMG STA that transmits either a DMG CTS or a DMG DTS shall use the same antenna configuration for the subsequent transmission of ACK frames and data frames within the SP as is used for the transmission of the DMG CTS or DMG DTS.

The source DMG STA of an SP can send a CF-End to the destination DMG STA of the SP to truncate a DMG Protected Period. Regardless of whether this CF-End is sent, a CF-End is also sent to the PCP/AP (see 9.33.8).

9.33.6.6.3 NAV Update in DMG Protected Period

STAs in the Listening Mode shall update their NAV timers according to the procedures described in 9.33.10.

NOTE—Support of multiple NAV timers as defined in 9.33.10 is not limited to be used in the Listening Mode only and is also used in any case a NAV update is performed.

When an SP terminates, either through time allocation expiration or truncation, then the source DMG STA of that SP may reset any NAV timer to 0 that has an associated variable NAV_DTSCANCELABLE with a value of true.

9.33.6.6.4 Interference report

A STA that receives an RTS and/or DMG CTS frame that updates the NAV and that overlaps in time with an SP where the STA is destination or source, may report the overlap to the PCP/AP by sending a DMG ADDTS Request frame variant (8.5.3.3.2) and including in the DMG TSPEC element (8.4.2.136) the indication of interference in the TSCONST field (Figure 8-401ag). Transmission of the DMG ADDTS Request frame variant shall follow the rules defined in 10.4, with the following exceptions.

The Allocation ID field of the DMG TSPEC element shall identify the allocation during which the interference was detected. One ADDTS Request frame is generated and transmitted for each allocation during which interference is detected.

The TSCONST field of the DMG TSPEC element may contain one or more Traffic Scheduling Constraint fields. Each Traffic Scheduling Constraint field provides information separately for each overlapping NAV event. The following NAV events should be reported:

a) Nonzero NAV at start of SP
b) Extension of NAV during the SP, including extension of an initial nonzero NAV and transitioning of the NAV from zero to nonzero value during the SP

c) Truncation of the NAV during the SP

The TSCONST Start Time field is set to the TSF value at which the NAV event is detected. For event a) above, the TSCONST Start Time field shall be set to the start of the SP. For event b) above, the TSCONST Start Time field shall be set to the time the NAV timer was updated or initialized to the value reported in the TSCONST Duration field. For event c) above, the TSCONST Start Time field shall be set to the time the NAV timer was reset.

The TSCONST Duration field shall be set to the NAV timer value at the TSCONST Start Time, which is the value zero for event c).

The TSCONST Period shall be set to 0 indicating that the field is not applicable.

The Interferer MAC Address shall be set to the NAVDST of the NAV timer from which the TSCONST Start Time was derived (9.33.10).

All values conveyed in the TSCONST field shall refer to the allocation identified by the value of the Allocation ID field of the TSPEC.

The value of other fields within the DMG TSPEC element shall conform to the rules specified in 10.4.

Use of the information conveyed in the TSCONST field is outside the scope of this standard.

9.33.6.7 Service period recovery

When a non-PCP/non-AP STA fails to receive the Extended Schedule element for a beacon interval, the non-PCP/non-AP STA has no knowledge of the nonpseudo-static SPs allocated during the beacon interval that indicate it is the source DMG STA; therefore, it fails to initiate transmission during those SPs. If the destination of the nonpseudo-static SP is a PCP/AP and it does not receive any frames from the source non-PCP/non-AP STA for the dot11SPIdleTimeout interval from the start of the SP, the PCP/AP may truncate the SP and use the mechanism described in 9.33.7 to reallocate the remaining duration of the SP to the source DMG STA of the SP or other STAs provided that it was a truncatable SP. If the SP is not a truncatable SP, the PCP may stay awake or may switch to Doze state. If the non-PCP/non-AP STA failed to receive the Extended Schedule element from the PCP/AP for that beacon interval, it may switch to Doze state or may direct its receive antenna towards the PCP/AP to receive a Grant during nonpseudo-static SPs or CBAPs in the current beacon interval.

A PCP/AP may reclaim the entire time allocated in an SP between two non-PCP/non-AP STAs if the following two conditions are met:

— The SP is announced within an Extended Schedule element transmitted during the ATI.
— The PCP/AP does not receive a response frame from at least one of the source and destination non-PCP/non-AP STAs of that SP as part of the ATI exchange (9.33.3).

In either case described in this subclause, the PCP/AP may reallocate the reclaimed SP time as a CBAP, SP, or take no further action. Otherwise, if none of these conditions apply, no time may be reclaimed.

9.33.7 Dynamic allocation of service period

9.33.7.1 General

Dynamic allocation of service period is employed to allocate channel time during scheduled SPs and CBAPs. The procedure includes an optional Polling Period (PP) phase and a Grant Period (GP) phase. Service periods allocated using this mechanism do not persist beyond a beacon interval. Persistent allocations are created using the allocation mechanisms described in 10.4.

The PP Available field in the STA Availability element (8.4.2.135) indicates whether a STA participates in the PP phase of the Dynamic Allocation of Service Period mechanism. A STA that participates in PP phase of the Dynamic Allocation of Service Periods responds to Poll frames during the PP. A STA that participates in Dynamic Allocation of Service Periods uses the time allocated through Grant frames during the GP to transmit frames. A STA may set the PP Available field in a transmitted STA Availability element to zero to indicate that the STA does not respond to Poll frames during the PP and the GP.

NOTE—A STA can receive a Grant frame in periods of the beacon interval other than the GP, in which case the STA uses the time allocated through the Grant frame. An example is described in 9.35.5.

The PCP/AP shall not transmit Poll frames to a STA whose PP Available field in the STA Availability element is 0. The PCP/AP shall not dynamically allocate a service period to a STA that is in a Doze BI (10.2.5). A PCP/AP may transmit Poll frames to a STA from which the PCP/AP has not received a STA Availability element with the PP Available field from the STA equal to 0.

If a PCP/AP wants to dynamically allocate Service Periods during a scheduled SP for which both the source and destination AID fields are set to the broadcast AID, the PCP/AP shall set the truncatable subfield to one within the Allocation field corresponding to the scheduled SP.

If a non-PCP/non-AP STA is neither source nor an individually addressed destination during a truncatable SP and the non-PCP/non-AP STA participates in Dynamic Allocation of Service Periods and the non-PCP/non-AP STA is in an Awake BI, then the non-PCP/non-AP STA should be in the Awake state for the duration of the truncatable SP.

A non-PCP/non-AP STA that participates in Dynamic Allocation of Service Periods shall be in the Awake state for dot11MinPPDuration from the start of each truncatable SP for which both the source and the destination AID fields are set to the broadcast AID and that occurs within each Awake BI of that STA. Following the expiration of dot11MinPPDuration, the non-PCP/non-AP STA should remain in the Awake state until the end of the truncatable SP.

A STA shall be in the Awake state for dot11MinPPDuration from the start of each scheduled CBAP that occurs within each Awake BI of that STA. A STA that enters the Doze state at any time during a CBAP and then returns to the Awake state later during that same CBAP shall not transmit except in response to a reception or when an explicit Grant frame is received that gives the STA permission to transmit during the CBAP.

As described in 9.33.8, a STA that participates in Dynamic Allocation of Service Periods and that is neither source nor destination during a truncatable SP can be in the receive state with its receive antennas configured in a quasi-omni antenna pattern for the duration of the truncatable SP.

A STA that receives a Grant frame with an SP allocation for which it is either source or destination shall not transmit longer than the time granted to it.

Any STA coordinated by an MM-SME that belongs to an MMSL cluster identified by the Source AID and Destination AID that are equal to, respectively, the Source AID and Destination AID of the Dynamic Allocation Info field in the Grant frame may transmit during the allocation, if the STA sent an MMS element to the peer STA and the BeamLink Cluster field within the MMS element is 1.

An example of dynamic allocation of service period is shown in Figure 9-46.

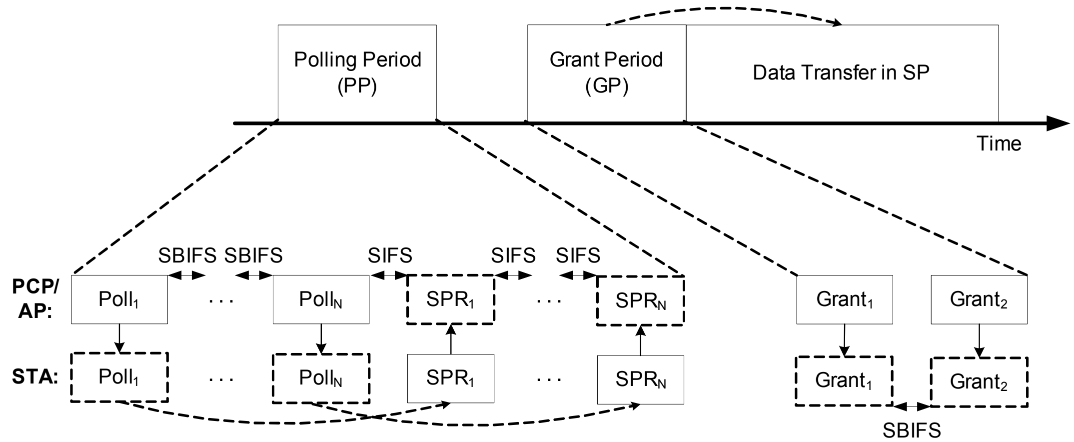


Figure 9-46—Example of dynamic allocation of service period mechanism

9.33.7.2 Polling period (PP)

A PCP/AP that uses a PP to dynamically allocate an SP within the DTI shall commence the PP at a time instant indicated by at least one of the following:

- Anytime during a scheduled SP for which the source AID and destination AID are equal to the broadcast AID, excluding any time that has been allocated dynamically
- Anytime during a TXOP within a scheduled CBAP for which the destination AID is equal to the broadcast AID, excluding any time that has been allocated dynamically
- Anytime during the relinquished channel time following an SP truncation, excluding any time that has been allocated dynamically

The PCP/AP shall not transmit a frame during a PP if any portion of that frame would extend beyond the end of the originally scheduled SP or CBAP.

During the PP, the PCP/AP may transmit individually addressed Poll frames to STAs to solicit SPR frames from those STAs. The Duration field within each Poll frame i out of a total of n ($0 < i <= n$) transmitted Poll frames in the PP shall be calculated as follows:

$$Duration_i = Duration\_of\_Poll\_transmission_{i,n} + Offset\_of\_SPR\_transmission_m + ceiling(TXTIME(SPR_m), aTSFResolution)$$

The PCP/AP expects an SPR frame in response to each transmitted Poll frame (i.e., m=n). The position of each SPR frame in the sequence of SPR frames is indicated as j. Thus, j=1 refers to the first SPR frame transmission in the sequence of SPR frames, and j=m refers to the last SPR frame transmission in the sequence of SPR frames. Based on this, the Response Offset field within each Poll frame i transmitted in the PP shall be calculated as follows:

$$Response\ Offset_i = Duration\_of\_Poll\_transmission_{i,n} + Offset\_of\_SPR\_transmission_j$$

where

$$Duration\_of\_Poll\_transmission_{i,n} = ceiling\left(\sum_{k=i+1}^{n}(\mathrm{TXTIME}(\mathrm{Poll}_k) + \mathrm{SBIFS} + \mathrm{AntennaSwitchingTime}_k + \mathrm{aSBIFSAccuracy}),\ \mathrm{aTSFResolution}\right)$$

Offset_of_SPR_transmission$_j$ is defined as

- For j=1, *Offset_of_SPR_transmission*$_1$= Poll_SPR_space
- For 2 < j <=m, *Offset_of_SPR_transmission*$_j$ = Offset_of_SPR_transmission$_{j-1}$+ floor(TXTIME(SPR$_j$) + SIFS, aTSFResolution)+1

AntennaSwitchingTime$_i$ is equal to 0 if the PCP/AP uses the same antenna to transmit frame i and frame i+1 and is equal to dot11AntennaSwitchingTime otherwise.

Poll_SPR_space is the time interval between the end of the last Poll frame transmitted by the PCP/AP and the expected start time of the first SPR frame by the non-PCP/non-AP STA, and is defined as *Poll_SPR_space* = SIFS.

NOTE—This Offset_of_SPR_transmission calculation guarantees that no less than SIFS or SIFS+dot11AntennaSwitchingTime is provided for the PCP/AP to switch antennas when receiving an SPR from different STAs.

A STA that receives an individually addressed Poll frame shall respond to the PCP/AP with a single directional and individually addressed SPR frame at the time offset from the end of the Poll frame indicated in the Response Offset field within the received Poll frame. The Duration field within the SPR frame shall be set to the value of the Duration field contained in the received Poll frame, minus the value of the Response Offset field contained in the received Poll frame, minus the time taken to transmit the SPR frame.

The PP ends at a time equal to the end of the last Poll frame transmission plus the value of the Response Offset field in that Poll frame plus the expected duration of the SPR transmission that is expected in response to that Poll frame plus SIFS.

9.33.7.3 Grant period (GP)

A PCP/AP that intends to dynamically allocate an SP within the DTI shall commence a GP at a time instant indicated by at least one of the following:

- SIFS interval following the end of a PP if the PP is present
- Anytime during a scheduled SP for which the source AID and destination AID are equal to the broadcast AID if a PP does not precede the GP, excluding any time that has been allocated dynamically
- Anytime during a TXOP within a scheduled CBAP for which the destination AID is equal to the broadcast AID, excluding any time that has been allocated dynamically
- Anytime during the relinquished channel time following an SP truncation if a PP does not precede the GP, excluding any time that has been allocated dynamically

The PCP/AP shall not transmit a frame during a GP if any portion of that frame would extend beyond the end of the originally scheduled SP or CBAP, or beyond the end of an immediately following SP if that SP has the broadcast AID as both source and destination AID, whichever is later.

A non-PCP/non-AP STA may switch to Doze state if it does not receive a Grant frame from the PCP/AP within dot11MinPPDuration from the start of the scheduled SP for which the source AID and destination AID are set to the broadcast AID.

To commence the GP, the PCP/AP shall transmit Grant frames to notify the source DMG STA and destination DMG STA about a dynamically allocated service period. The PCP/AP should transmit the last Grant frame within a GP to the source of the dynamically allocated SP if the source of the dynamically allocated SP is not the PCP/AP. In each transmitted Grant frame, the PCP/AP shall set the Duration field within the Grant frame to a time that does not overlap in time with another SP that has either the source AID or destination AID different from the broadcast AID. In addition, the source AID and destination AID fields shall be set to the source and destination, respectively, of the dynamically allocated SP, the AllocationType field set to indicate the channel access mechanism during the allocation, and the Allocation Duration field set to a value that is not greater than the result of the subtraction of the duration of all remaining Grant frame transmissions, if any, plus all appropriate IFSs (9.3.2.3), plus 2×SIFS from the value of the Duration field. An allocation that is indicated in this manner begins at the time that is equal to the PHY-TXEND.indication of the Grant frame plus the value from the Duration field of the Grant frame minus the value of the Allocation Duration field of the Grant frame, and continues for the time indicated in the Allocation Duration field of the Grant frame.

The Dynamic Allocation Info field within Grant frames transmitted as part of the same GP shall be the same.

NOTE—This means the PCP/AP can create only one allocation per GP.

During an SP between a source DMG STA and a destination DMG STA, the source DMG STA may transmit a Grant frame to the destination DMG STA to relinquish the remainder of the SP to the destination DMG STA. In the Allocation Info field of the transmitted Grant frame, the source DMG STA shall set source AID field to the AID of the destination DMG STA, the destination AID field to the AID of the source DMG STA, the AllocationType field set to indicate SP, and the Allocation Duration field set to the time remaining in the SP minus the time taken to transmit the Grant frame. The Duration field in the Grant frame shall be set to the value of the Allocation Duration field. Upon transmission of the Grant frame, for the remainder the SP the roles of source DMG STA and destination DMG STA are swapped between the STAs.

During a TXOP between a TXOP holder and a TXOP responder, the TXOP holder may transmit a Grant frame to the TXOP responder to relinquish the remainder of the TXOP to the TXOP responder. In the transmitted Grant frame, the TXOP holder shall set source AID field to the AID of the TXOP responder, the destination AID field to the AID of the TXOP holder, the AllocationType field set to indicate CBAP, and the Allocation Duration field set to the time remaining in the TXOP minus the time taken to transmit the Grant frame. The Duration field in the Grant frame shall be set to the value of the Allocation Duration field. Upon transmission of the Grant frame, for the remainder the TXOP the roles of TXOP holder and TXOP responder are swapped between the STAs.

A STA that receives a Grant frame shall not update its NAV if the value of either the source AID or destination AID fields in the Grant frame are equal to the STA’s AID.

The PCP/AP may grant a dynamic allocation of service period to a STA that does not transmit a SPR frame during the PP.

9.33.8 Dynamic truncation of service period

A STA truncates an SP to release the remaining time in the SP. The STA can use the CF-End frame to truncate the SP at the peer STA, to reset NAV in third party STAs and to return to the PCP/AP the time left in the SP, thus allowing the PCP/AP to grant any portion of the released time as part of an SP to any other STA or to allocate any portion of it as a CBAP. The STA can use the Grant frame to release any part of the time left in the SP as a CBAP.

If a STA is neither source nor destination during a truncatable SP and the STA desires to participate in Dynamic allocation of service period, the STA should be in the receive state with its receive antenna configured in a quasi-omni antenna pattern for the duration of the truncatable SP. If both the source and destination AID fields of a truncatable SP are set to the broadcast AID, a non-PCP/non-AP STA may direct its receive antenna to its PCP/AP for the duration of the truncatable SP if the non-PCP/non-AP STA does not participate in a frame exchange and the truncatable SP is not dynamically allocated to the non-PCP/non-AP STA.

Only the source DMG STA of an SP may truncate the SP, except that the destination DMG STA may truncate the SP if it does not receive an expected transmission from the source DMG STA at the start of the SP as defined in 9.33.6.7.

In order to advertise the availability of truncatable SP time for reuse through PCP/AP dynamic allocation, a non-PCP/non-AP STA shall transmit an CF-End frame to the PCP/AP. A STA is not required to truncate an SP if a portion of the SP is unused.

In order to enable CBAP access during the time released through SP truncation, the STA shall broadcast a Grant frame with the Source AID and Destination AID set to broadcast AID, the AllocationType field set to indicate CBAP and the Duration field set to the time needed to transmit the Grant frame(s) (the Duration field in a Grant frame does not include duration of that frame) plus SIFS and plus the time needed to transmit the following CF-End frame and the response CF-End frame, if required and appropriate IFS (9.3.2.3) values. The Allocation Duration field shall be set to a value that is not greater than the result of the subtraction of the value in the Duration field from the time remaining in the SP. The CBAP that is indicated in this manner begins at the time that is equal to the PHY-TXEND.indication of the Grant frame plus the value from the Duration field of the Grant frame and continues for the time indicated in the Allocation Duration field of the Grant frame.

The STA shall not transmit the Grant frame and shall not transmit the CF-End frame to the PCP/AP if the SP is not indicated as truncatable.

After transmission of the CF-End frame to the PCP/AP or after broadcasting a Grant frame, the STA shall transmit a CF-End frame to the peer STA of the SP. The CF-End frame releases any time remaining in the SP at the recipient and resets the NAV in third party STAs. The NAV is reset only if the RA and TA of the CF-End frame match the addresses of the frame that established the NAV (see 9.33.10). The recipient STA may transmit a CF-End frame SIFS after the reception if the Duration field of the received frame is not equal to 0 and the transmission does not extend beyond the end of the originally scheduled SP.

A STA shall not initiate SP truncation if there is not enough time left in the SP to complete the frame exchange required for truncation of the SP.

After the truncation is completed, the PCP/AP may dynamically allocate any portion of the relinquished channel time that has not been allocated to a CBAP through a transmitted Grant frame (9.33.7).

9.33.9 Dynamic extension of service period

A non-PCP/non-AP STA uses dynamic extension of SP to extend the allocated time in the current SP. The additional time can be used to support variable bit rate traffic, for retransmissions or for other purposes. The SPR frame is sent by a non-PCP/non-AP STA to the PCP/AP to request additional SP time in the current beacon interval.

Except in response to a Poll frame from the PCP/AP, a non-PCP/non-AP STA shall not transmit an SPR frame within an SP if the current SP is not extendable (see 8.4.2.134).

Only the source DMG STA and destination DMG STA of an SP can transmit an SPR during that SP.

If the PCP/AP is not the source of an extendable SP, it should be in the receive state and with its receive antennas configured in a quasi-omni antenna pattern for the duration of the extendable SP.

To request extension of the current SP, a non-PCP/non-AP STA shall transmit an SPR frame to the PCP/AP. The non-PCP/non-AP STA shall not request extension of the current SP if there is not enough time left in the SP to complete the frame exchange required for the SP extension. In the transmitted SPR frame, the STA shall set the RA field to the address of the PCP/AP, the Duration field to the time left in the SP (not including the SPR transmission time), and the Allocation Duration field to the additional amount of time requested by the STA following the end of the current SP.

The PCP/AP may grant the request for an extension of an SP only if the following SP has the broadcast AID as both source and destination AID, and the duration of the following SP is larger than the value of the Allocation Duration field in the received SPR frame. To grant an extension request, the PCP/AP shall transmit a Grant frame with the RA field set to the value of the TA in the received SPR frame, the Duration field set to the value of the Duration field received in the SPR frame minus SIFS and minus the duration of this Grant frame transmission, and the Allocation Duration field set to the amount of additional time granted by the PCP/AP.

To decline a request for an extension of an SP, the PCP/AP shall transmit a Grant frame with the RA field set to the value of the TA in the received SPR frame, the Duration field set to the value of the Duration field received in the SPR frame minus SIFS and minus the duration of this Grant frame transmission, and the Allocation Duration field set to 0.

The extension request is successful if the non-PCP/non-AP STA receives from the PCP/AP a Grant frame with a nonzero value for the Allocation Duration field SIFS after the SPR. SIFS after the reception of a Grant frame from the PCP/AP with a nonzero value for the Allocation Duration field, the non-PCP/non-AP STA shall transmit a Grant frame to the partner STA of the SP with the Duration field set to the value of the Duration field of the Grant frame received from the PCP/AP minus the duration of this Grant frame transmission minus SIFS, and the Allocation Duration field set to the value of the Allocation Duration field of the Grant frame received from the PCP/AP.

The PCP/AP shall not transmit an SPR frame if it wants to extend an SP in which it is the source. A PCP/AP that extends an SP for which it is the source DMG STA shall transmit a Grant frame to the destination DMG STA of the SP to indicate the extension of the SP. The Duration field in the transmitted Grant frame shall be set to the remaining time in the SP plus any additional channel time allocated by the PCP/AP following the end of the SP. The Allocation Duration field of the Grant frame shall be set to the additional channel time allocated by the PCP/AP following the end of the SP.

9.33.10 Updating multiple NAV timers

If a DMG STA supports multiple NAV timers, the number of available NAV timers within the DMG STA shall be not less than aMinNAVTimersNumber. Each NAV timer is identified by a pair of MAC addresses, NAVSRC and NAVDST, and has associated variables NAV_RTSCANCELABLE and NAV_DTSCANCELABLE. Each STA also maintains a variable UPDATE_OPTIONAL. When a STA is enabled for operation, all NAV timers shall have NULL values for their NAVSRC and NAVDST identifiers, the value of NAV_RTSCANCELABLE shall be false, the value of NAV_DTSCANCELABLE shall be false, and each NAV timer shall have the value 0. NAV timer address pairs correspond to the NAV-SA and NAV-DA fields in DMG DTS frames and correspond to the RA and TA fields of all other received frames that are used to update the NAV timers. Receipt of any frame can cause an update to the NAV timer whose identifying address pair corresponds to the specified address fields of the received frame according to the rules in this subclause.

STAs receiving any valid frame shall perform the following NAV Timer update operation expressed using the following pseudocode:

NAV_TIMER_UPDATE(received_frame):

```
UPDATE_OPTIONAL ← false

If (received_frame = DMG DTS) {
        UPDATE_OPTIONAL ← true
}

If (received_frame(RA) ≠ This STA MAC address || UPDATE_OPTIONAL = true) {
        If (received_frame = DMG DTS) {
                R_DST ← received_frame(NAV-DA)
                R_SRC ← received_frame(NAV-SA)
        } else if (received_frame = ACK) {
                R_DST ← received_frame(RA)
                R_SRC ← 0
        } else {
                R_DST ← received_frame(RA)
                R_SRC ← received_frame(TA)
        }

        R_DUR ← received_frame(DUR)

        N_TIMER ← -1

        // Searching for a matching NAV timer
        For (x ← 0; x < aMinNAVTimersNumber; x++) {
                If (received_frame = ACK || NAVSRC(x)=R_DST) {
                        If(NAVDST(x) = R_DST) {
                                N_TIMER ← x
                                Break
                        }
                } else if (NAVSRC(x) = R_SRC && (NAVDST(x) = R_DST
                                        || NAVDST(x) = 0) ||
                        (NAVSRC(x)=0 && NAVDST(x) = R_DST) ||
                        (NAVDST(x)=R_SRC && NAVSRC(x)=R_DST)) {
                        N_TIMER ← x
                        Break
                }
        }

        // No NAV timer has been found that matches the addresses
        If (N_TIMER < 0) {
                For (x ← 0; x < aMinNAVTimersNumber; x++) {
                        If (NAVSRC(x) = NULL && NAVDST(x) = NULL
                                || NAV(x) = 0) {
                                NAVSRC(x) ← R_SRC
                                NAVDST(x) ← R_DST
                                N_TIMER ← x
                                Break
                        }
                }
```



```
        }

        // Existing NAV timer found
        If (N_TIMER ≥ 0) {
                If (UPDATE_OPTIONAL = false
                        && R_DUR > NAV(N_TIMER) ) {
                        NAV(N_TIMER) ← R_DUR
                        If (received_frame = RTS) {
                                NAV_RTSCANCELABLE(N_TIMER) ← true
                        } else {
                                NAV_RTSCANCELABLE(N_TIMER) ← false
                        }
                } else if (UPDATE_OPTIONAL = true && R_DUR > NAV(N_TIMER)) {
                        If ((implementation decision to update = true) ||
                        (received_frame(RA) = This STA MAC address &&
                        This STA MAC address = source DMG STA MAC address for current
SP))
                        ) {
                                        NAV_DTSCANCELABLE(N_TIMER) ← true
                                        NAV(N_TIMER) ← R_DUR
                                }
                }
        }

} else {
        No change to NAV timers
}
```

END OF NAV_TIMER_UPDATE

During a time period beginning with the completion of each NAV Timer update operation as a result of an RTS reception and lasting for TXTIME(DMG CTS) +2×SIFS, each STA that desires to reset its NAV shall monitor the channel to determine if a preamble or carrier detect event has occurred. If such an event has not occurred during this time period, then the STA may reset to 0 any NAV Timer that has a value of true for its associated NAV_RTSCANCELABLE variable.

Subsequent to the NAV Timer update operation, each NAV timer counts down until it reaches the value zero or until it reaches zero through a reset operation.

If a STA receives a valid CF-End response with RA and TA values that match the NAVSRC and NAVDST values, in any order, for any NAV Timer, then the STA shall set the associated NAV Timer to the value of the Duration field in the received CF-End frame. If one of NAVSRC or NAVDST of a NAV timer is 0 and the corresponding NAVDST or NAVSRC, respectively, of the NAV timer match the RA or the TA value of the received valid CF-End frame, then the STA shall set the associated NAV Timer to the value of the Duration field in the received CF-End frame.

If one of NAVSRC or NAVDST of a NAV timer is 0 and the nonzero NAVDST or NAVSRC of the NAV timer match either the RA or the TA value of a received valid frame, the NAVSRC or NAVDST that is 0 shall be set to the RA or TA that does not match the nonzero NAVSRC or NAVDST.

9.34 DMG PCP/AP clustering

9.34.1 General

A PCP/AP may use the PCP/AP clustering mechanism to improve spatial sharing and interference mitigation with other co-channel DMG BSSs. There are two types of clustering:

- Decentralized PCP/AP clustering that involves a single S-PCP/S-AP in the BSA of the S-PCP/S-AP
- Centralized PCP/AP clustering where there can be multiple S-APs in the BSA of any one S-AP, and all S-APs are coordinated via a single centralized coordination service set

PCP/AP clustering allows a PCP/AP that is a member of a cluster to schedule transmissions in nonoverlapping time periods with respect to other members of the same cluster since the PCP/AP can receive DMG Beacon and Announce frames containing the Extended Schedule element of other PCPs/APs that are members of the cluster and can also receive the Extended Schedule element from another BSS through associated non-PCP/non-AP STAs (9.34.4).

A STA is decentralized PCP/AP clustering capable if it sets the Decentralized PCP/AP Clustering field to 1 within the DMG PCP/AP Capability Information field in the DMG Capabilities element. A STA is centralized PCP/AP clustering capable if it sets the Centralized PCP/AP Clustering field to 1 within the DMG PCP/AP Capability Information field in the DMG Capabilities element. The PCP/AP employs the Clustering Control field and ECPAC Policy Enforced field defined in 8.3.4.1 to configure the use of PCP/AP Clustering. A decentralized PCP/AP clustering capable or centralized PCP/AP clustering capable PCP/AP that transmits the Clustering Control field is decentralized clustering enabled or centralized clustering enabled, respectively. A PCP/AP that does not transmit the Clustering Control field is clustering disabled.

Decentralized clustering enabled PCPs/APs operating on the same channel may form a decentralized PCP/AP cluster. A PCP/AP cluster includes one S-PCP/S-AP and zero or more member PCPs/APs. The MAC address of the S-PCP/S-AP shall be the Cluster ID of the decentralized PCP/AP cluster. Centralized clustering enabled PCPs/APs operating on the same channel as a S-AP form a centralized PCP/AP cluster as described in 9.34.2.2. The Cluster ID of the centralized PCP/AP cluster shall be set to the MAC address of the S-AP.

A clustering enabled PCP/AP that is not a member of any cluster shall set the Cluster Member Role subfield to zero in transmitted frames that contain the Clustering Control field.

Each PCP/AP that is a member of a PCP/AP cluster shall include the Clustering Control field in each DMG Beacon it transmits.

For each cluster, there exists a set of ClusterMaxMem Beacon SPs. The n^{th} Beacon SP, Beacon SP_n, begins at $ClusterTimeOffset_{n-1}$ μs following the TBTT of the S-PCP/S-AP, where

$$ClusterTimeOffset_{n-1} = 1024 \times (dot11BeaconPeriod/ClusterMaxMem) \times (n-1)$$

and n=2, 3,…, $ClusterMaxMem$

The $ClusterTimeOffset_{n-1}$ and Beacon SP_n where n equals one is reserved for the S-PCP/S-AP.

A PCP/AP that is a member of a PCP/AP cluster shall transmit its DMG Beacon frame during one of the Beacon SPs as specified in 9.34.2.

The maximum size of the Beacon SP Duration field transmitted by a S-PCP/S-AP shall be the beacon interval of the S-PCP/S-AP divided by ClusterMaxMem.

9.34.2 Cluster formation

9.34.2.1 Decentralized PCP/AP cluster formation

A clustering enabled PCP/AP starts a decentralized PCP/AP cluster by becoming an S-PCP/S-AP, subject to the absence of existing clusters as described below and in 9.34.2.2. A decentralized clustering enabled PCP/AP becomes an S-PCP/S-AP of a decentralized PCP/AP cluster by transmitting a DMG Beacon at least once every aMinBTIPeriod beacon intervals that has the ECPAC Policy Enforced subfield in the DMG Parameters field set to 0 and that includes a Clustering Control field with the Beacon SP duration subfield set to the value of dot11BeaconSPDuration, the Cluster ID subfield set to the S-PCP/S-AP MAC address, and the Cluster Member Role subfield set to the value for an S-PCP/S-AP. The value of ClusterMaxMem subfield shall be chosen to keep the result of (beacon interval length/ClusterMaxMem) as an integer number of microseconds.

A decentralized clustering enabled PCP/AP that receives a DMG Beacon frame with the ECPAC Policy Enforced subfield in the DMG Parameters field set to 0 from an S-PCP/S-AP on the channel the PCP/AP selects to establish a BSS shall monitor the channel for DMG Beacon transmissions during each Beacon SP for an interval of length at least aMinChannelTime. Beacon SP_n is empty if no DMG Beacon frame is received during Beacon SP_n over an interval of length aMinChannelTime. The PCP/AP shall not become a member of the cluster if no Beacon SP is determined to be empty during aMinChannelTime, in which case, subject to the requirements described in 9.34.2.2, then the PCP/AP may become the S-PCP/S-AP of a new cluster, or may cease its activity on this channel and, if desired, attempt operation on a different channel.

A decentralized clustering enabled PCP/AP that operates its BSS on a channel on which it discovered an S-PCP/S-AP within a decentralized PCP/AP cluster and at least one empty Beacon SP shall transmit its DMG Beacon during an empty Beacon SP. By transmitting its DMG Beacon during an empty Beacon SP and by setting the clustering control field appropriately as described in 8.3.4.1, the PCP/AP becomes a member PCP/AP.

The member PCP/AP shall select a beacon interval length that is equal to the beacon interval length of its S-PCP/S-AP.

The member PCP/AP shall transmit its DMG Beacon with the ECPAC Policy Enforced field set to 0, the Beacon SP duration subfield set to the value of the Beacon SP duration subfield contained in the S-PCP/S-AP DMG Beacon, the Cluster ID subfield set to the MAC address of the S-PCP/S-AP, the Cluster Member Role subfield set to the member PCP/AP value, and the ClusterMaxMem subfield set to the value of the ClusterMaxMem field contained in the S-PCP/S-AP DMG Beacon.

A PCP/AP with a value of Cluster Member Role that is not zero shall schedule a Beacon SP that is allocated for DMG Beacon transmission of other cluster member PCPs/APs within the decentralized PCP/AP cluster at each of $\text{ClusterTimeOffset}_n$, at any time the PCP/AP transmits its own DMG Beacon. The minimum size of the Beacon SP should be equal to the value of the Beacon SP duration subfield within the S-PCP/S-AP DMG Beacon.

An S-PCP/S-AP and a member PCP/AP of a decentralized PCP/AP cluster should not transmit or schedule transmissions during a Beacon SP that is not its own Beacon SP.

Figure 9-47 illustrates, for three PCPs/APs, the Beacon SPs of the S-PCP/S-AP and member PCPs/APs of a decentralized PCP/AP cluster.

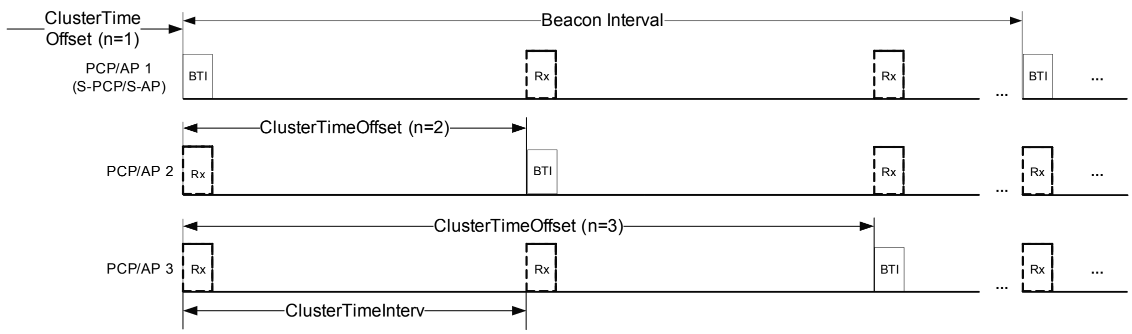


Figure 9-47—Decentralized PCP/AP clustering for 3 PCPs/APs

9.34.2.2 Centralized PCP/AP cluster formation

In order to become an S-AP, a centralized clustering enabled STA that is stationary with respect to its local environment shall successfully perform both the following steps in order:

- Configuration step
- Verification step

Once these steps have been performed successfully, the STA has become an S-AP.

- **Configuration step**: The configuration step is defined to be successful if the following occur:
  - The STA obtains the MAC address of the CCSR; and
  - The STA obtains an ECPAC Policy Detail field, beacon interval, ClusterMaxMem, Beacon SP duration, TXSS CBAP Offset, TXSS CBAP Duration, TXSS CBAP MaxMem, TSF synchronization parameters, Cluster Time Offset availability information, and a nonempty list of excluded channels for the intended operating class of the STA from the CCSR; and
  - Either the Channel Starting Frequency of the intended operating class of the STA is defined in Annex E to be 56.16 GHz and channel 2 is an allowed channel in the current regulatory domain and the list of excluded channels includes channel 2, or the Channel Starting Frequency of the intended operating class of the STA is defined in Annex E to be 56.16 GHz and channel 2 is not an allowed channel in the current regulatory domain; and
  - The beacon interval/ClusterMaxMem is an integer number of microseconds; and
  - At least one of beacon interval/TXSS CBAP MaxMem or TXSS CBAP MaxMem/beacon interval is an integer.

  Otherwise, the configuration step is defined to be unsuccessful. If the configuration step is unsuccessful, then the STA can attempt to resolve the problem or quit attempting to start a centralized PCP/AP cluster. The method by which the STA obtains the configuration information from the CCSR is not defined in this standard.
- **Verification step**: The verification step is defined to be the following procedure:
  - The centralized clustering enabled STA monitors the channel for DMG Beacon frames over an interval of at least aMinChannelTime.
  - During this monitoring period, for each distinct Cluster ID received in a DMG Beacon frame that has the ECPAC Policy Enforced field set to 1 in the DMG Parameters field and Cluster Member Role set to 1 (S-PCP/S-AP of the cluster) or 2 (a member PCP/AP of the cluster), the centralized clustering enabled STA determines if an S-AP with a MAC address equal to the Cluster ID belongs to the same CCSS as the centralized clustering enabled STA, via i) attempting to receive an Announce frame from the S-AP that transmitted the DMG Beacon according to the channel access rules described in 9.33 in order to solicit an ECPAC Policy

element or ii) any other means. Any such DMG Beacon frame whose transmitter cannot be determined in this way to belong to the same CCSS as the centralized clustering enabled STA is defined to be from another ECPAC.

The verification step is defined to be unsuccessful if, at the end of the monitoring period, there are one or more received DMG Beacon frames that are from another ECPAC. Otherwise, the verification step is defined to be successful.

If at least one DMG Beacon frame that has the ECPAC Policy Enforced field set to 1 and was sent by an S-AP/member PCP/member AP from another ECPAC is received during the monitoring period, the centralized clustering enabled STA

- Shall cease its activity on this channel and, if desired, attempt operation on a different channel, or
- If one of the received DMG Beacon frames was sent by an S-AP, may elect to unenroll from its current CCSS and join the cluster of the S-AP as a member PCP/AP.

If at least one DMG Beacon frame that has the ECPAC Policy Enforced field set to 1 and was sent by an S-AP from the same CCSS is received during the monitoring period, the centralized clustering enabled STA may elect either to unenroll from its current CCSS and join the cluster of the S-AP as a member PCP/AP or to continue and become an S-AP in the CCSS.

In order to become an S-AP in a centralized PCP/AP cluster, a centralized clustering enabled STA shall take the following actions:

- Set dot11MgmtOptionChannelUsageImplemented to true
- Start a BSS as an AP
  - On a channel that is not listed as excluded by the CCSR, and
  - At the start time and with the beacon interval configured by the CCSR
- Include in transmitted DMG Beacon frames
  - The ECPAC Policy Enforced field set to 1 in the DMG Parameters field, and
  - A Clustering Control field with the ClusterMaxMem subfield set to the values configured by the CCSR, the Beacon SP Duration subfield set to the value most recently configured by the CCSR, the Cluster ID subfield set to the S-AP MAC address, and the Cluster Member Role subfield set to 1 (S-PCP/S-AP of the cluster).

An S-AP in a centralized PCP/AP cluster shall set the ECPAC Policy Enforced subfield in the DMG Parameters field to 1 for the lifetime of the BSS.

An S-AP within a centralized PCP/AP cluster shall include the ECPAC Policy element in (Re)Association Response, Announce, and Information Response frames with the ECPAC Policy Detail, TXSS CBAP Offset, and TXSS CBAP Duration fields set to the respective values most recently configured by the CCSR for the S-AP, the TXSS CBAP MaxMem subfield set to the policy configured by the CCSR, the CCSR ID subfield set to the MAC address of the CCSR, and bits in the Available Cluster Time Offset Bitmap subfield set to 0 to indicate the Cluster Time Offsets that are determined to be already in use, excluding the recipient if sent within an individually addressed frame. The means by which a Cluster Time Offset is determined to be in use are unspecified. Bits in the Available Cluster Time Offset Bitmap subfield for other Cluster Time Offsets shall be set to 1.

A PCP/AP that receives a DMG Beacon frame that has the ECPAC Policy Enforced subfield in the DMG Parameters field set to 1 sent by an S-AP on a channel and that does not receive at least one DMG Beacon frame that has the ECPAC Policy Enforced subfield in the DMG Parameters field set to 1 sent by an S-AP on every channel supported by the PCP/AP in the Operating Class within the next aMinChannelTime shall either join the cluster of the S-AP as a member PCP/AP if centralized clustering enabled or cease its activity on this channel and, if desired, attempt operation on a different channel. S-APs within a CCSS report the channels unused by the ECPAC via the Channel Usage procedures (see 10.23.14).

A PCP/AP within a decentralized PCP/AP cluster that receives a DMG Beacon frame that has the ECPAC Policy Enforced subfield in the DMG Parameters field set to 1 sent by an S-AP and that does not receive at least one DMG Beacon frame that has the ECPAC Policy Enforced subfield in the DMG Parameters field set to 1 sent by an S-AP on every channel supported by the PCP/AP in the Operating Class within the next aMinChannelTime shall quit the decentralized PCP/AP cluster before the next TBTT + beacon interval length, then the PCP/AP shall either join the cluster of the S-AP as a member PCP/AP if centralized PCP/AP clustering enabled or cease its activity on this channel and, if desired, attempt operation on a different channel.

A PCP/AP that receives at least one DMG Beacon frame that has the ECPAC Policy Enforced subfield in the DMG Parameters field set to 1 sent by an S-AP on every channel supported by the PCP/AP in the Operating Class within the most recent aMinChannelTime may ignore DMG Beacon frames that have the ECPAC Policy Enforced subfield in the DMG Parameters field set to 1 sent by an S-AP for $300 \times$ aMinChannelTime.

NOTE—A PCP/AP within a decentralized PCP/AP cluster does not cease DMG Beacon transmission when quitting a decentralized PCP/AP cluster. Hence, data communication is unaffected while performing these procedures.

A centralized clustering enabled PCP/AP that attempts to join the centralized PCP/AP cluster of an S-AP as a member PCP/AP shall be a STA coordinated by an MM-SME that also coordinates a second non-PCP/non-AP STA, and shall successfully perform the following steps in order:

— The PCP/AP shall monitor the channel for DMG Beacon frames during each Beacon SP over an interval of length at least aMinChannelTime. A Beacon SP_n is empty if no DMG Beacon frame is received during the Beacon SP_n over an interval of length aMinChannelTime.
— The second non-PCP/non-AP STA shall attempt to associate with the S-AP and thereby receive an Announce frame from the S-AP. The contents of the Announce frame are passed to the PCP/AP.
— Upon receiving an Announce frame that includes the ECPAC Policy element, the PCP/AP shall select a Cluster Time Offset index from the intersection of a) the Cluster Time Offset indices of the empty Beacon SPs with b) the indices indicated by the Available Cluster Offset Bitmap field in the ECPAC Policy element. If the intersection is empty, the PCP/AP shall select a Cluster Time Offset index of an empty Beacon SP. The selected Cluster Time Offset index is passed to the second non-PCP/non-AP STA.
— The second non-PCP/non-AP STA shall respond to the Announce frame with an Information Response frame that includes the Cluster Time Offset element containing the Cluster Time Offset Index set to the selected index.
— The PCP/AP shall operate its BSS at the selected Cluster Time Offset on the channel of the S-AP and include the PCP/AP clustering control field in transmitted DMG Beacon frames.

The PCP/AP shall not become a member of the centralized PCP/AP cluster if no Beacon SP is determined to be empty during aMinChannelTime or if the second non-PCP/non-AP STA did not associate to the S-AP, in which case the PCP/AP may attempt to join the cluster of another S-AP or cease its activity on this channel and, if desired, attempt operation on a different channel.

A member PCP/AP within a centralized PCP/AP cluster shall select a beacon interval that is equal to the beacon interval of the S-AP of the cluster.

The member PCP/AP within a centralized PCP/AP cluster shall transmit its DMG Beacon frames with the ECPAC Policy Enforced subfield in the DMG Parameters field set to 1, the Beacon SP duration subfield in the Clustering Control field set to the value of the Beacon SP duration subfield contained in the most recently received S-AP DMG Beacon, the Cluster ID subfield set to the MAC address of the S-AP, the

Cluster Member Role subfield set to 2 (a member PCP/AP of the cluster), and the ClusterMaxMem subfields set to the value of the ClusterMaxMem field contained in the S-AP DMG Beacon.

A member PCP/AP within a centralized PCP/AP cluster shall include the ECPAC Policy element in (Re)Association Response, Announce, and Information Response frames with the ECPAC Policy Detail, TXSS CBAP Offset, and TXSS CBAP Duration fields set to the most recently received respective field from the S-AP of the cluster, the TXSS CBAP MaxMem field set to the value of the TXSS CBAP MaxMem field received from the S-AP of the cluster, with the CCSR ID set to the MAC address of the CCSR field received from the S-AP of the cluster, and with the Available Cluster Time Offset Bitmap field reserved.

At any time a PCP/AP within a centralized PCP/AP cluster transmits a DMG Beacon frame, the PCP/AP shall schedule a Beacon SP that reserves time for BHI transmission by other PCPs/APs within the centralized PCP/AP cluster at each in use $\text{ClusterTimeOffset}_{n-1}$ as indicated by the most recently transmitted (if S-AP) or received (if member PCP/AP) Available Cluster Time Offset Bitmap. The minimum size of the Beacon SP shall be equal to the value of the Beacon SP duration subfield within the DMG Beacon frame of the S-AP of the centralized PCP/AP cluster. An S-AP/member PCP/member AP of a centralized PCP/AP cluster shall not transmit or schedule transmissions during a Beacon SP of another S-AP/member PCP/ member AP.

9.34.3 Cluster maintenance

9.34.3.1 General cluster maintenance

The TBTT of the S-PCP/S-AP provides a timing reference for the Beacon SPs of the member PCPs/APs. Timing synchronization among the member PCPs/APs facilitates equitable sharing of the common medium among the member PCPs/APs. As long as a member PCP/AP periodically receives DMG Beacons from the S-PCP/S-AP, the member PCP/AP is able to maintain synchronization with the S-PCP/S-AP and hence the other member PCPs/APs.

9.34.3.2 Decentralized PCP/AP cluster maintenance

In the case when the S-PCP/S-AP of a decentralized PCP/AP cluster is lost, or appears to a member PCP/AP to have been lost, another PCP/AP needs to become the S-PCP/S-AP of the decentralized PCP/AP cluster in order to allow the remaining member PCPs/APs to maintain synchronization with the cluster. The creation of a new S-PCP/S-AP is called S-PCP/S-AP handover. After an S-PCP/S-AP handover, the cluster might continue to function as before, except with altered membership, or the cluster might no longer exist, or there might be one or more new clusters.

A member PCP/AP of the decentralized PCP/AP cluster shall start an S-PCP/S-AP handover if, within a time period of 4×aMinBTIPeriod beacon intervals, it does not receive a DMG Beacon with the ECPAC Policy Enforced field set to 0, with the value of the Cluster ID field equal to the Cluster ID of the cluster of which the PCP/AP is a member and with the Cluster Member Role field set to the S-PCP/S-AP value. This is the first Cluster Monitoring Period. During the next step in the S-PCP/S-AP handover, the member PCP/AP performs another Cluster Monitoring Period. A Cluster Monitoring Period is a time period of 4×aMinBTIPeriod beacon intervals during which the PCP/AP listens for DMG Beacons while continuing to transmit DMG Beacons using its current Beacon SP_n.

NOTE—A decentralized clustering enabled PCP/AP does not cease DMG Beacon transmission during Cluster Monitoring and S-PCP/S-AP handover. Hence, data communication is unaffected while performing these procedures.

If, during a Cluster Monitoring Period, the member PCP/AP receives a DMG Beacon with the value of Cluster Member Role set to the S-PCP/S-AP value, the member PCP/AP shall follow the rules in 9.34.2 to become a member PCP/AP of the cluster corresponding to the detected S-PCP/S-AP or cease operation on the channel; in either case, the Cluster Monitoring Period is terminated.

If, during a Cluster Monitoring Period, the PCP/AP receives no DMG Beacons with the value of Cluster Member Role set to the S-PCP/S-AP value and one or more DMG Beacons with the ECPAC Policy Enforced field set to 0 and with Cluster ID equal to the Cluster ID of its last S-PCP/S-AP, then at the end of the Cluster Monitoring Period the PCP/AP compares the MAC addresses of all such received DMG Beacons with its own MAC address. If its MAC address is the lowest, the PCP/AP shall become an S-PCP/S-AP according to the rules in 9.34.2. If its MAC address is not the lowest, the PCP/AP shall perform a new Cluster Monitoring Period. If the number of Cluster Monitoring Periods performed by the PCP/AP exceeds dot11MaxNumberOfClusteringMonitoringPeriods, the PCP/AP may cease cluster maintenance and initiate cluster formation as described in 9.34.2.

If, during a Cluster Monitoring Period, the PCP/AP does not receive a DMG Beacon that contains the value of S-PCP/S-AP in the Cluster Member Role field and does not receive a DMG Beacon with the ECPAC Policy Enforced field set to 0 and with Cluster ID equal to the Cluster ID of the cluster of which it is currently a member, then at the end of the Cluster Monitoring Period the PCP/AP may become an S-PCP/S-AP according to the rules of 9.34.2, or it may cease its activity on this channel and, if desired, attempt operation on a different channel.

NOTE—An assumption to allow the establishment of an S-PCP/S-AP in this case is that the PCPs/APs cannot hear each other’s DMG Beacons. The rule how to decide to switch the channel or to establish an S-PCP/S-AP is implementation dependent.

If, during a Cluster Monitoring Period, the member PCP/AP of a decentralized PCP/AP cluster receives no DMG Beacons from clustering enabled STAs, then the PCP/AP shall establish itself as an S-PCP/S-AP according to the rules in 9.34.2.

If an S-PCP/S-AP of a decentralized PCP/AP cluster detects the presence of a S-PCP/S-AP of another decentralized PCP/AP cluster on the same channel, it should schedule a Beacon SP for the DMG Beacon transmission of the other S-PCP/S-AP if the MAC address of the other S-PCP/S-AP is lower than the MAC address of this S-PCP/S-AP. The S-PCP/S-AP with higher MAC address should become a member PCP/AP of the cluster corresponding to the S-PCP/S-AP with the lower MAC address according to the rules in 9.34.2.

9.34.3.3 Centralized PCP/AP cluster maintenance

A STA, while operating as an S-AP, remains stationary with respect to its local environment.

An S-AP within a centralized PCP/AP cluster, upon a change of the Beacon SP Duration field or the ECPAC Policy element configured by the CCSR, shall update the Clustering Control field sent in subsequent frames and shall send individually addressed Announce or Information Response frames to other STAs within the BSS in order notify them of the changes.

When a member PCP/AP is coordinated by an MM-SME and the member PCP/AP elects to change its S-AP within a centralized PCP/AP cluster, then a second non-PCP/non-AP STA coordinated by the MM-SME of the member PCP/AP should disassociate from the previous S-AP, and the member PCP/AP shall perform the steps described in 9.34.2.2 that allow a clustering enabled PCP/AP to join the centralized PCP/AP cluster of an S-AP as a member PCP/AP.

When a member PCP/AP is coordinated by an MM-SME and the member PCP/AP elects to change its Cluster Time Offset within a centralized PCP/AP cluster, then the member PCP/AP shall pass the updated Cluster Time Offset to a second non-PCP/non-AP STA coordinated by the MM-SME of the member PCP/AP, and the second non-PCP/non-AP STA shall send an Information Response frame that includes a Cluster Time Offset element containing the Cluster Time Offset Index set to the updated index to the S-AP of the centralized PCP/AP cluster.

A member PCP/AP within a centralized PCP/AP cluster, upon a change of the Clustering Control field received from its S-AP, shall update the Clustering Control field sent in subsequent frames. Upon a change of the ECPAC Policy Detail field received from its S-AP, a member PCP/AP within a centralized PCP/AP cluster shall update the ECPAC Policy element sent in subsequent frames and send individually addressed Announce or Information Response frames to other STAs within the BSS in order notify them of the changes. The member PCP/AP within the centralized PCP/AP cluster shall attempt to receive a DMG Beacon frame from its S-AP at least once every dot11DMGEcssPolicyDetailUpdateDurationMax TUs.

In the case when a member PCP/AP of a cluster has not received DMG Beacon frames from its S-AP for a duration exceeding 4×aMinBTIPeriod beacon intervals, and the member PCP/AP intends to continue to operate a BSS on the channel, the PCP/AP shall either

- Stop the current BSS then become an S-AP within the CCSS as described in 9.34.2.2; or
- Monitor the channel for DMG Beacon frames for an interval of length at least aMinChannelTime. During this period, if one or more DMG Beacon frames are received with the ECPAC Policy Enforced field set to 1 in the DMG Parameters field and the Cluster Member Role set to 1 (S-PCP/S-AP of cluster) from one or more S-APs, then the PCP/AP shall join a selected S-AP as a cluster member as described in 9.34.2.2. If, after the period elapses, no DMG Beacon frames are received with the ECPAC Policy Enforced field in the DMG Parameters field set to 1 and the Cluster Member Role set to 1 (S-PCP/S-AP of cluster) and if the PCP/AP is decentralized PCP/AP clustering capable, then the PCP/AP shall attempt to join a decentralized PCP/AP cluster if present as described in 9.34.2.1. If the PCP/AP is not decentralized PCP/AP clustering capable or a decentralized PCP/AP cluster is not present, then the PCP/AP shall set its Cluster Member Role to 0 (not currently participating in a cluster). In either case, the PCP/AP
  - Shall set the ECPAC Policy Enforced bit to 0 and shall not include the ECPAC Policy element in (Re)Association Response, Announce, or Information Response frames and
  - Should send individually addressed Announce or Information Response frames to other STAs within the BSS to notify them of the changes.

9.34.3.4 Centralized PCP/AP cluster MAC requirements

If the most recent ECPAC Policy element transmitted by an S-AP/member PCP/member AP includes the BHI Enforced field set to 1, the S-AP/member PCP/member AP shall complete the BTI, A-BFT, and ATI for each subsequent beacon interval before TBTT + 8/1024×Beacon SP duration. The most recently transmitted (if an S-AP) or received (if a member PCP/member AP or non-PCP/non-AP STA) value of Beacon SP duration is used.

If the most recent ECPAC Policy element transmitted by an S-AP/member PCP/member AP has the TXSS CBAP Enforced field set to 1, the S-AP/member PCP/member AP shall complete each of its TXSSs in the DTI within one or more TXSS CBAPs.

If the most recent ECPAC Policy element, received by a non-PCP/non-AP STA in a BSS from the S-AP/member PCP/member AP of the BSS, has the TXSS CBAP Enforced field set to 1, then the non-PCP/non-AP STA shall perform each of its TXSSs in the DTI within one or more TXSS CBAPs. If the non-PCP/non-AP STA is the source DMG STA of an SP and if the non-PCP/non-AP determines that it needs to perform a TXSS before continuing to transmit to the destination DMG STA of the SP, then the non-PCP/non-AP STA should truncate the SP (see 9.33.8).

A TXSS CBAP shall last from TBTT + 8×TXSS CBAP Offset + (n-1)×1024×beacon interval/TXSS CBAP MaxMem until TBTT + 8×TXSS CBAP Offset + (n-1)×1024×beacon interval/TXSS CBAP MaxMem + 8×TXSS CBAP Duration for n = 1 to TXSS CBAP MaxMem, excluding any time that overlaps a BHI or an SP that has source and destination DMG AIDs set to 255 (such as for a Beacon SP). The most recently transmitted (if an S-AP) or received (if a member PCP/member AP or non-PCP/non-AP STA) value of TXSS CBAP Offset and TXSS CBAP Duration fields are used.

The TXSS CBAP is available to all STAs in an ECPAC. STAs may also use the TXSS CBAP for sending frames not related to transmit sector sweeping. Transmission rules during a TXSS CBAP are defined in 9.33.5.

NOTE—Frames, such as data frames, sent in a TXSS CBAP when the TXSS CBAP Enforced field is set to 1 might experience erratically higher interference than frames sent at other times due to the TXSSs of other nearby STAs.

Additional centralized PCP/AP cluster requirements are defined in 9.33.6.6 and 10.1.3.2a.

9.34.4 Cluster report and re-scheduling

A clustering enabled PCP/AP that receives an Extended Schedule element from another clustering enabled PCP/AP may re-schedule SPs and CBAPs in its beacon interval, or move the BTI (10.1.3.2a), in an attempt to mitigate any interference with the transmissions indicated in the received Extended Schedule element. The PCP/AP can create SPs in its beacon interval with the source and destination AID set to 255 to prevent transmissions during specific periods in the beacon interval (9.33.6.2).

A non-PCP/non-AP STA that is a member of a BSS and that receives a DMG Beacon should send a Cluster Report element to its PCP/AP if the received DMG Beacon frame meets all of the following conditions:

- The DMG Beacon is not from the STA's PCP/AP.
- The DMG Beacon contains the Clustering Control field.
- Either
  - The value of the Cluster ID field within the Clustering Control field is different from the MAC address of the STA's PCP/AP; or
  - The value of the Cluster ID field within the Clustering Control field is the same as the MAC address of the STA's PCP/AP, the TBTTs of the two BSSs are less than dot11BeaconPeriod/(2×ClusterMemMax) apart in time, and the ECPAC Policy Enforced field in the DMG Beacon frame received most recently from the STA's PCP/AP is equal to 1.

The non-PCP/non-AP STA shall not send a Cluster Report element to its PCP/AP if the received DMG Beacon frame does not meet the preceding conditions.

A Cluster Report element meeting the conditions above shall be transmitted in an Announce or Information Response frame sent to the STA's PCP/AP. Within the transmitted Cluster Report element, the STA shall set the Cluster report subfield to one. The STA shall set the Clustering Control field within a transmitted Cluster Report element to the corresponding field values within the Clustering Control of the received DMG Beacon, shall set the Reported BSSID field to the BSSID of the received DMG Beacon, and shall set the Reference timestamp field to indicate the DMG Beacon reception time. The STA shall set the Schedule present subfield to one if the Extended Schedule field is present in the transmitted Cluster Report element; otherwise, it shall set Schedule present subfield to zero. The STA shall set the TSCONST present subfield to one if the TSCONST field is present in the transmitted Cluster Report element; otherwise, it shall set TSCONST present subfield to zero.

The STA shall set the ECPAC Policy Enforced field in the Cluster Report Control field to the value of the ECPAC Policy Enforced field in the received DMG Beacon. The STA should attempt to receive an Announce frame from the PCP/AP that transmitted the DMG Beacon according to the channel access rules described in 9.33 in order to solicit an ECPAC Policy element. If the STA obtains an ECPAC Policy element from the PCP/AP that transmitted the DMG Beacon, the STA shall set the ECPAC Policy Present subfield to 1 and include the ECPAC Policy element in the transmitted Cluster Report element; otherwise, the STA shall set ECPAC Policy Present subfield to 0 and not include the ECPAC Policy element in the transmitted Cluster Report element. If present, the Extended Schedule Element field within the Cluster Report element shall be set to the corresponding field values within the Extended Schedule element of the received DMG Beacon. If present, the TSCONST field shall be set to indicate periods of time with respect to the TBTT of the beacon interval of the BSS the STA participates where the transmitting STA experiences poor channel conditions, such as due to interference.

If the received DMG Beacon contains more than one Extended Schedule element entry, the STA shall repeat the aforementioned procedure and transmit a Cluster Report element corresponding to each Extended Schedule element entry.

Upon receiving a Cluster Report element from a non-PCP/non-AP STA with the Cluster report field set to 1, a clustering enabled PCP/AP may re-schedule SPs and CBAPs in its beacon interval, move the BTI if the clustering enabled PCP/AP is an S-PCP/S-AP in a decentralized PCP/AP cluster, or change the Cluster Time Offset if the clustering enabled PCP/AP is a member PCP/AP, or perform other actions, in an attempt to mitigate any interference with the transmissions indicated in the received Cluster Report element. The clustering enabled PCP/AP may also create SPs in its beacon interval with the source and destination AID set to 255 to prevent transmissions during specific periods in the beacon interval.

A member PCP/AP within a centralized PCP/AP cluster should report new interference information and may report all interference information to the S-AP of the cluster

- When the member PCP/AP receives one or more of the following:
  - A DMG Beacon frame from another PCP/AP in another centralized PCP/AP cluster within the same CCSS or another CCSS
  - A Cluster Report element with the Cluster Report field set to 1 from a non-PCP/non-AP STA within the same BSS characterizing a PCP/AP in another centralized PCP/AP cluster within the same CCSS or another CCSS; and
- If at least dot11DMGEcssClusterReportDurationMin TUs have elapsed since the last report.

The report should aggregate the information received from all sources and minimize duplication. The member PCP/AP passes the report to a second non-PCP/non-AP STA coordinated by the MM-SME of the member PCP/AP, and the second non-PCP/non-AP STA sends the report in an Information Response frame that includes one or more Cluster Report elements to the S-AP of its centralized PCP/AP cluster. If the member PCP/AP does not elect to change its Cluster Time Offset at this time, the second non-PCP/non-AP STA includes a Cluster Time Offset element with an unchanged Cluster Time Offset Index field.

Via an unspecified means, the S-AP might aggregate received DMG Beacon frames and Cluster Report elements and send the aggregate to the CCSR. Upon receiving this information, the CCSR might reconfigure the TSF offsets of an S-AP, reconfigure the ECPAC Policy Detail of an S-AP, update the Cluster Time Offset availability information provided in an individually addressed frame by an S-AP to a member PCP/AP, or perform other actions.

9.34.5 Decentralized PCP/AP cluster request

A non-PCP/non-AP STA that is a member of a BSS may transmit a Cluster Report element to its PCP/AP to request that decentralized PCP/AP clustering be enabled in the BSS. The non-PCP/non-AP STA can make this request if, for example, the device containing the non-PCP/non-AP STA intends to initialize another co-channel BSS (10.1) in which it performs the role of PCP/AP and, when performing this role, it wishes to become a member PCP/AP of the decentralized PCP/AP clustering enabled by its current PCP/AP.

To request PCP/AP clustering to be enabled in the BSS, the STA shall transmit a Cluster Report element with the Cluster request subfield set to 1 to its PCP/AP. Upon receiving a Cluster Report element with the Cluster request subfield set to 1, the PCP/AP should form and maintain decentralized PCP/AP clustering in the BSS according to the procedures described in 9.34.2 and 9.34.3. In doing that, the PCP/AP should set the minimum duration of the Beacon SP to be equal to the Beacon SP duration.

If the non-PCP/non-AP STA does not receive a DMG Beacon frame from its PCP/AP with decentralized PCP/AP clustering enabled after dot11ClusterEnableTime following the transmission to its PCP/AP of a Cluster Report element with the Cluster request subfield set to 1, the non-PCP/non-AP STA may transmit an Announce frame including the last Extended Schedule element transmitted by the PCP/AP. If the Announce frame is transmitted, it shall use MCS 0, and the TA field shall be set to the broadcast address. If a DMG STA receives an Announce frame with the TA field set to the broadcast address and with the BSSID field different from the BSSID of its BSS, the DMG STA may send a Cluster Report element containing the Extended Schedule element within the received Announce frame to its PCP/AP, which might be used by the PCP/AP to reschedule SPs in portions of the beacon interval that are nonoverlapping in time with the SPs contained in the Extended Schedule element reported by the DMG STA.

If a non-PCP/non-AP STA becomes a member PCP/AP of the clustering enabled by its current PCP/AP, the non-PCP/non-AP STA can synchronize scheduled CBAP allocations, if any, between the BSS in which it performs the role of PCP/AP and the BSS of its current PCP/AP. The non-PCP/non-AP STA can disallow STAs in the BSS in which it plays the role of PCP/AP from transmitting during the Beacon SPs of the cluster it is a part of, and this can be done by allocating an SP time-overlapping with each Beacon SP such that each allocated SP has both the source AID and destination AID fields within the Extended Schedule element set to the AID of the non-PCP/non-AP STA.

9.35 DMG beamforming

9.35.1 General

Beamforming (BF) is a mechanism that is used by a pair of STAs to achieve the necessary DMG link budget for subsequent communication. BF training is a bidirectional sequence of BF training frame transmissions that uses sector sweep and provides the necessary signaling to allow each STA to determine appropriate antenna system settings for both transmission and reception. After the successful completion of BF training, BF is said to be established. A BF training frame is an SSW frame, a DMG Beacon frame or a BRP frame. Figure 9-48 gives an example of the beamforming training procedure.

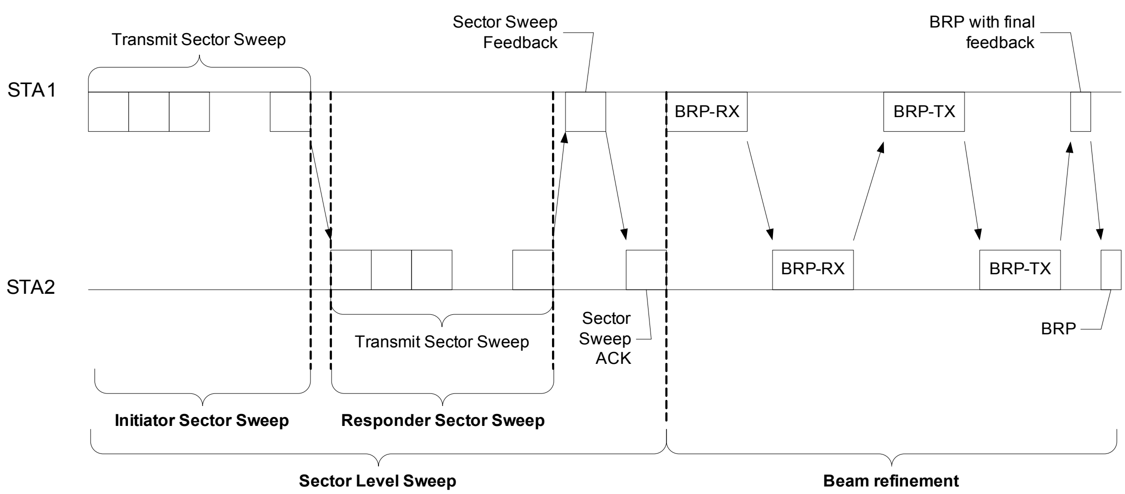


Figure 9-48—An example of beamforming training

In this subclause, the STA that initiates BF training through the transmission of a BF frame is referred to as the initiator, and the recipient STA of the BF frame that participates in BF training with the initiator is referred to as the responder. For BF training that occurs within the A-BFT allocation, the PCP/AP is the initiator and a non-PCP/non-AP STA becomes the responder. For BF training that occurs during an SP allocation, the source DMG STA of the SP is the initiator and the destination DMG STA of the SP becomes the responder. For BF training during a TXOP allocation, the TXOP holder is the initiator and the TXOP responder is the responder.

The link from the initiator to the responder is referred to as the initiator link and the link from the responder to the initiator is referred to as the responder link.

BF training starts with a SLS from the initiator. A beam refinement protocol (BRP) may follow, if requested by either the initiator or the responder. The purpose of the SLS phase is to enable communications between the two participating STAs at the control PHY rate or higher MCS. Normally, the SLS phase provides only transmit BF training. The purpose of the BRP phase is to enable receiver training and enable iterative refinement of the AWV of both transmitter and receiver at both participating STAs. If one of the participating STAs chooses to use only one transmit antenna pattern, receive training may be performed as part of the SLS.

Any BF information obtained by an initiator or a responder during a BF training attempt shall be considered invalid if either or both of the following conditions are satisfied:

a) The SLS phase was not completed within dot11MaxBFTime beacon intervals from the start of the SLS phase.
b) The BRP phase, if initiated, was not completed within dot11MaxBFTime beacon intervals from the start of the BRP phase.

A STA shall abort an SLS if the SLS is not completed within dot11MaxBFTime beacon intervals from the start of the SLS, and shall abort a BRP if the BRP is not completed within dot11MaxBFTime beacon intervals from the start of the BRP.

The number of sectors per DMG antenna shall not be greater than 64. The total number of sectors across all DMG antennas in a STA shall not be greater than 128.

Table 9-16 shows the mandatory and optional procedures in the beamforming mechanism described in this subclause.

Table 9-16—Mandatory and optional procedures in the Beamforming mechanism

Beamforming item	Support mandatory	Notes
SLS phase (9.35.2, 9.35.6.2)	Yes	A DMG STA is capable to participate in an SLS with any other DMG STA as described in 9.35.2 and 9.35.6.2
Beamforming in BTI (9.35.4)	Yes	When operating as a PCP/AP, a DMG STA is capable to perform beamforming in the BTI as described in 9.35.4
Beamforming in A-BFT (9.35.5)	Yes	When operating as a PCP/AP, a DMG STA is capable to perform beamforming in the A-BFT as described in 9.35.5
BRP setup subphase (9.35.3.2)	Yes	A DMG STA is capable to negotiate BRP settings with any other DMG STA as described in 9.35.3.2

Table 9-16—Mandatory and optional procedures in the Beamforming mechanism *(continued)*

Beamforming item		Support mandatory	Notes
MIDC subphase (9.35.6.3)	MID subphase	No	A DMG STA does not have to be capable to perform MID as described in 9.35.6.3
	BC subphase	No	A DMG STA does not have to be capable to perform BC as described in 9.35.6.3
BRP phase (9.35.3, 9.35.6.4)	Feedback = BS-FBCK	Yes	A DMG STA is capable to perform the BRP with any other DMG STA as described in 9.35.3 and 9.35.6.4, and is capable to return the BS-FBCK
	Feedback = Channel measurement	No	A DMG STA is capable to perform the BRP with any other DMG STA as described in 9.35.3 and 9.35.6.4, but does not have to be capable to return channel measurements
Beam tracking (9.35.7)	Feedback = BS-FBCK	Yes	A DMG STA is capable of responding to a receive beam tracking request. A DMG STA is capable of responding to a transmit beam tracking request with the BS-FBCK.
	Feedback = Channel measurement	No	A DMG STA is capable of responding to a receive beam tracking request. A DMG STA does not have to be capable of responding to a transmit beam tracking request with channel measurements.

An SLS between an initiator and a responder is successful for the initiator if, after the completion of the SLS, the initiator receives a response to a frame transmitted to the responder using the sector and antenna selected during the SLS. The SLS is successful for the responder if, after the completion of the SLS, the responder receives a response to a frame transmitted to the initiator using the sector and antenna selected during the SLS.

In this subclause, the last negotiated Total Number of Sectors field, Number of RX DMG Antennas field, and RXSS Length field held by the initiator with respect to the responder refer to the last value for the corresponding field received by the initiator from the responder and that the SLS between the initiator and responder using this value was successful for the initiator. Similarly, the last negotiated Total Number of Sectors field, Number of RX DMG Antennas field, and RXSS Length field held by the responder with respect to the initiator refer to the last value for the corresponding field received by the responder from the initiator and that the SLS between the responder and initiator using this value was successful for the responder.

Until an SLS is successful between an initiator and a responder, the last negotiated Total Number of Sectors field, Number of RX DMG Antennas field, and RXSS Length field used by the initiator with respect to the responder refer to the value of these fields in the responder’s DMG Capabilities element, and the last negotiated Total Number of Sectors field, Number of RX DMG Antennas field, and RXSS Length field used by the responder with respect to the initiator refer to the value of these fields in the initiator’s DMG Capabilities element.

If an MMSL cluster capable STA has successfully transmitted to a peer STA an MMS element with the BeamLink Cluster field set to 1, then all MAC entities coordinated by the same MM-SME as the MMSL cluster capable STA shall use a single beamformed link for the MMSL cluster. Also, the MAC address used by the MMSL cluster capable STA to initiate the beamforming procedure shall remain the same until the completion of the beamforming procedure.

9.35.2 Sector-level sweep (SLS) phase

9.35.2.1 General

The SLS phase can include as many as four components: an initiator sector sweep (ISS) to train the initiator link as described in 9.35.2.2, a responder sector sweep (RSS) to train the responder link as described in 9.35.2.3, an SSW Feedback as described in 9.35.2.4, and an SSW ACK as described in 9.35.2.5.

An initiator shall begin the SLS phase by transmitting the frames of the ISS.

A responder shall not begin transmitting the frames of an RSS before the ISS is successfully completed, except when the ISS occurs in the BTI (9.35.5).

An initiator shall not begin an SSW Feedback before the RSS phase is successfully completed, except when the RSS occurs in the A-BFT.

A responder shall not begin an SSW ACK with an initiator in the A-BFT. A responder shall begin an SSW ACK with an initiator immediately following the successful completion of the SSW Feedback with the initiator.

During the SLS phase the only BF frames an initiator may transmit are the DMG Beacon frame, the SSW frame, and the SSW-Feedback frame. During the SLS phase the only BF frames a responder may transmit are the SSW frame and the SSW-ACK frame.

If during the SLS the initiator and responder each execute a TXSS, then at the end of the SLS phase both the initiator and the responder possess their own transmit sector. If either the ISS or the RSS employs a receive sector sweep, then the responder or the initiator, respectively, possesses its own receive sector.

The following rule applies to all channel access in DMG BSSs. A STA shall not transmit a frame as part of a sector sweep comprising at least two sectors if a response is expected within SIFS interval from the STA identified in the RA field of the transmitted frame.

A STA shall not change its transmit power during a sector sweep.

Two examples of the SLS phases are shown in Figure 9-49 and Figure 9-50.

In Figure 9-49 the initiator has many sectors, the responder has only one transmit sector and receive sector sweep is used at the responder sector sweep (the responder is transmitting all responder SSW frames through the same transmit sector, the initiator is switching receive antennas at the same time).

In Figure 9-50 the initiator has many transmit sectors, the responder has one transmit sector. In this case, receive training for the initiator is performed in the BRP phase.

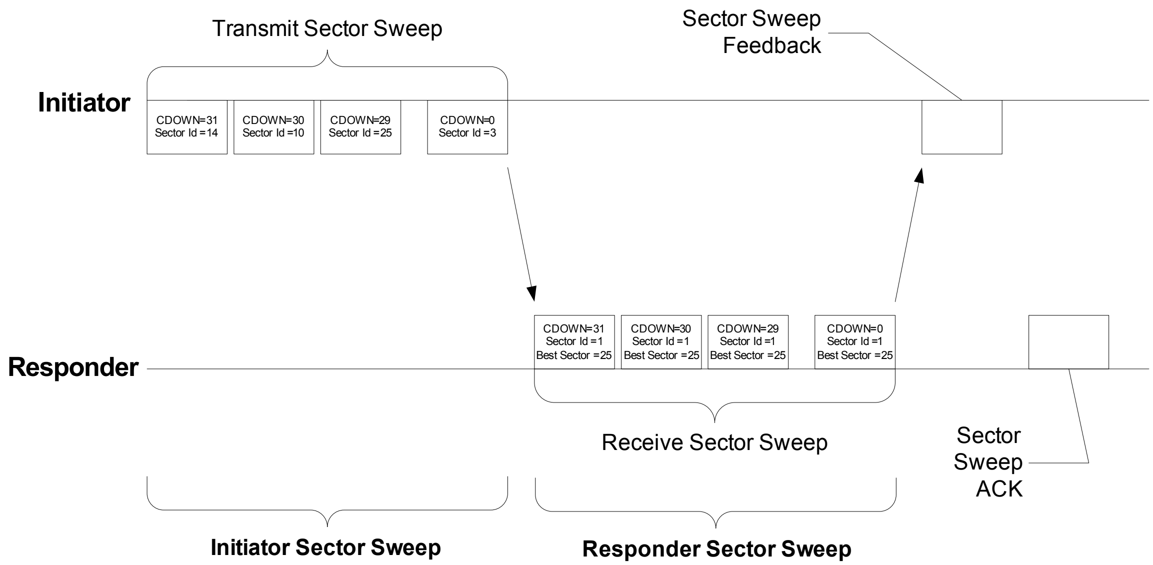


Figure 9-49—An example of SLS

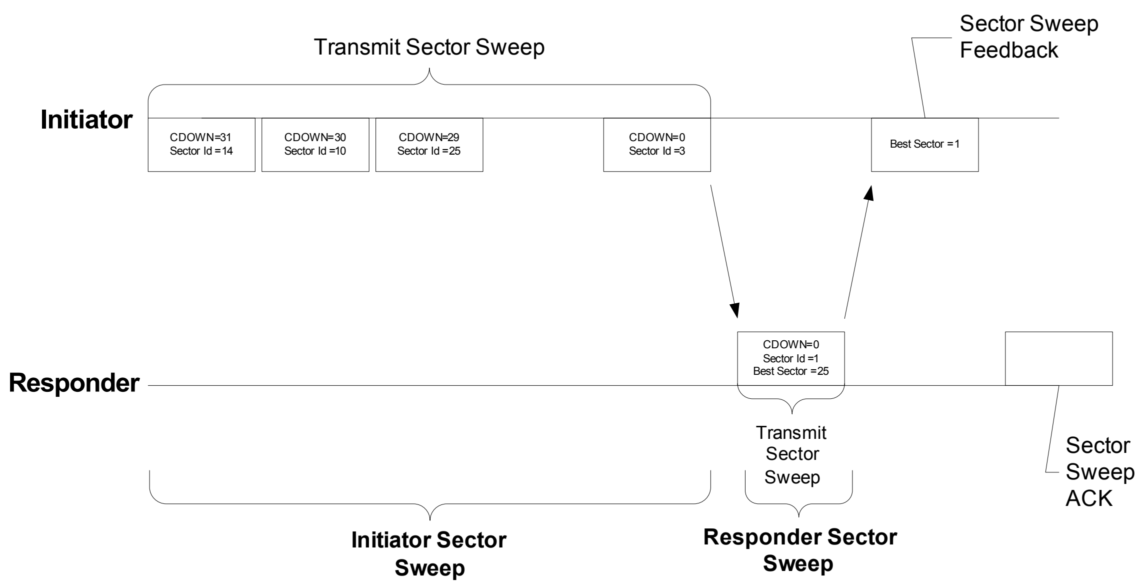


Figure 9-50—An example of SLS

9.35.2.2 Initiator Sector Sweep

9.35.2.2.1 General

An ISS comprises either an initiator TXSS or an initiator RXSS.

An initiator RXSS may be performed in an ISS when the initiator chooses to use only one transmit antenna pattern across each of its DMG antennas.

An initiator may employ either DMG Beacon frames or SSW frames in the ISS. If the initiator begins an ISS with the transmission of a DMG Beacon frame, it shall use the DMG Beacon frame for all subsequent transmissions during the ISS. Conversely, if the initiator begins an ISS with the transmission of an SSW frame, it shall use the SSW frame for all subsequent transmissions during the ISS. A responder never begins an ISS.

The Duration field within each transmitted DMG Beacon frame is set to the time remaining until the end of the current BTI (see 9.35.4). The Duration field of each transmitted SSW frame shall be set to the time remaining until the end of the ISS or the end of the current allocation, whichever is earlier.

The initiator shall set the Direction subfield in the Sector Sweep field to 0 within each DMG Beacon and SSW frame transmitted during an ISS.

The initiator shall set the Total Sectors in ISS subfield within the SSW Feedback field to the total number of sectors that it is using in the ISS. The total is computed as the sum of all sectors employed on all antennas in the ISS multiplied by the number of the responder's receive DMG antennas. For example, if 4 sectors are used on antenna 0, 3 sectors on antenna 1, 5 sectors on antenna 2, and the responder has two receive DMG antennas, then the Total Sectors in ISS subfield is set to 24.

9.35.2.2.2 Initiator TXSS

When the IsInitiatorTXSS field for a specific SP is 1 in a received Extended Schedule element (see 8.4.2.134) or Grant frame (see 8.3.1.13) and the Beamforming Training field of the BF Control field for that SP in the same Extended Schedule element or Grant frame is 1, then the SP contains an initiator TXSS, and the initiator shall start an initiator TXSS at the start of the next SP as indicated by the received Extended Schedule element or Grant frame.

During the BTI, the initiator shall start an initiator TXSS (see also 9.35.4).

During a CBAP, an initiator may obtain a TXOP with an initiator TXSS or may transmit a Grant frame to the responder with the Beamforming Training and IsInitiatorTXSS fields of the BF Control field set to 1. A responder that receives such a Grant frame in a CBAP and that has the Grant ACK Supported field equal to 1 in the responder's DMG Capabilities element shall respond with a Grant ACK frame SIFS interval after the reception of the Grant frame. In the Grant ACK frame, the responder shall set the Beamforming Training field to 1. The initiator starts the initiator TXSS SIFS interval after the reception of the Grant ACK frame if the Grant ACK Supported field in the responder's DMG Capabilities element is 1 or PIFS interval after the transmission the Grant frame otherwise. To transmit a Grant frame during a TXOP, the TXOP holder shall first terminate the TXOP by transmitting a CF-End frame followed by the transmission of the Grant frame PIFS interval after the end of the last CF-End frame transmission.

During an initiator TXSS, the Sector ID field in each BF frame shall be set to a value that uniquely identifies the transmit antenna sector employed when the BF frame is transmitted. The CDOWN field in each transmitted frame shall contain the total number of transmissions remaining until the end of the initiator TXSS, such that the last BF frame transmission of the initiator TXSS has the CDOWN field set to 0. Each transmitted BF frame shall be separated by a time interval equal to SBIFS, unless the allocation ends as described in 9.35.6. This is indicated in Figure 9-51.

If the initiator has more than one DMG antenna, the initiator transmits the BF frame through a number of sectors equal to the value of the last negotiated Total Number of Sectors field that was transmitted by the initiator to the responder. In each transmitted BF frame, the initiator shall set the Sector ID and DMG Antenna ID fields to uniquely identify the sector and the DMG Antenna ID, respectively, the initiator is using for the frame transmission and shall set the CDOWN field to the total number of transmissions remaining from all of the initiator's DMG antennas. The initiator shall transmit from its DMG antennas in increasing order of Antenna ID.

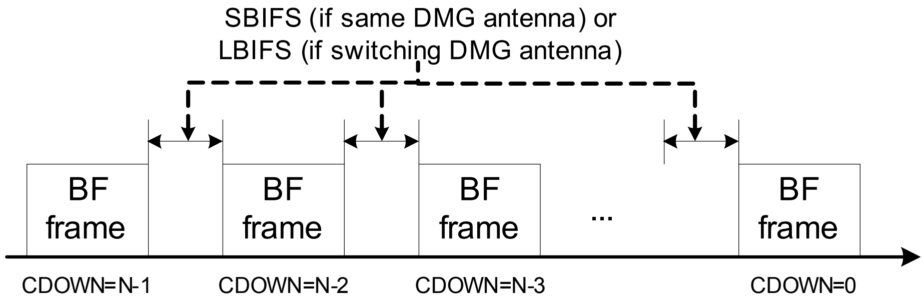


Figure 9-51—Initiator TXSS or Initiator RXSS

For an ISS outside the BTI and if the responder has more than one DMG antenna, the initiator repeats its initiator sector sweep for the number of DMG antennas indicated by the responder in the last negotiated Number of RX DMG Antennas field that was transmitted by the responder. Repetitions of the initiator sector sweep are separated by an interval equal to LBIFS time. In this case CDOWN indicates the number of sectors until the end of transmission from all initiator's DMG antennas to all responder's DMG antennas. At the start of an initiator TXSS, the responder should have its first receive DMG antenna configured to a quasi-omni pattern and should not change its receive antenna configuration for a time corresponding to the value of the last negotiated Total Number of Sectors field transmitted by the initiator multiplied by the time to transmit a single SSW frame, plus appropriate IFSs (9.3.2.3). After this time, the responder may switch to a quasi-omni pattern in another DMG antenna.

The initiator TXSS ends at the end time of the BF frame from the initiator with the CDOWN field set to 0. If the responder is unable to receive this frame, the responder shall assume that the initiator TXSS has completed at the expected end time of this frame.

9.35.2.2.3 Initiator RXSS

An initiator RXSS may be requested only when an initiator is aware of the capabilities of a responder, which includes the RXSS Length field. An initiator can obtain the capabilities of a responder using the Information Request and Response procedure as described in 10.29.1.

When the IsInitiatorTXSS field for a specific SP in a received Extended Schedule element or Grant frame is 0 and the Beamforming Training field of the BF Control field for that SP in the same Extended Schedule element or Grant frame is 1, then the SP shall contain an initiator RXSS, and the initiator shall start an initiator RXSS at the start of the next SP described by the received Extended Schedule element or Grant frame.

The initiator never performs an initiator RXSS during the BTI.

During a CBAP, an initiator shall not obtain a TXOP with an initiator RXSS. Within a CBAP, an initiator may transmit a Grant frame to the responder with the Beamforming Training field set to 1 and the IsInitiatorTXSS field set to 0. A responder that receives such a Grant frame in a CBAP and that has the Grant ACK Supported field equal to 1 in the responder's DMG Capabilities element shall respond with a Grant ACK frame SIFS interval after the reception of the Grant frame. In the Grant ACK frame, the responder shall set the Beamforming Training field to 1. The initiator starts the initiator RXSS SIFS interval after the reception of the Grant ACK frame if the Grant ACK Supported field in the responder's DMG Capabilities element is 1 or PIFS interval after the transmission the Grant frame otherwise.

During the initiator RXSS, the initiator shall transmit from each of the initiator's DMG antennas the number of BF frames indicated by the responder in the last negotiated RXSS Length field transmitted by the responder. Each transmitted BF frame shall be transmitted with the same fixed antenna sector or pattern. The initiator shall set the Sector ID and DMG Antenna ID fields in each transmitted BF frame to a value that uniquely identifies the single sector through which the BF frame is transmitted. The initiator shall set the CDOWN field in each transmitted BF frame to contain the total number of transmissions remaining to the end of the initiator RXSS, such that the last BF frame transmission of the initiator RXSS has the CDOWN field set to 0. Each transmitted BF frame shall be separated by a time interval equal to SBIFS, except if the allocation ends as described in 9.35.6. This is indicated in Figure 9-51.

During an initiator RXSS, the responder should have its receive antenna array configured to sweep RXSS Length sectors for each of the initiator's DMG antennas while attempting to receive SSW frames from the initiator.

The initiator RXSS ends at the end time of the SSW frame from the initiator with the CDOWN field set to 0. If the responder is unable to receive this frame, the responder shall assume that the initiator RXSS has completed at the expected end time of this frame.

9.35.2.3 Responder Sector Sweep

9.35.2.3.1 General

An RSS comprises either a responder TXSS or a responder RXSS.

A responder RXSS may be performed in an RSS when the responder chooses to use only one transmit antenna pattern across each of its DMG antennas.

The responder initiates an RSS with the transmission of an SSW frame, which is the only frame allowed during an RSS.

The responder shall set the Direction subfield in the Sector Sweep field to 1 within each SSW frame transmitted during an RSS.

The Duration field within each transmitted SSW frame shall be set to the time remaining until the end of the RSS or the end of the current allocation (i.e., SP, TXOP or SSW slot in the case of the A-BFT), whichever comes first.

9.35.2.3.2 Responder TXSS

If the DMG Beacon immediately preceding an A-BFT contained a value of one in the IsResponderTXSS subfield of the Beacon Interval Control field, then the A-BFT is a responder TXSS A-BFT.

When the IsResponderTXSS field for a specific SP in a received Extended Schedule element or Grant frame is 1 and the Beamforming Training field of the BF Control field for that SP in the same Extended Schedule element or Grant frame is 1, then the SP contains a responder TXSS, and the responder shall initiate a TXSS following the completion of the ISS in the SP described by the received Extended Schedule element or Grant frame.

When the RXSS Length field within an SSW frame used to obtain a TXOP during a CBAP is 0, the responder shall initiate a TXSS following the completion of the ISS in the TXOP described by the received SSW frame.

During a responder TXSS, the responder shall set the Sector ID and the DMG Antenna ID fields in each transmitted SSW frame to a value that uniquely identifies the sector through which the SSW frame is transmitted. The initial value of CDOWN is set to the total number of sectors in the responder (covering all DMG antennas) multiplied by the number of DMG antennas at the initiator minus one. The responder shall set the CDOWN field in each transmitted SSW frame to contain the total number of transmissions remaining to the end of the responder TXSS, such that the last SSW frame transmission of the responder TXSS has the CDOWN field set to 0. The responder shall transmit from its DMG antennas in increasing order of Antenna ID. Each transmitted SSW frame shall be separated by an interval of time equal to SBIFS. Transmissions are not separated by SBIFS if the allocation ends as described in 9.35.4 and 9.35.6 or if the end of an SSW slot is reached as described in 9.35.5 or when the responder completed a full sweep of all its transmit sectors and is ready to transmit to another DMG antenna of the initiator. In the latter case, the next transmission is separated from the previous transmission by LBIFS interval. This is indicated in Figure 9-52.

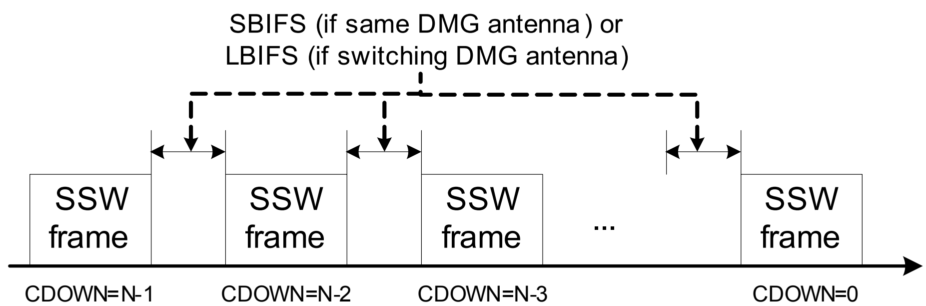


Figure 9-52—Responder TXSS or Responder RXSS

A responder that has more than one DMG antenna and has set the value of the DMG Antenna Reciprocity field in its DMG Capabilities element to 0 transmits sequentially through all the sectors of all of its DMG antennas. A responder that has more than one DMG antenna and has set the value of the DMG Antenna Reciprocity field in the responder's DMG Capabilities element to 1 transmits through the DMG antenna from which it had the best reception in the initiator sector sweep. The length of the sector sweep to each of the initiator's DMG antennas is not dependent on the value of the DMG Antenna Reciprocity field.

A responder that has only one DMG antenna should transmits through all its sectors, regardless of the setting of the DMG Antenna Reciprocity field.

The responder shall set the Sector Select field and the DMG Antenna Select field in each transmitted SSW frame to the value of the Sector ID field and DMG Antenna ID field, respectively, of the frame received with the best quality during the ISS. The determination of which frame is received with best quality is implementation dependent and beyond the scope of this standard. The responder shall set the SNR Report field to the SNR measured for the frame indicated by the Sector Select field and DMG Antenna Select field.

If the initiator has more than one DMG antenna, the responder repeats its responder sector sweep for the number of DMG antennas indicated by the initiator in the last negotiated Number of RX DMG Antennas field transmitted by the initiator. At the start of a responder TXSS, the initiator should have its receive antenna array configured to a quasi-omni antenna pattern in one of its DMG antennas for a time corresponding to the value of the last negotiated Total Number of Sectors field transmitted by the responder multiplied by the time to transmit a single SSW frame, plus any appropriate IFSs (9.3.2.3). After this time, the initiator may switch to a quasi-omni pattern in another DMG antenna.

The responder TXSS ends at the end time of the SSW frame from the responder with the CDOWN field set to 0. If the initiator is unable to receive this frame, the initiator shall assume that the responder TXSS has completed at the expected end time of this frame.

9.35.2.3.3 Responder RXSS

If the DMG Beacon immediately preceding an A-BFT contained a value of zero in the IsResponderTXSS subfield of the Beacon Interval Control field within the DMG Beacon, then the A-BFT is a responder RXSS A-BFT.

When the IsResponderTXSS field for a specific SP in a received Extended Schedule element or Grant frame is 0 and the Beamforming Training field of the BF Control field for that SP in the same Extended Schedule element or Grant frame is 1, then the SP contains a responder RXSS, and the responder shall initiate an RXSS following the completion of the ISS in the SP described by the received Extended Schedule element or Grant frame.

When the RXSS Length field within an SSW frame used to obtain a TXOP during a CBAP is equal to a nonzero value, the responder shall initiate an RXSS following the completion of the ISS in the TXOP described by the received SSW frame.

During the responder RXSS, the responder shall transmit the number of SSW frames indicated by the initiator in the initiator's most recently transmitted RXSS Length field (non-A-BFT) or FSS field (A-BFT) from each of the responder's DMG antennas, each time with the same antenna sector or pattern fixed for all SSW frames transmission originating from the same DMG antenna. The responder shall set the Sector ID and DMG Antenna ID fields in each transmitted frame to a value that uniquely identifies the sector and DMG antenna, respectively, through which the BF frame is transmitted. The responder shall set the CDOWN field in each transmitted SSW frame to contain the total number of transmissions remaining until the end of the responder RXSS, such that the last SSW frame transmission of the responder RXSS has the CDOWN field equal to zero. Each transmitted SSW frame shall be separated by an interval of time equal to SBIFS, except if the allocation ends as described in 9.35.6 or if the end of an SSW slot is reached as described in 9.35.5. This is indicated in Figure 9-52.

The responder shall set the Sector Select field and the DMG Antenna Select field in each transmitted SSW frame to the value of the Sector ID field and the DMG Antenna ID field, respectively, of the frame received with the best quality during the ISS. The determination of which frame is received with best quality is implementation dependent and beyond the scope of this standard.

At the start of a responder RXSS, the initiator should have its receive antenna array configured to sweep over RXSS Length sectors for each of the responder DMG antennas when it attempts to receive frames from the responder until the completion of the responder RXSS.

The responder RXSS ends at the end time of the SSW frame from the responder with the CDOWN field set to 0. If the initiator is unable to receive this frame, the initiator shall assume that the responder RXSS has completed at the expected end time of this frame.

9.35.2.4 Sector Sweep Feedback

Sector Sweep Feedback (SSW Feedback) occurs following each RSS.

During SSW Feedback, the initiator shall transmit an SSW-Feedback frame to the responder.

During SSW Feedback, the responder should have its receive antenna array configured to a quasi-omni antenna pattern in the DMG antenna through which it received with the highest quality during the ISS, or to the best antenna configuration it has found during RXSS if RXSS has been performed during the ISS, and should not change its receive antenna configuration when it communicates with the initiator until the expected end of the SSW Feedback.

When responder TXSS was performed during the preceding RSS, the initiator shall set the Sector Select field and the DMG Antenna Select field in the SSW-Feedback frame it transmits to the value of the Sector ID field and DMG Antenna ID field, respectively, of the frame received with the best quality during the responder TXSS. The determination of which frame is received with the best quality is implementation dependent and beyond the scope of this standard. In addition, the initiator shall set the SNR Report field to the SNR measured for the frame received by the sector and DMG antenna indicated by the Sector Select field and DMG Antenna Select field. The SSW-Feedback frame shall be transmitted through the sector identified by the value of the Sector Select field and DMG Antenna Select field received from the responder during the preceding responder TXSS.

When responder RXSS was performed during the preceding RSS, the Sector Select field and the DMG Antenna select field in the transmitted SSW-Feedback frame are reserved. The initiator shall set the SNR Report field to the SNR measured on the frame on the receive sector designated by the RSS. The SSW-Feedback frame shall be transmitted through the sector identified by the value of the Sector Select field received from the responder during its most recently completed RSS with the initiator.

In the transmitted SSW-Feedback frame, the initiator shall set the TX-TRN-REQ field to one if it desires to have transmitter training as part of the beam refinement phase and shall set the L-RX field to indicate the length of the training sequence it requests the responder to use in the beam refinement phase. If the initiator desires to carry out the MIDC subphase as part of the beam refinement, it shall set the BC-REQ field to 1 to request a BC subphase and shall set the MID-REQ field to 1 to request an MID subphase; in this case, the L-RX field shall be set to indicate the number of receive AWVs the initiator uses during the MID subphase.

If the responder receives an SSW-Feedback frame from the initiator before it completes the RSS with the initiator such as described in 9.35.5, the responder may cease the RSS.

9.35.2.5 Sector Sweep ACK

When present, the Sector Sweep ACK (SSW ACK) occurs following an SSW Feedback.

When a responder TXSS is performed during an RSS, the responder shall transmit an SSW-ACK frame to the initiator to perform an SSW ACK. The SSW-ACK frame shall be transmitted through the sector identified by the value of the Sector Select field and the DMG Antenna Select field received from the initiator in the last SSW Feedback.

When an RXSS was performed during an RSS, an SSW-ACK frame shall be sent by the responder to the initiator. The SSW-ACK should be sent by the DMG antenna indicated in the DMG Antenna Select field in the last SSW-Feedback frame.

In the transmitted SSW-ACK frame, the responder shall set the TX-TRN-REQ field to one if it requires transmitter training as part of the beam refinement phase and shall set the L-RX field to indicate the length of the training sequence it requests the initiator to use in the beam refinement phase as described in 8.4a.4. If the responder desires to carry out a MID subphase, it sets the MID-REQ bit to 1 in the BRP Request field of the SSW frame. In this case, it shall also set the L-RX field to indicate the number of receive AWVs it uses during the MID subphase. If the responder desires to carry out a BC subphase, it sets the BC-REQ bit to 1. If the initiator has set either the MID-REQ or the BC-REQ fields to 1 in the SSW-Feedback frame, the responder may set the MID-Grant or the BC-Grant fields to 1, or both, to grant the requests.

At the start of an SSW ACK, the initiator should have its receive antenna array configured to a quasi-omni antenna pattern using the DMG antenna through which it received with the highest quality during the RSS, or the best receive sector if an RXSS has been performed during the RSS, and should not change its receive antenna configuration while it attempts to receive from the responder until the expected end of the SSW ACK.

9.35.3 Beam Refinement Protocol (BRP) phase

9.35.3.1 General

BRP is a process in which a STA trains its RX and TX antenna array(s) and improves its TX antenna configuration and RX antenna configuration using an iterative procedure. BRP may be used regardless of the antenna configuration a STA supports.

The BRP phase is composed of a BRP setup subphase, a Multiple sector ID Detection (MID) subphase, a Beam Combining (BC) subphase, a subset of the previous subphases, and one or more beam refinement transactions. BRP setup allows STAs to exchange beam refinement capability information and to request the execution of the other BRP subphases. MID and BC (collectively, the MIDC subphase) are optionally used to find better initial AWVs for iterative beam refinement than might have been found by SLS due to imperfect quasi-omni receive antenna patterns. In MID, a quasi-omni transmit pattern is tested against a number of receive AWVs; this reverses the scanning roles from the transmit sector sweep. In BC, a small set of transmit and receive AWVs are tested in pairwise combinations, thus avoiding the use of quasi-omni patterns. Finally, given the starting point from SLS or MIDC, STAs can explore a broader set of transmit and receive AWVs using a request/response exchange referred to as a beam refinement transaction.

The BRP setup subphase may be skipped if the BRP follows an SSW-ACK frame and no MID or BC subphases were requested during the SLS. MID and BC subphases can be skipped if either STA indicates that the subphase is not needed by setting the MID-REQ and BC-REQ fields to 0 or by setting the MID-Grant and BC-Grant fields to 0. The beam refinement transaction can be skipped if both sides indicate that the transaction is not needed by setting the L-RX and TX-TRN-REQ fields to 0.

The BRP setup phase is defined in 9.35.3.2.

The MID subphase is composed of either an R-MID subphase or an I-MID subphase or both, which are composed of one or more transmissions of BRP-RX packets (21.10.2.2), followed by feedback contained in the next BRP frames from the initiator and responder.

The BC subphase is composed of either an R-BC subphase or an I-BC subphase or both, which are composed of transmission of BRP-RX packets to select a beam, followed by feedback.

A beam refinement transaction is a set of BRP frames consisting of beam refinement requests and responses. A beam refinement request can be either a transmit beam refinement request or a receive beam refinement request or both.

A transmit beam refinement request (TX-TRN-REQ field within the BRP Request field set to 1) indicates the need for transmit antenna array training by the transmitting STA. The BRP packet that has the TX-TRN-REQ set to 1 (or the next BRP packet from this STA) shall include transmit training (TRN-T) subfields appended to it. The STA responding to the BRP packet shall include feedback based on measurements it performed during the reception of the BRP packet. The feedback type is dictated by the FBCK-TYPE field within the DMG Beam Refinement element contained in the BRP packet.

A receive beam refinement request (L-RX field within the BRP Request field greater than zero) indicates the need of the receive antenna array training for the transmitting STA. The responding STA shall respond with a BRP packet with receive training (TRN-R) subfields appended to it.

Requests and responses can be combined in the same frame. As an example, the same frame can be both a transmit beam refinement request and a receive beam refinement request. The same frame can also be used as receive beam refinement response and a receive beam refinement request. See the example in Figure 9-53.

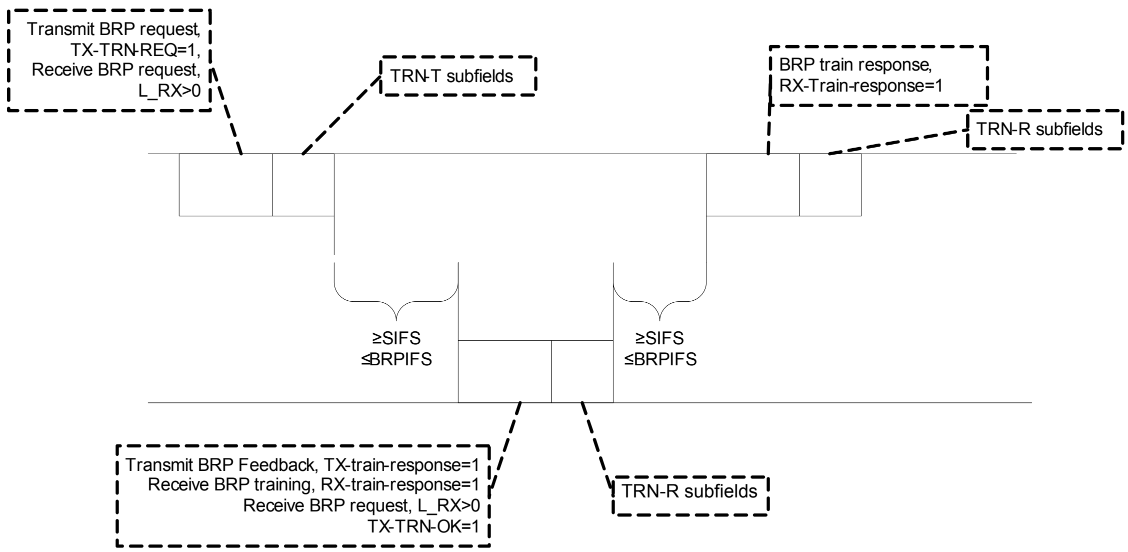


Figure 9-53—An example of a beam refinement transaction

Beam refinement responses are separated from beam refinement requests by at least a SIFS interval and at most a BRPIFS interval provided sufficient time is available for the complete transmission of those frames within the allocation. Similarly, a beam refinement request, if any, is separated from a preceding beam refinement response by at least a SIFS interval and at most a BRPIFS interval provided sufficient time is available for the complete transmission of the beam refinement request within the allocation.

When performing BRP, if a responding STA requires longer than SIFS to transmit a BRP frame as a response for beam refinement training request from a requesting STA, the responding STA should keep the IFS not longer than SIFS by transmitting one or more PPDUs to the requesting STA.

When the beam refinement occurs within the same allocation as the SLS, the SLS initiator is the beam refinement initiator. If the beam refinement occurs in a separate allocation, the STA that transmits the first beam refinement request is the beam refinement initiator. The other STA is the beam refinement responder.

A beam refinement transaction is complete when the initiator determines that it does not need further training and it has received a BRP frame with no training requests from the beam refinement responder.

In Figure 9-53, the first packet (from the initiator) has TX-TRN-REQ=1, the L-RX field has a value greater than zero and TRN-T subfields are appended to the packet. The second packet (from the responder) has a value greater than zero in the L-RX field, the TX-train-response field set to 1, the RX-train-response field set to 1, and TRN-R subfields are appended to the packet. The last packet (from the initiator) has RX-train-response set to 1 and TRN-R subfields are appended to the packet.

9.35.3.2 BRP setup subphase

The BRP setup subphase is used to exchange the intent and capabilities to conduct some or all of the subphases and beam refinement transactions in a subsequent BRP phase. The BRP setup subphase is used to set up the MIDC subphase, but can also be used to set up beam refinement transactions.

The BRP setup subphase shall be used in the following two cases:

— When the RSS part of the SLS phase occurred in an A-BFT, in which case the SSW-ACK frame was not part of the SLS.

— When the initiator set the MID-REQ or BC-REQ fields in the SSW-Feedback frame to 1 or the responder set the MID-REQ or BC-REQ fields in the SSW-ACK frame to 1.

The BRP setup subphase starts with the initiator sending a BRP packet with the Capability Request subfield set to 1 and with the remaining subfields within the BRP Request field set according to the initiator's need for an MID subphase, a BC subphase, and a beam refinement subphase. The BRP setup subphase can also start when the responder grants a MID-REQ or BC-REQ through the SSW-ACK frame or when the responder requests MID or BC in the SSW-ACK frame. Upon receiving a BRP packet with the Capability Request subfield set to 1, the responder shall respond with a BRP packet with the subfields within the BRP Request field set according to the responder's desire for an MID subphase, a BC subphase and a beam refinement subphase. This process is repeated until the responder transmits to the initiator a BRP packet with the Capability Request subfield set to 0 and the initiator sends as a response a BRP packet with the Capability Request subfield also set to 0. The BRP packet from the initiator that initiates the termination of the BRP setup subphase can be the first BRP packet of the BRP phase, either as part of beam refinement or as part of a MID or BC subphase.

A DMG STA (either initiator or responder) requests a MID subphase with MID and BC subphases (see 9.35.6.3.2) by setting both the MID-REQ and BC-REQ subfields to 1 in the BRP Request field of an SSW-Feedback, SSW-ACK or BRP frame. It shall also set the L-RX subfield in the BRP Request field to the number of RX AWV settings it needs in each BRP-RX packet during the MID subphase. The peer DMG STA grants the request by setting the MID-Grant and BC-Grant subfields to 1 in the BRP Request field within the next SSW-ACK or BRP frame transmitted to the requesting DMG STA. If either the MID or BC were not granted by the peer STA, the MID and BC subphases shall not occur.

A DMG STA (either initiator or responder) requests an MID only subphase (see 9.35.6.3.3) by setting the MID-REQ subfield to 1 in the BRP Request field of an SSW-Feedback, SSW-ACK or BRP frame. The STA shall also set the L-RX subfield in the BRP Request field to the number of RX AWV settings it needs in each BRP-RX packet during the MID-subphase. The peer DMG STA grants the request by setting the MID-Grant subfield to 1 in the BRP Request field within the next SSW-ACK or BRP frame transmitted to the requesting DMG STA. The Capability Request subfield and request subfields (TX-TRN-REQ, L-RX, MID-REQ, BC-REQ) within the granting frame shall be set to 0.

If the MID-REQ was granted, the requesting STA shall transmit a BRP frame with the SNR Present and Sector ID Order Present subfields set to 1 and with the N_{meas} field in the FBCK-TYPE field indicating the number of SNR measurements from the last SLS phase. In the Channel Measurement Feedback element, the requesting STA sets the SNR subfields to the SNRs corresponding to the TX sectors received during the SLS phase. In the Sector ID Order subfield, the requesting STA lists the sector IDs of the received sectors. The Capability Request field within the BRP frame shall be set to 0. The MID subphase starts with the transmission of a BRP packet from the peer STA after the reception of the list of sectors. A STA that has granted a MID only request shall not request MID or BC in the response packet. The STA may request MID or BC in the last packet it transmits to the requesting STA as part of the MID. The MID only subphase shall not occur if it was not granted by the peer STA.

A DMG STA (either initiator or responder) requests a BC only subphase (see 9.35.6.3.4) by setting the BC-REQ subfield to 1 in the BRP Request field of an SSW-Feedback, SSW-ACK, or BRP frame. The peer DMG STA (either a responder or initiator) grants the request by setting the BC-Grant subfield to 1 in the BRP Request field within the next SSW-ACK or BRP frame transmitted to the requesting STA. The BC subphase shall not occur if the peer STA does not grant the request.

A DMG STA indicates that beam refinement transactions (9.35.6.4.2) occur by setting the L-RX field to a value greater than 0 to indicate the need for receive beam refinement or by setting the value of the TX-TRN-REQ field to 1 to indicate the need for transmit beam refinement or by setting both. The beam refinement transactions shall occur if at least one of these conditions is met.

If the initiator has requested an MID subphase by setting the MID-REQ subfield or the BC-REQ subfield to 1 and the responder rejected by setting in the response the MID-Grant subfield or the BC-Grant subfield to 0, respectively, the initiator should send a BRP frame with the MID-REQ field set to 0 and the L-RX field set to indicate the number of TRN-R fields the initiator requests for use in the BRP transaction.

If the responder has requested an MID subphase by setting the MID-REQ subfield or the BC-REQ subfield to 1 and the initiator rejected by setting in the response the MID-Grant or the BC-Grant subfields to 0, the initiator should send a BRP frame with the Capability Request subfield set to 1. The responder shall respond with a BRP frame with the MID-REQ field set to 0 and the L-RX field set to indicate the number of TRN-R fields the responder requests for use in the BRP transaction.

Beam refinement transactions shall occur following a MIDC subphase when one or both of the following conditions are met at the last BRP frame transmitted by either the initiator or responder as part of the MID or BC subphases:

a) Either the initiator or the responder set the L-RX field to a value greater than 0.
b) Either the initiator or responder has set the value of the TX-TRN-REQ field to 1.

If within the appropriate IFS the initiator does not receive a response from the responder to a packet transmitted to the responder, the initiator may retransmit the packet.

After the BRP setup subphase, beamforming training shall immediately continue to the next phase (i.e., either MIDC subphase or the beam refinement transactions). Examples of BRP setup subphase procedures are illustrated in Figure 9-54, Figure 9-55, Figure 9-59, Figure 9-60, and Figure 9-66.

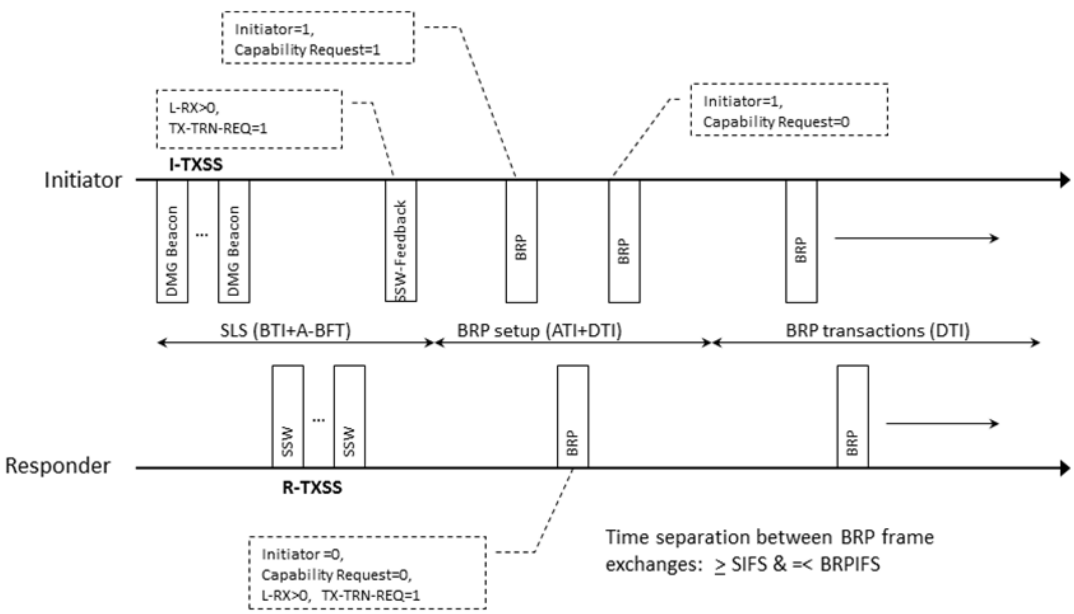


Figure 9-54—Example of BRP setup subphase procedure (SLS in BTI and A-BFT)

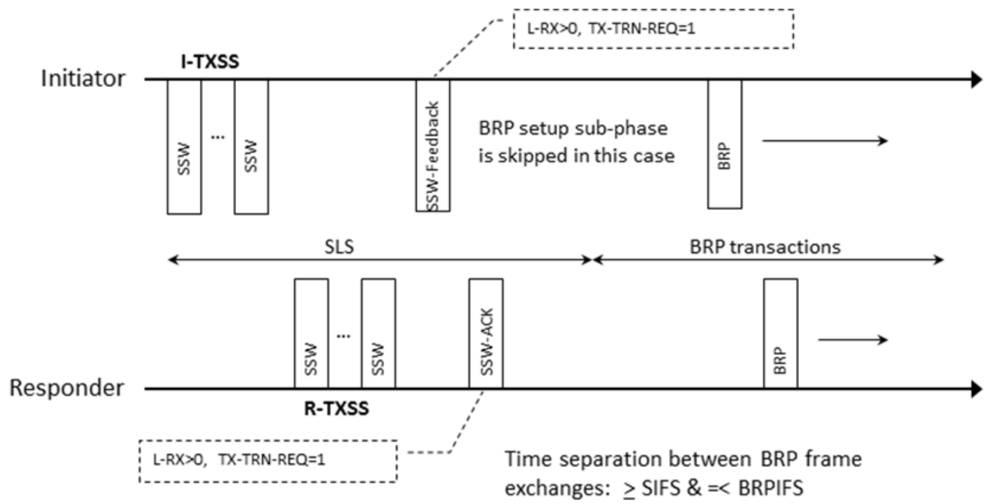


Figure 9-55—Example of BRP setup subphase procedure (SLS in DTI)

9.35.4 Beamforming in BTI

In the BTI, the PCP/AP performs an initiator TXSS as the first part of the SLS with the transmission of at least one DMG Beacon frame. The PCP/AP does not transmit SSW frames in the BTI (9.35.2.2.1).

The PCP/AP may fragment the initiator TXSS over multiple consecutive BTIs by not transmitting a DMG Beacon frame through all sectors available to the PCP/AP in a single BTI. In a BTI with a fragmented initiator TXSS, the PCP/AP shall transmit DMG Beacon frames with the Fragmented TXSS field set to 1. Otherwise, the PCP/AP shall set the Fragmented TXSS field to zero. The PCP/AP shall not change the duration of the next BTI if at least one of the DMG Beacon frames transmitted in the current BTI have the Fragmented TXSS field set to 1. The CDOWN field shall be set to the total number of transmissions remaining to the end of the initiator TXSS, such that the last DMG Beacon frame transmission of the initiator TXSS has the CDOWN field set to 0 (i.e., in a fragmented TXSS, the value of the CDOWN field covers the total number of transmissions remaining in the fragmented TXSS). The TXSS Span field shall be set to the total number of beacon intervals it takes the PCP/AP to complete the entire TXSS phase. The Duration field within each transmitted DMG Beacon shall be set to the time remaining until the end of the current BTI.

When a PCP/AP has more than one DMG antenna, the TXSS shall cover all the sectors in all DMG antennas. The TXSS Span field indicates the total number of beacon intervals it takes the PCP/AP to cover all sectors in all DMG antennas. The value of the TXSS Span field shall be lower than dot11MaximalSectorScan. The PCP/AP shall not change DMG antennas within a BTI. The PCP/AP has a regular schedule of transmitting through each DMG antenna (see 9.35.5.4).

NOTE—If an unassociated responder receives a DMG Beacon frame in the BTI with a fragmented initiator TXSS, the responder may start a responder TXSS in the following A-BFT, or it may scan for the number of beacon intervals indicated in a received TXSS Span field in order to cover a complete initiator TXSS and find a suitable TX sector from the PCP/AP.

From start until the completion of a TXSS phase, all DMG Beacon frames transmitted by the PCP/AP shall have the same value for all the subfields within the Beacon Interval Control field and DMG Parameters field.

9.35.5 Beamforming in A-BFT

9.35.5.1 Allocation of A-BFT

The PCP/AP shall allocate an A-BFT period MBIFS time following the end of a BTI that included a DMG Beacon frame transmission with Next A-BFT equal to 0.

Following the end of a BTI, the PCP/AP shall decrement the value of the Next A-BFT field by one provided it is not equal to zero and shall announce this value in the next BTI. When the Next A-BFT field in a transmitted DMG Beacon is equal to 0, the value of the A-BFT Length field is no less than aMinSSSlotsPerABFT as described in 9.35.5.2. The PCP/AP may increase the Next A-BFT field value following a BTI in which the Next A-BFT field was equal to zero. A STA shall consider that a BTI is completed at the expiration of the value within the Duration field of the last DMG Beacon frame received in that BTI.

All DMG Beacon frames transmitted within the number of beacon intervals specified within the most recently updated TXSS Span field have the same value for all the subfields within the Beacon Interval Control field (10.1.3.2a).

9.35.5.2 Operation during the A-BFT

Beamforming training in the A-BFT consists of the RSS and SSW Feedback of the SLS between the PCP/AP and a STA.

In the A-BFT, the PCP/AP is the initiator and the STA is the responder in the RSS part of the SLS (9.35.2.3). The BRP phase shall not be performed within the A-BFT. A STA shall not transmit in the A-BFT of a beacon interval if it does not receive at least one DMG Beacon frame during the BTI of that beacon interval.

A DMG STA that receives a DMG Beacon frame with the Discovery Mode field equal to 1 and the CC Present field equal to 1 may transmit in the A-BFT following the BTI where the DMG Beacon frame is received if at least one of the following conditions is met:

— The STA's MAC address is equal to the value of the A-BFT Responder Address subfield within the DMG Beacon.
— The value of the A-BFT Responder Address subfield within the DMG Beacon is a group address of a group to which the STA belongs.

If none of these conditions is met following the reception of the DMG Beacon frame with the Discovery Mode field equal to 1 and the CC Present field equal to 1, the DMG STA shall not transmit in the A-BFT.

The A-BFT is slotted and the length of the A-BFT is an integral multiple of the sector sweep slot time. The structure of the A-BFT is shown in Figure 9-56. The PCP/AP shall announce the size of the A-BFT in the A-BFT Length subfield of the Beacon Interval Control field (8.3.4.1), which shall be no less than aMinSSSlotsPerABFT sector sweep (SSW) slots. The first SSW slot begins at the start of the A-BFT, and the following SSW slots are adjacent and nonoverlapping. An SSW slot (Figure 9-57) is a period of time within the A-BFT that can be used by a responder to transmit at least one SSW frame. An SSW slot has a duration of aSSSlotTime. aSSSlotTime is defined to be

aSSSlotTime = aAirPropagationTime + aSSDuration + MBIFS + aSSFBDuration + MBIFS

The parameter aAirPropagationTime accounts for the propagation delay between the initiator and the responder. The parameter aSSDuration (10.38) provides time for a responder to transmit up to the number of SSW frames announced in the FSS subfield of the Beacon Interval Control field in the DMG Beacon. The initiator shall set the FSS subfield of the Beacon Interval Control field in the DMG Beacon to a value that is no less than aSSFramesPerSlot. Finally, the parameter aSSFBDuration provides time for the initiator to perform SSW Feedback.

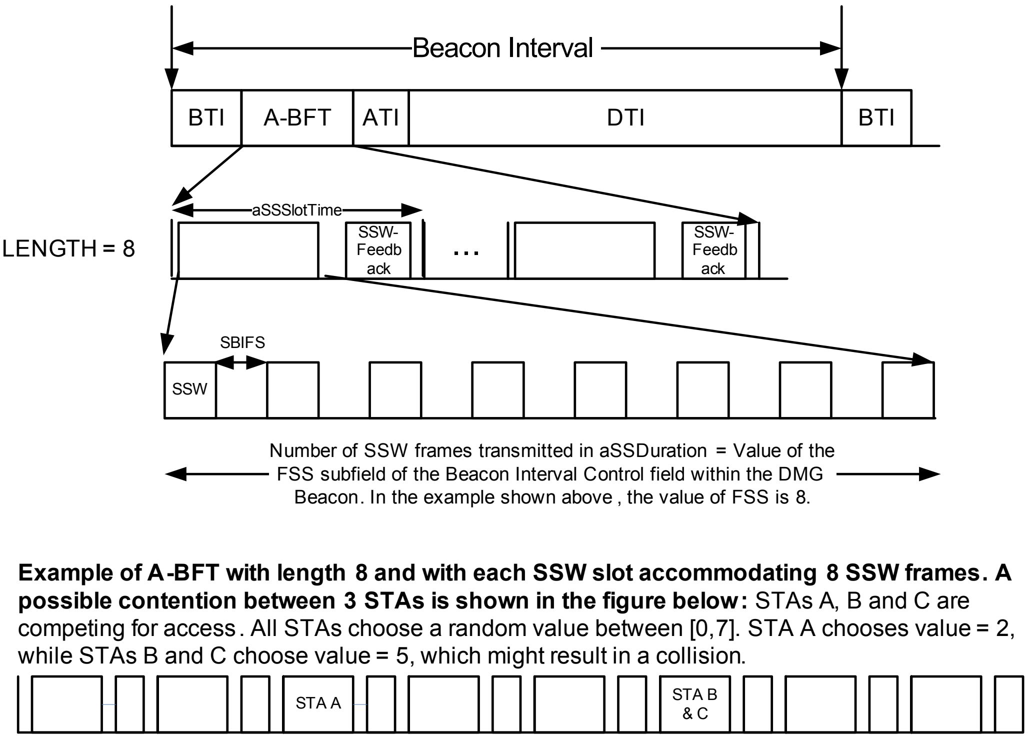


Figure 9-56—A-BFT structure

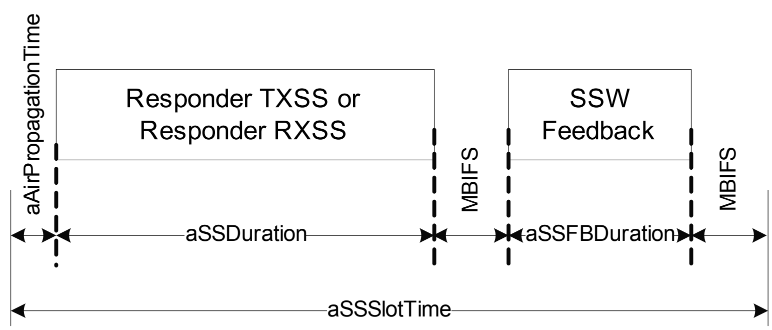


Figure 9-57—SSW slot (aSSSlotTime) definition

If the IsResponderTXSS subfield of the Beacon Interval Control field is equal to 1, the A-BFT shall be used to perform a responder TXSS. Otherwise, the A-BFT shall be used to perform a responder RXSS. In the case of a responder RXSS, the same slotted structure described above is used and the responder shall transmit the number of SSW frames announced in the FSS field in the DMG Beacon. If the PCP/AP allocates the A-BFT as a responder RXSS, it should set the value of the FSS field within the Beacon Interval Control to the number of receive sectors supported by the PCP/AP. The PCP/AP shall allocate the A-BFT as a responder TXSS at least once every dot11ABFTRTXSSSwitch beacon intervals in which an A-BFT is present.

At the start of each A-BFT, the responder(s) shall invoke a random backoff procedure to initiate or resume an RSS as follows. The random backoff procedure begins at the start of the A-BFT with the responder selecting a backoff count as a random integer drawn from a uniform distribution [0, A-BFT Length), i.e., 0 to A-BFT Length – 1, where A-BFT Length is the value of the A-BFT Length field in the last received DMG Beacon. The responder shall decrement the backoff count by one at the end of each SSW slot, even if the CS function at the responder indicates the medium busy condition for that SSW slot. The responder may initiate the RSS only at the start of the SSW slot for which the backoff count is 0 at the beginning of the SSW slot.

The responder shall transmit no more SSW frames within an SSW slot than indicated in the value of the FSS subfield in the DMG Beacon. If the responder has more SSW frames to transmit as part of the RSS, but is not allowed to send any more SSW frames in the current SSW slot, then the responder may resume the RSS at the start of the following SSW slot provided that the A-BFT has not ended. If the responder cannot complete the RSS before the end of the A-BFT, it may use the same backoff procedure described above to resume the RSS at the next A-BFT for which the value of the IsResponderTXSS field is the same as the current A-BFT.

The initiator shall initiate an SSW Feedback to a responder (9.35.2.4) at a time such that the beginning of the first symbol of the SSW-Feedback frame on the air occurs at aSSFBDuration + MBIFS before the end of the SSW slot. A responder that transmitted at least one SSW frame within a SSW slot shall be in quasi-omni receive mode for a period of aSSFBDuration ending MBIFS time before the end of the SSW slot. The initiator may initiate an SSW Feedback to the responder at an SSW slot even if the responder did not complete RSS within that SSW slot. If the initiator transmits an SSW-Feedback under this circumstance, it can transmit an Announce frame to the responder in an ATI. Following the reception of the Announce frame, the responder can respond with an SPR frame requesting time for the responder to continue with the RSS. Alternatively, the responder can transmit an SPR frame to the PCP/AP in accordance with the channel access rules.

The information contained in an SSW-Feedback frame is based on the SSW frames received during the SSW slot in which the SSW-Feedback frame was transmitted. To communicate with each other following an SLS, an initiator and responder should use the information contained within the SSW-Feedback frame that had the highest value for the SNR Report field and was transmitted or received, respectively, as part of the most recent SLS between the initiator and responder.

A responder that receives an SSW-Feedback frame from the initiator during an A-BFT that was allocated with a DMG Beacon frame with Discovery Mode equal to 1 should not attempt to access the following aMaxABFTAccessPeriod A-BFT allocations to redo beamforming with the initiator, unless in the BTI preceding the A-BFT the responder receives a DMG Beacon frame that has the Discovery Mode field equal to 1, the CC Present field equal to 1 and the value of the A-BFT Responder Address subfield equal to the responder's MAC address. This allows other STAs the opportunity to successfully contend for A-BFT access and perform beamforming with the initiator.

The responder may attempt to restart the RSS within the same A-BFT if it does not receive a SSW-Feedback frame from the initiator by the end of the SSW slot in which it completes the RSS. To do this, the responder shall invoke the random backoff procedure beginning at the start of the SSW slot following the completion of the RSS. The responder shall select a backoff count as a random integer drawn from a uniform distribution [0, A-BFT Length), i.e., 0 to A-BFT Length – 1, where A-BFT Length is the value of the A-BFT Length field in the last received DMG Beacon. The responder shall decrement the backoff count by one at the end of each SSW slot, even if the CS function at the responder indicates the medium busy condition for that SSW slot. The responder may restart the RSS at the start of the SSW slot for which the backoff count is 0 at the beginning of the SSW slot provided the A-BFT still has SSW slots available.

At the end of an A-BFT the responder shall cancel a backoff procedure that was started during the A-BFT, but has not been completed at the end of the A-BFT. As described above, the responder invokes a random backoff procedure at the start of each A-BFT.

Each STA maintains a counter, FailedRSSAttempts, of the consecutive number of times the STA initiates RSS during A-BFTs but does not successfully receive an SSW-Feedback frame as a response. If FailedRSSAttempts exceeds dot11RSSRetryLimit, the STA shall select a backoff count as a random integer drawn from a uniform distribution [0, dot11RSSBackoff), i.e., 0 inclusive through dot11RSSBackoff exclusive. The responder shall decrement the backoff count by one at the end of each A-BFT period in the following beacon intervals. The responder may re-initiate RSS only during an A-BFT when the backoff count becomes zero. The STA shall set FailedRSSAttempts to 0 upon successfully receiving an SSW-Feedback frame during the A-BFT.

In an A-BFT, the responder shall not initiate SSW ACK (9.35.2.5) in response to the reception of a SSW-Feedback frame from the initiator. The SSW ACK only occurs within the DTI of a beacon interval (9.35.6.2).

If the PCP/AP receives an SSW frame from the responder during the RSS with the Poll Required field within the SSW frame equal to 1 and the TDDTI field within the PCP/AP's DMG Capabilities element is 1, the PCP/AP shall allocate time for the responder and the PCP/AP to communicate during the ATI or within an SP of the DTI of at least one of the following aMinBTIPeriod beacon intervals beginning with the beacon interval in which the SSW frame was received. This can be done through the Extended Schedule element or the transmission of a Poll or Grant frame addressed to the responder, and the allocated time can be used for at least one of association, authentication, and service period request.

After transmitting an SSW-Feedback frame to the responder, the initiator shall send a BRP frame with the Capability Request subfield within the BRP Request field set to 1 and addressed to the responder. The BRP frame shall be sent in one of the following aMinBTIPeriod beacon intervals beginning with the beacon interval in which the RSS phase with the responder was last completed. The BRP frame shall be transmitted at MCS 0 using the sector identified by the Sector Select field received from the responder during the RSS.

In an ATI after the completion of the SSW Feedback, a responder should have its receive antenna configured to a quasi-omni antenna pattern in the DMG antenna in which it received the best sector from the initiator during the preceding ISS in order to receive an Announce, Grant, or BRP frame (with the Capability Request subfield within the BRP Request field set to 1) from the initiator, while the initiator should configure its transmit DMG antenna to the value of the Sector Select and the DMG Antenna Select fields received from the responder during the preceding RSS. If the responder does not receive an Announce or Grant frame from the initiator with the RA address equal to the responder's MAC address until aMinBTIPeriod beacon intervals after the beacon interval in which the SLS phase with the initiator was last attempted, it may retry BF with the initiator in the A-BFT.

Due to the multiple access nature of RSS in the A-BFT, the PCP/AP might not receive the best sector for communication with the STA. The PCP/AP may schedule an SP to perform BF again with the STA to find the best sector for communication with the STA.

9.35.5.3 STA Beamforming after A-BFT

The initiator shall either initiate BRP execution with the responder in the next CBAP or shall schedule time in the DTI for BRP execution with the responder if the initiator needs BRP training or the responder indicated a need for training (by setting any of the L-RX, TX-TRN-REQ, MID-REQ, or BC-REQ fields to a nonzero value) as a response to an SSW-Feedback or BRP frame with Capability Request subfield within the BRP Request field set to 1.

The responder may initiate BRP in a CBAP by sending a BRP frame with any of the training request fields (i.e., L-RX, TX-TRN-REQ, MID-REQ, BC-REQ) set to 1.

To schedule time in the DTI for BRP execution with the responder, the initiator shall transmit a Grant frame to the responder in one of the following aMinBTIPeriod beacon intervals beginning with the beacon interval in which the SLS phase with the responder was last completed. In the Grant frame, the initiator shall set the RA field to the MAC address of the responder and the TA field to the MAC address of the initiator. In the Dynamic Allocation Info field of the Grant frame, the AllocationType field shall be set to indicate SP, the source AID field shall be set to the AID of the initiator, the destination AID field shall be set to the broadcast AID and the Allocation Duration field shall be set to the expected duration of the BRP phase.

If the initiator receives at least one SSW frame from a responder within an A-BFT but did not transmit an SSW-Feedback frame to the responder within that A-BFT, the initiator may schedule time in the DTI for the responder to complete the RSS. To do that, the initiator shall transmit a Grant frame to the responder before the next A-BFT. In the Grant frame, the initiator shall set the RA field to the MAC address of the responder and the TA field to the MAC address of the initiator. In the Dynamic Allocation Info field of the Grant frame, the AllocationType field shall be set to indicate SP, the source AID field shall be set to the broadcast AID, the destination AID field shall be set to the AID of the initiator and the Allocation Duration field shall be set to cover for at least the remaining duration of the RSS.

The initiator may transmit an Announce frame to the responder during the ATI to announce a CBAP allocation in the beacon interval. If the responder receives the Announce frame with a CBAP allocation, the responder may contend for a TXOP during a CBAP to perform the BRP execution with the initiator or continue the RSS with the initiator.

Any Announce or Grant frames the initiator sends to a responder after initiating beamforming with the responder in the A-BFT but before beamforming with the responder is completed shall be transmitted at MCS 0 using the sector identified by the Sector Select field received from the responder in the RSS.

The execution of the beamforming procedure in an allocation in the DTI is described in 9.35.6.

9.35.5.4 Beamforming in A-BFT with multiple DMG antennas

A PCP/AP shall receive through a quasi-omni antenna pattern from a single DMG antenna throughout an A-BFT unless RXSS is used in the A-BFT, in which case it switches through antenna patterns as described in 9.35.5.2.

A PCP/AP shall have an A-BFT every *k* beacon intervals, where *k* is the value indicated by the N BIs A-BFT subfield in the Beacon Interval Control field. In an A-BFT, the PCP/AP shall receive in a quasi-omni antenna pattern using the DMG antenna indicated by the value of the DMG Antenna ID subfield within the SSW field transmitted in the DMG Beacon. A PCP/AP with multiple DMG antennas has a regular schedule of receiving through each DMG antenna corresponding to the DMG antenna in which a DMG Beacon is transmitted through. The PCP/AP shall switch RX DMG antenna every *l* allocations, where *l* is the value of the N A-BFT in Ant subfield within the Beacon Interval Control field.

In each DMG Beacon, the A-BFT Count subfield in the Beacon Interval Control field indicates the number of A-BFTs that have passed since the PCP/AP last switched RX DMG antennas.

9.35.6 Beamforming in DTI

9.35.6.1 General

An initiator and responder may perform BF training in the DTI within an SP allocation or within a TXOP allocation.

An initiator shall determine the capabilities of the responder prior to initiating BF training with the responder if the responder is associated. A STA may obtain the capabilities of other STAs through the Information Request and Information Response frames (10.29.1) or following a STA’s association with the

PBSS/infrastructure BSS. The initiator should use its own capabilities and the capabilities of the responder to compute the required allocation size to perform BF training and BF training related timeouts.

An initiator may request the PCP/AP to schedule an SP to perform BF training with a responder by setting the Beamforming Training subfield in the BF Control field of the DMG TSPEC element or SPR frame to 1. The PCP/AP shall set the Beamforming Training subfield to 1 in the Allocation field of the Extended Schedule element if the Beamforming Training subfield in the BF Control field of the DMG TSPEC element or SPR frame that generated this Allocation field is equal to 1. The PCP/AP should set the Beamforming Training subfield in an Allocation field of the Extended Schedule element to 0 if this subfield was equal to 1 when the allocation was last transmitted by the PCP/AP in an Extended Schedule element and if, since that last transmission, the PCP/AP did not receive a DMG TSPEC element for this allocation with the Beamforming Training subfield equal to 1.

9.35.6.2 SLS phase execution

For BF training in the DTI, both the initiator and responder shall use the SSW frame for the ISS and RSS.

The initiator shall begin an ISS (9.35.2.2) at the start of the allocation with an initiator TXSS, except when the allocation is an SP and the IsInitiatorTXSS field for this SP is equal to 0 in which case the initiator shall begin an ISS with an initiator RXSS.

If the initiator begins the SLS within a CBAP and the responder has more than one DMG antenna, the initiator shall repeat its ISS k+1 times, where k is the value indicated by the responder in the last negotiated Number of RX DMG Antennas field transmitted by the responder. Repetitions of the ISS are separated by an interval equal to LBIFS. The value of the CDOWN field within SSW frames transmitted in the ISS indicates the number of sectors until the end of transmissions from all of the initiator's DMG antennas to all of the responder's DMG antennas.

The RSS is a TXSS unless the allocation is an SP and the IsResponderTXSS field for this SP is equal to 0 or the allocation is a TXOP and the RXSS Length field within the SSW frame received by the responder during the ISS and used to obtain the TXOP is equal to a nonzero value. The responder shall begin an RSS (9.35.2.3) MBIFS time following the completion of an ISS, provided there is sufficient time in the allocation for the responder to transmit an SSW frame and the responder received an SSW frame from the initiator during the ISS.

The initiator may restart the ISS up to dot11BFRetryLimit times if it does not receive an SSW frame from the responder in dot11BFTXSSTime time following the end of the ISS. The initiator shall restart the ISS SIFS time following dot11BFTXSSTime time, provided there is sufficient time left in the allocation for the initiator to transmit an SSW frame. If there is not sufficient time left in the allocation for the transmission of an SSW frame, the initiator shall restart the ISS at the start of the following allocation between the initiator and the responder.

The initiator shall begin an SSW Feedback (9.35.2.4) MBIFS time following the completion of an RSS, provided the initiator received an SSW frame from the responder during the RSS and there is sufficient time left in the allocation to complete the SSW Feedback followed by an SSW ACK (9.35.2.5) from the responder in SIFS time. If there is not sufficient time left in the allocation for the completion of the SSW Feedback and SSW ACK, the initiator shall begin the SSW Feedback at the start of the following allocation between the initiator and the responder.

The responder shall begin an SSW ACK (9.35.2.5) to the initiator in MBIFS time following the reception of a SSW-Feedback frame from the initiator.

The initiator may restart the SSW Feedback up to dot11BFRetryLimit times if it does not receive an SSW-ACK frame from the responder in MBIFS time following the completion of the SSW Feedback. The initiator shall restart the SSW Feedback PIFS time following the expected end of the SSW ACK by the responder, provided there is sufficient time left in the allocation for the initiator to begin the SSW Feedback followed by an SSW ACK from the responder in SIFS time. If there is not sufficient time left in the allocation for the completion of the SSW Feedback and SSW ACK, the initiator shall restart the SSW Feedback at the start of the following allocation between the initiator and the responder.

Once started, the initiator and responder shall complete the SLS phase before any additional frame exchange takes place between these STAs.

9.35.6.3 MIDC (multiple sector ID capture) subphase

9.35.6.3.1 General

In practice, the quasi-omni RX antenna patterns used in the SLS phase might exhibit imperfections that lead to an incorrect choice of the best TX sector and consequently a sub-optimal starting point for beam refinement in the BRP phase. To remedy this, a multiple sector ID capture (MIDC) phase may be used. Instead of selecting the starting point for the beam refinement transactions (i.e., the best TX sector) based on information obtained with quasi-omni RX antenna patterns from the SLS phase, the MIDC subphase enables the use of additional information based on the trial of multiple TX and RX sectors.

The MIDC subphase can be implemented in two ways. The first option is to conduct a trial between a small set of TX and RX AWV settings with wide (e.g., quasi-omni) antenna patterns. The second option is to carry out a trial between a small set of TX sectors and a set of RX AWV settings, chosen by the receiver in an implementation-dependent manner, that maximizes the probability of determining the RX AWVs that best match the chosen set of TX sectors. Note that this may involve using a set of RX AWVs that correspond to the "full set" of RX sectors (from the SLS phase). The set of TX sectors are chosen from a TX sector sweep with a quasi-omni RX antenna pattern. With either option, the end result from the MIDC subphase can be the better starting point TX and RX sector pair for further beam refinement.

For the first option above, the MIDC subphase consists of a MID subphase and a BC subphase. This is further elaborated upon in 9.35.6.3.2, and a sample time allocation is illustrated in Figure 9-58. For the second option, the MIDC subphase consists only of a MID subphase. This is further elaborated upon in 9.35.6.3.3, and a sample time allocation is illustrated in Figure 9-59.

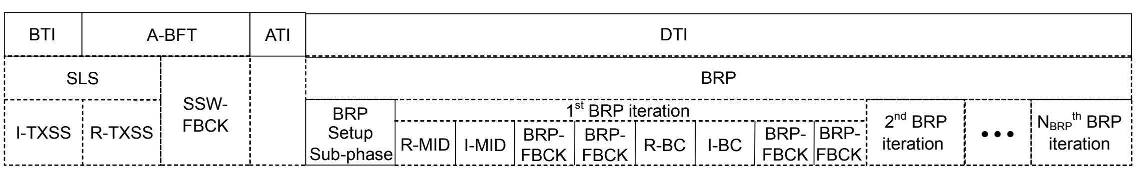


Figure 9-58—Example of time allocation for the MIDC subphase with MID and BC subphases

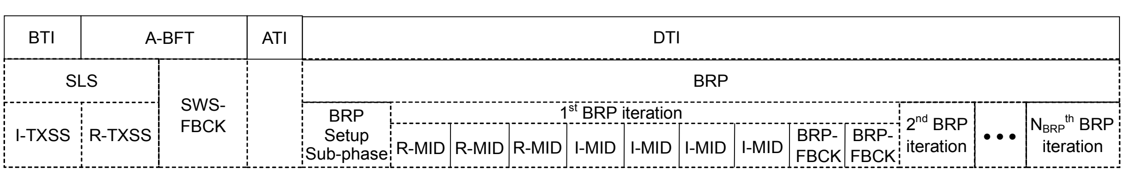


Figure 9-59—Example of time allocation for the MIDC subphase with the MID subphase only

Prior to the beginning of the MIDC subphase, a BRP setup subphase is carried out as specified in 9.35.3.2. This subphase enables the two DMG STAs involved to negotiate whether and how the MIDC subphase is carried out. Examples of how the MIDC subphase is set up, depending on whether beamforming is initiated in the BTI and A-BFT or in the DTI, are illustrated in Figure 9-60 and Figure 9-61, respectively. Note that the MIDC subphase is applicable only when both the initiator and the responder have the ability to switch among their sectors.

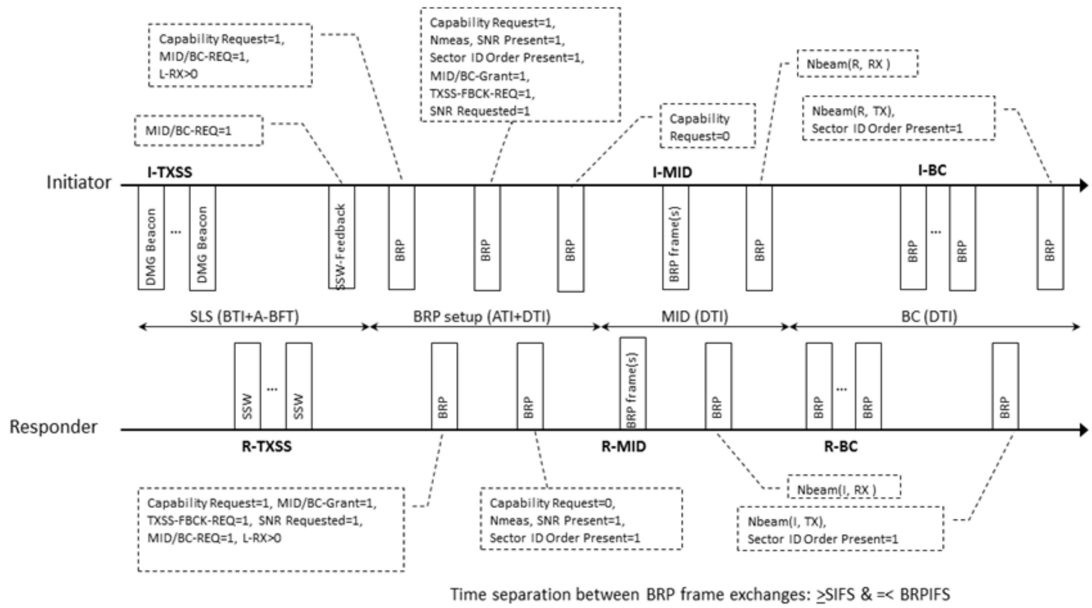


Figure 9-60—Example of the use of the BRP setup subphase to set up the subsequent MIDC subphase in the A-BFT and DTI

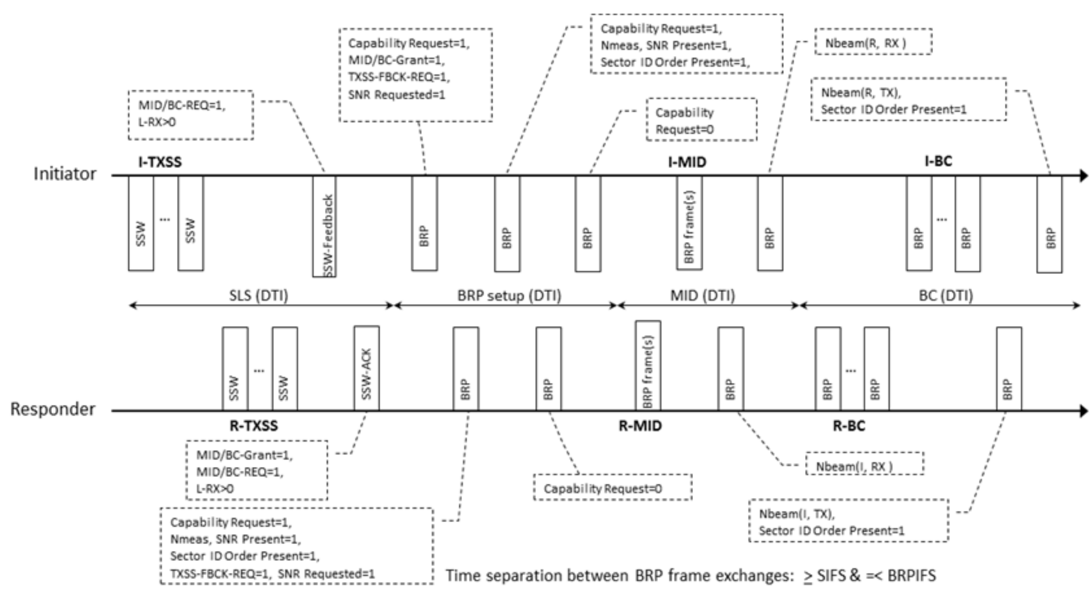


Figure 9-61—Example of the use of the BRP setup subphase to set up the subsequent MIDC subphase in the DTI

9.35.6.3.2 MIDC subphase with MID and BC subphases

The MIDC subphase can be implemented such that small subsets of TX Sector IDs and RX AWVs are first chosen, followed by trials between these subsets to determine the optimal starting TX Sector ID and RX AWV pair. The set of TX sectors is chosen from an a priori TX sector sweep with a quasi-omni RX antenna pattern (in the SLS phase). To enable the selection of the RX sectors, and the subsequent trial between the TX and RX sectors, the MIDC subphase consists of an MID subphase and a BC (or beam combining) subphase. In the MID subphase, a wide TX beam (e.g., quasi-omni) is used while the receiver sweeps through its choice of AWV settings to determine the set of RX AWVs with the highest link quality. This is followed by the BC subphase, which involves testing the multiple RX AWVs together with multiple TX AWVs.

This is conceptually illustrated in Figure 9-62. Note that the consecutive numbering of TX Sector IDs (e.g., TX Sector ID1, TX Sector ID2, …) or RX AWVs is just used for representation purposes. It is used to indicate the subset of TX Sector IDs without placing any restrictions on how these Sector IDs are selected (i.e., consecutive numbering of TX Sector IDs does not mean that the selected TX Sector IDs should be those that are consecutively numbered).

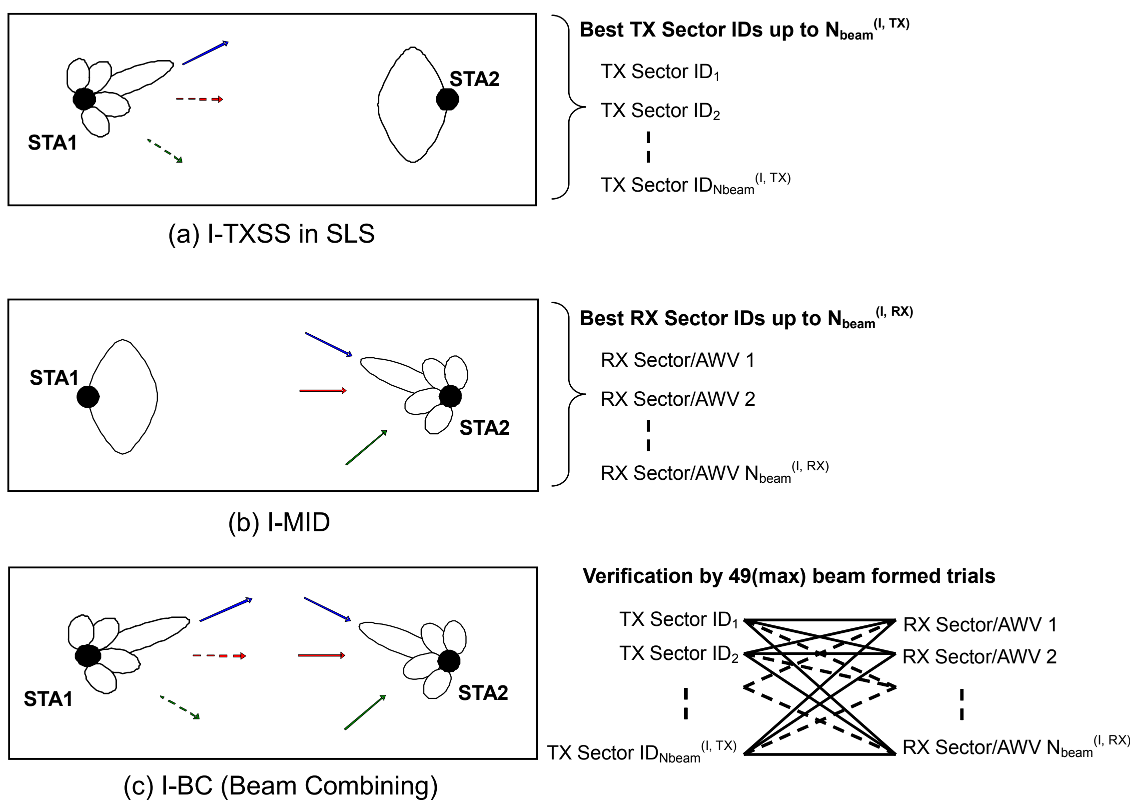


Figure 9-62—Conceptual flow of a sample MIDC subphase execution with MID and BC subphases for the initiator link

a) Setting up the MID and BC subphases: To request a MIDC subphase with the MID and the BC subphases, the initiator shall transmit an SSW-Feedback or BRP frame with the MID-REQ and the BC-REQ fields set to 1 in the BRP Request field. The responder may grant this request by setting the MID-Grant and the BC-Grant fields to 1 in the BRP Request field within the next SSW-ACK or BRP frame transmitted to the initiator. The R-MID and R-BC subphases are performed if the request is granted and are not performed otherwise.

The responder shall transmit an SSW-ACK or BRP frame to request a MIDC subphase, with the I-MID and I-BC subphases. It shall do so by setting the MID-REQ and the BC-REQ fields to 1 in the BRP Request field within the transmitted frame. The initiator may grant this request by setting the MID-Grant and the BC-Grant fields to 1 in the BRP Request field within the next BRP frame transmitted to the responder. The I-MID and I-BC subphases are performed if the request is granted and are not performed otherwise.

If all of R-MID, R-BC, I-MID, and I-BC subphases are performed, the MID subphases are performed before the BC subphases. Within the MID subphase, R-MID is performed before I-MID. Within the BC subphase, R-BC is performed before I-BC (see Figure 9-58 and Figure 9-59).

In addition to the MID-REQ, BC-REQ, MID-Grant and BC-Grant fields, the responder (and/or initiator) needs to obtain the number of RX AWV settings to be appended to BRP-RX packets in the R/I-MID subphase. To do this, the initiator (and/or responder) should use the L-RX field in the BRP Request field to convey this information. Similarly, the responder (and/or initiator) needs to obtain the IDs and SNRs of the TX sectors received during the SLS phase for use in the R-BC and I-BC subphases. To do this, the responder (and/or initiator) shall send a BRP packet with the TXSS-FBCK-REQ subfield and SNR Requested subfield set to 1 in the FBCK-REQ field of the DMG Beam Refinement element. In response, the initiator (and/or responder) should send a BRP frame with both the SNR Present subfield and the Sector ID Order Present subfield set to 1. The N_{meas} subfield in the FBCK-TYPE field is set to indicate the number of sectors received during the last SLS for which an SNR measurement is included. In the Channel Measurement field, the initiator (or responder) should set the SNR subfield to the SNRs corresponding to the TX sectors trialed during the SLS phase. In the Sector ID subfield, it should list the sector IDs of the received sectors. The responder (and/or initiator) should then use the SNR information, and any additional information such as angular separation between sectors, to determine the TX sectors for use in the BC subphase. The responder (or initiator) shall inform the initiator (or responder) of the number of TX sectors using the N_{beam} subfield in the FBCK-TYPE field during the BRP setup subphase. After the R/I-MID subphases, the same field is used to exchange information about the number of RX AWVs to be trialed during the BC subphase.

b) Executing the MID subphase: If R-MID was requested and granted during the SLS and/or subsequent BRP setup subphase, then after the BRP setup subphase, the R-MID shall be initiated by the responder sending a BRP frame with TRN-R fields (as requested in the BRP setup subphase). This packet may be transmitted using a wide pattern, approaching an omni transmit pattern, or using a sector antenna pattern. The receiver may use the TRN-R fields for receiver training.

If the MID Extension field in the packet is equal to 1, the responder shall transmit another BRP-RX packet, which may be transmitted using another transmit pattern. It may continue transmitting BRP-RX packets as long as the MID Extension field in all of them is equal to 1. The last BRP-RX packet transmitted by the responder shall have the MID Extension field set to 0.

If the initiator does not receive a BRP-RX packet within BRPIFS after transmitting the last packet of the BRP setup subphase, it may retransmit the last packet of the BRP setup subphase.

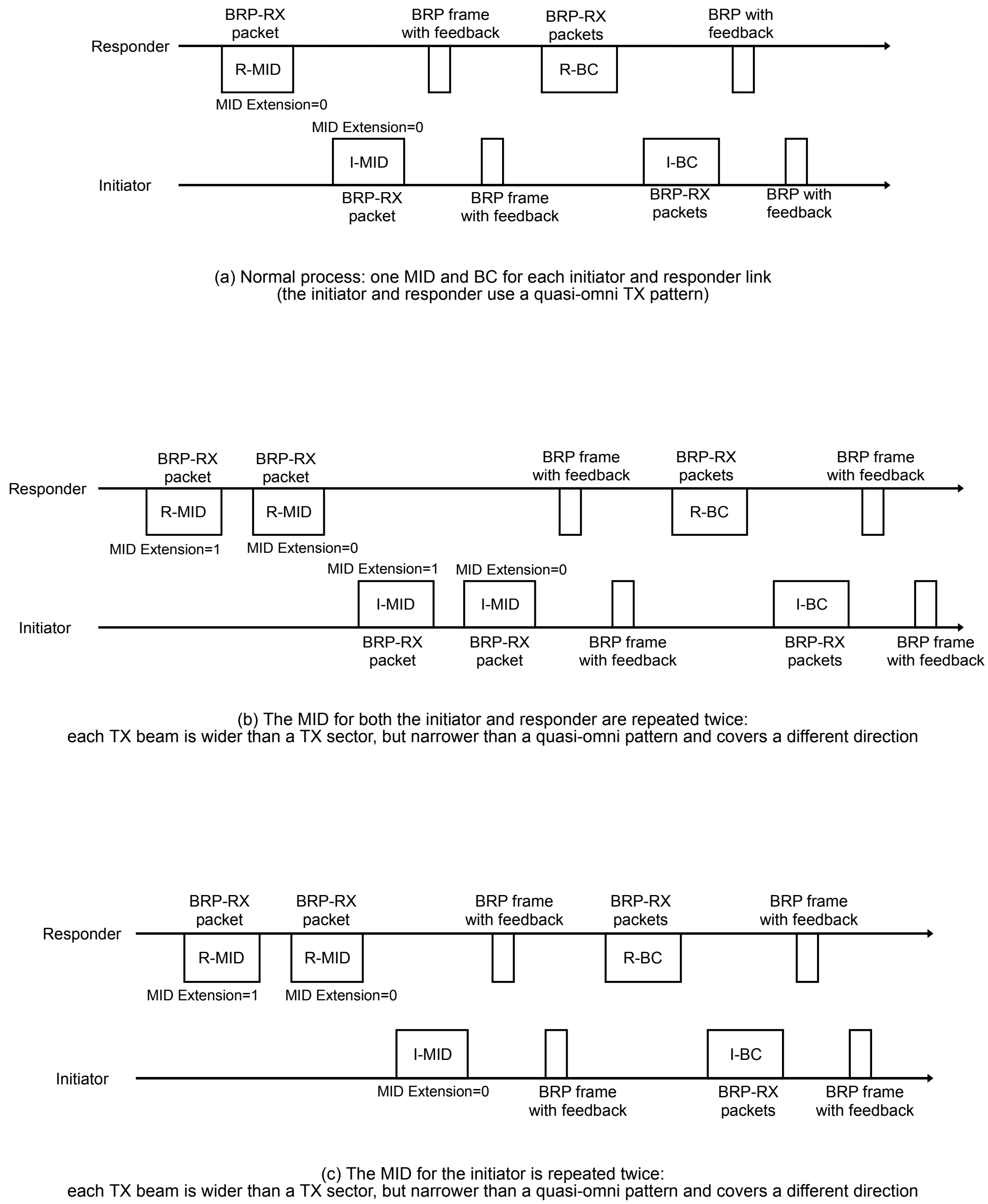
After the initiator receives a BRP-RX packet with the MID Extension field set to 0, it shall respond with a BRP frame with the appropriate feedback. This BRP frame should be sent using the best TX sector as determined in the SLS phase, while the responder should use a quasi-omni pattern to receive this frame. The feedback included in this BRP frame is the number of RX AWVs to be tested in the subsequent R-BC subphase using the N_{beam} subfield in the FBCK-TYPE field.

If I-MID was granted in addition to R-MID, the initiator shall send a BRP frame with TRN-R fields (as requested in the BRP setup subphase). The initiator shall continue to send BRP packets if the MID Extension was set to 1 as in the R-MID.

After the responder receives a BRP-RX packet with the MID Extension set to 0, it shall respond by sending a BRP frame with feedback. This BRP frame should be sent using the best TX sector as determined in the SLS phase, while the initiator should use a quasi-omni pattern to receive this frame. The feedback included in this BRP frame is the number of RX AWVs to be tested in the subsequent I-BC subphase using the N_{beam} subfield in the FBCK-TYPE field. The initiator shall respond with a BRP frame with the TX-TRN-OK field set to 1 as an acknowledgment. The R-BC subphase then follows.

If I-MID does not follow R-MID, the BC subphase follows immediately.

c) Executing the BC subphase: The execution of an I-BC subphase is used as an example. In an I-BC subphase, the initiator shall transmit $N_{beam}^{(I,TX)}$ BRP-RX frames using the number of TX sectors specified during the BRP setup subphase. Each BRP-RX frame shall be appended with $N_{beam}^{(I,RX)}$ *TRN-R* subfields, and shall include the *Sector ID* subfield of the TX sector used. While receiving these *TRN-R* subfields, the responder shall switch through the RX AWVs selected during the prior I-MID subphase. To conclude the I-BC subphase, the responder shall feed back to the initiator a BRP frame with (a) the BS-FBCK field set to the TX sector ID of the BRP-RX packet received with the highest link quality, and (b) the ordered list of transmit sectors (based on received link quality during the I-BC) using the Sector ID Order subfield in the Channel Measurement Feedback element. This BRP frame should be sent using the best TX sector as determined in the SLS phase, while the initiator should use a quasi-omni pattern to receive this frame. The complete procedure is illustrated in Figure 9-63, while Figure 9-64 depicts the beam combining subphase.



(a) Normal process: one MID and BC for each initiator and responder link
(the initiator and responder use a quasi-omni TX pattern)

(b) The MID for both the initiator and responder are repeated twice:
each TX beam is wider than a TX sector, but narrower than a quasi-omni pattern and covers a different direction

(c) The MID for the initiator is repeated twice:
each TX beam is wider than a TX sector, but narrower than a quasi-omni pattern and covers a different direction

Figure 9-63—Examples of the use of the MID Extension field during the execution of the MID subphase

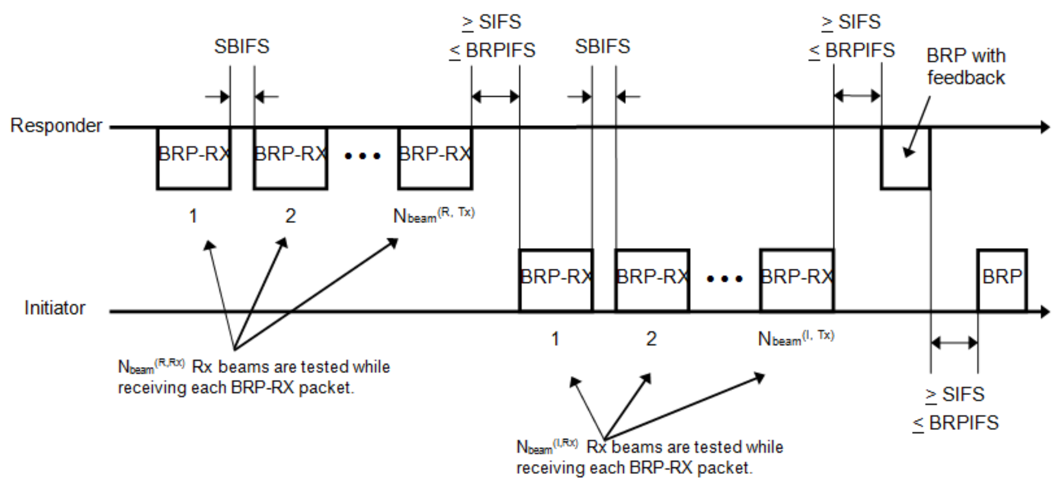


Figure 9-64—Beam combining

9.35.6.3.3 MIDC subphase with MID subphase only

The MIDC subphase may also be implemented such that multiple TX sectors, obtained from the TXSS in the SLS phase, are used instead of wide TX beams. Here, the receiver employs multiple RX AWVs for each TX sector chosen by the transmitter. Based on this joint trial of TX and RX AWVs, the optimal starting TX and RX AWV pair is chosen for further refinement in the BRP phase. In this case, the MIDC subphase consists only of the MID subphase. This is conceptually illustrated in Figure 9-65.

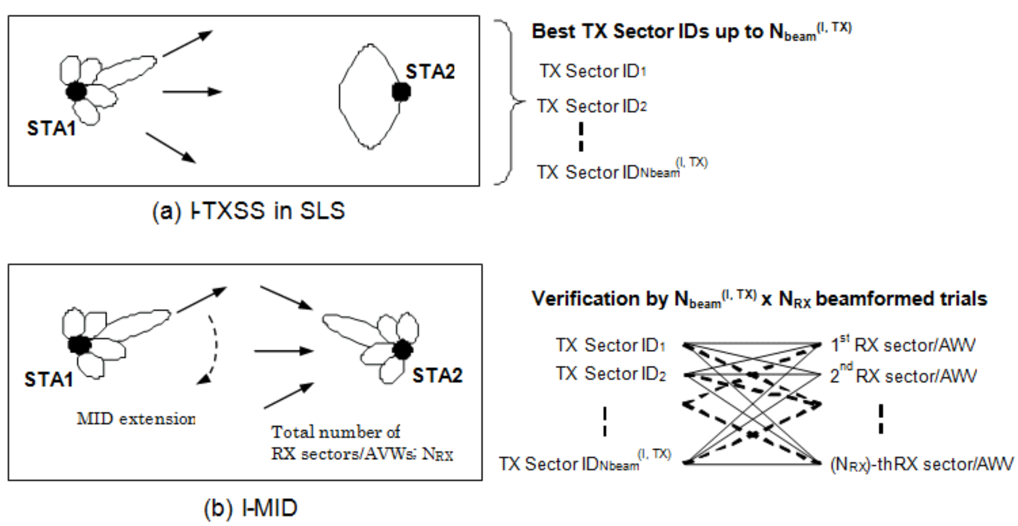


Figure 9-65—Conceptual flow of a sample MIDC subphase execution with only the MID subphase for the initiator link

a) Setting up the MID subphase: The procedure of setting up the MID-subphase is described in 9.35.3.2.

In the example of Figure 9-66, the initiator transmits an SSW-Feedback with the MID-REQ subfield set to 1 and the BC-REQ subfield set to 0 in the BRP Request field, thus requesting an MIDC with only the R-MID subphase. The responder grants the MID-REQ by setting the MID-Grant subfield to 1 in the SSW-ACK frame. The initiator then sends a frame with the SNR Present and Sector ID Order Present subfields both set to 1, the N_{meas} subfield in the FBCK-TYPE field indicating the number of SNR measurements from the last SLS phase, and the SNR and Sector ID subfields with the SNRs measured during the SLS phase and the list of received sectors, respectively. The L-RX subfield is set according to the number of training fields the initiator needs in each packet as part of the R-MID. The responder then starts the R-MID process by transmitting BRP-RX packets.

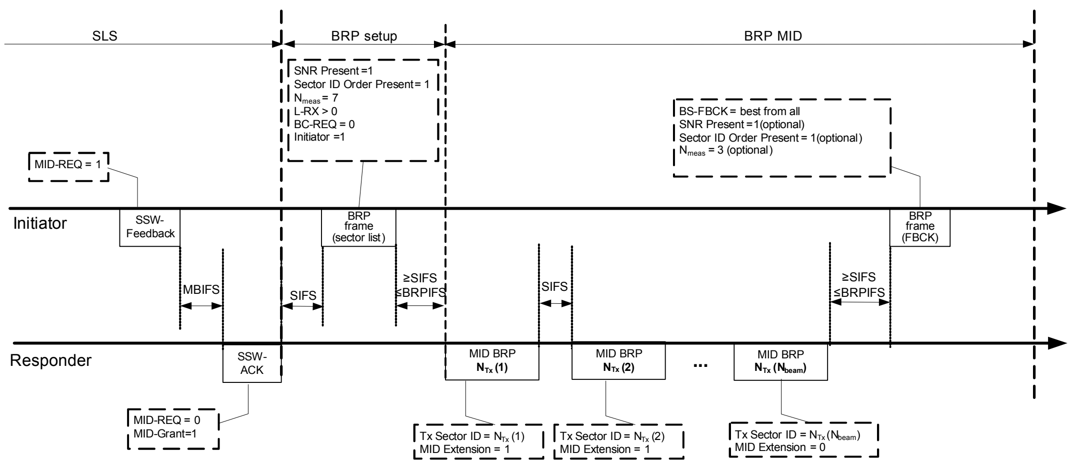


Figure 9-66—Example of the use of the BRP setup subphase to set up the subsequent I-MID subphase

b) Executing the MID subphase: The execution of the MID subphase for the responder link (i.e., R-MID) is used as an example. Execution of the MID subphase for the initiator link (i.e., I-MID) is similar, except for a change in the direction of the corresponding frames. In an R-MID subphase, the responder shall transmit one BRP-RX packet each from one of the chosen TX sectors. In each packet, it shall indicate the sector ID of the TX sector used using the Sector ID field in the BRP Request field. Each transmitted BRP-RX packet should be appended with multiple TRN-R subfields such that the initiator can train its receiver antenna during the R-MID subphase. The initiator shall train its receiver antenna by cycling through its choice of RX AWVs while receiving the TRN-R subfields. The initiator shall indicate to the responder the number of TRN-R subfields to be appended using the *L-RX* field in the BRP request field during the SLS phase or the BRP setup phase. For all BRP-RX packets except the last one, the responder shall also set the MID Extension field to 1.

In the R-MID subphase, the initiator shall send a BRP frame with feedback. This BRP frame should be sent using the best TX sector as determined in the SLS phase, while the responder should use a quasi-omni pattern to receive this frame. The feedback included in this BRP frame should be (a) the BS-FBCK field set to the TX sector ID of the BRP-RX packet received with the highest link quality, and (b) the ordered list of transmit sectors (based on received link quality during the R-MID) using the Sector ID Order subfield.

9.35.6.3.4 MIDC subphase with BC subphase only

An MIDC subphase with only the BC subphase is carried out when the MID and BC subphases have been carried out earlier. In this case, the initiator and responder keep track of the TX and RX sectors, for use in the BC subphase, from earlier iterations. Since the best TX and RX sectors (in terms of link quality) are kept track of, this information can be used to deal with link blockage events. STAs can utilize only the chosen set of TX sectors in the SLS phase to reduce beamforming training time, and jump to the BC subphase directly without executing the MID subphase. In this manner, fast recovery is possible when some of backup links are available after partial blockage around the STA.

To carry out the MIDC subphase with the BC subphase only, the MID-REQ field is set to 0 and the BC-REQ field is set to 1 in SSW-Feedback or SSW-ACK or BRP frames, and the BC-Grant field is set to 1 in the following SSW-ACK or BRP frame. The BC subphase can include an I-BC and/or an R-BC (9.35.6.3.2).

9.35.6.4 BRP phase execution

9.35.6.4.1 General

Beam refinement is a request/response based process. A STA requests receive beam refinement training by sending a BRP frame with a nonzero value in the L-RX field. The STA that receives a BRP frame shall respond with a BRP packet (21.10.2.2) including as many TRN-R fields as indicated in the value of the L-RX field within the received BRP frame and with the RX-train-response field in the DMG Beam Refinement element set to 1.

A STA requests transmit beam refinement training by sending a BRP frame as follows. In the BRP Request field, the TX-TRN-REQ field is set to 1, and the FBCK-REQ field is set to the desired feedback type. In the PLCP header, the Packet Type and the Training Length fields are set to indicate the number of AGC and TRN-T fields appended to the packet.

The responding STA shall reply to the transmit beam refinement training with a BRP frame containing a DMG Beam Refinement element with the TX-TRN-OK field and TX-train-response field both set to 1 and the BS-FBCK field set to indicate the TRN-T field on which the responding STA received the best signal (the determination of best signal is implementation dependent). The FBCK-TYPE field shall be set to according to the format of the Channel Measurement Feedback element, if one is included in the frame. If the SNR Present and Channel Measurement Present subfields of this FBCK-TYPE field are set to 0, the Channel Measurement Feedback element shall not be included. The number of taps indicated in the FBCK-TYPE field shall be less than or equal to the number of taps indicated in the FBCK-REQ field of the request frame.

If a STA requests transmit beam refinement training, but does not send TRN-T fields, the responding STA shall reply with a BRP frame containing a DMG Beam Refinement element with the TX-TRN-OK field set to 1. In this case (i.e., when the TX-train-response field is equal to 0), the responding STA shall set L-RX field to 0. The requesting STA shall then transmit a BRP packet with TRN-T fields. The responding STA shall then respond with a BRP frame with the TX-train-response field set to 1 and the BS-FBCK and Channel Measurement Feedback element as above.

Beam refinement can start immediately following SLS (9.35.6.4.3). If the responder receives an SSW-Feedback frame from the PCP/AP in an A-BFT, the PCP/AP allocates an SP for the beam refinement if required (see 9.35.5.3). A STA may transmit a BRP packet to another STA whenever the STA transmits a frame to that STA, provided that the transmitting STA knows that the recipient STA's receive antennas are directed to it or are in a quasi-omni antenna pattern.

A STA shall set the Initiator field to 1 within a DMG Beam Refinement element if the previous received frame was not a BRP frame, or the last packet the STA transmitted was a BRP frame with the Initiator field set to 1.

A STA that has transmitted a BRP frame with the Initiator field set to 1 and has not received a response BRPIFS after the transmission may retransmit the frame.

A STA may request a TXSS sector list feedback by sending a BRP frame with the TXSS-FBCK-REQ field set to 1, the SNR Requested subfield within the FBCK-REQ field set to 1 and the remaining subfields within the FBCK-REQ field set to 0. The responding STA shall respond with a BRP frame with the SNR Requested subfield within the FBCK-REQ field set to 1, with the remaining subfields within the FBCK-REQ field set to 0, with a list of Sector IDs indicating the sector IDs of the received SSW frames or DMG Beacon frames, and with the SNR values with which those frames were received in the last TXSS.

A STA shall not set the TXSS-FBCK-REQ and the TX-TRN-REQ fields to 1 in the same BRP frame.

Two or more BRP frames shall not be aggregated in the same A-MPDU. A BRP frame may be aggregated with another frame in the same A-MPDU only if the other frame is a single ACK, BA or QoS-Null data frame.

The Duration field within each BRP frame is set to the time remaining until the end of the current allocation.

9.35.6.4.2 Beam refinement transaction

A beam refinement transaction is a set of BRP frames composed of request and responses.

A beam refinement transaction starts with the beamforming initiator STA sending a BRP frame with the Initiator field set to 1.

A beam refinement responder is a STA that receives a BRP frame (which is directed to it) with the Initiator field set to 1.

A beam refinement transaction participant shall respond to a BRP frame with a BRP frame.

If the beam refinement transaction initiator received a BRP frame from the responder with no training requests, the initiator may terminate the transaction by not transmitting any further BRP packets.

Figure 9-67, Figure 9-68, and Figure 9-69 show examples of beam refinement transactions.

9.35.6.4.3 Beam refinement transaction after SLS

If either L-RX or TX-TRN-REQ is nonzero within the BRP Request field in the SSW-ACK frame of the most recent SLS phase execution, no MID or BC was granted during the BRP setup subphase, and no beam refinement transaction has been done since the most recent SLS phase execution, then the initiator shall initiate the beam refinement transaction with the responder by sending a BRP frame to the responder. If the value of the L-RX field is greater than 0 in the SSW-ACK frame, the first BRP frame the initiator transmits to the responder is a BRP-RX frame. If the value of the L-RX field is 0 and the value of the TX-TRN-REQ field is 1, the first BRP frame the initiator transmits to the responder shall have either the TX-TRN-OK field set to 1 or the L-RX field greater than 0.

9.35.6.4.4 Antenna configuration setting during a beam refinement transaction

A STA that has requested beam refinement receive training shall, except when receiving TRN-R fields, set its receive antenna configuration to the best known receive antenna configuration based on previous beam refinement receive training or RXSS. If the STA has not received a BRP frame since the last SLS and the SLS did not include an RXSS, the STA should set its receive antenna configuration to a quasi-omni antenna pattern in the DMG antenna through which the STA received the best sector during the SLS.

A STA that has received a beam refinement transmit training request shall send the response frame and then set its antenna configuration to the best known receive antenna configuration based on previous beam refinement receive training or RXSS, except if both the initiator STA and responder STA support the Other_AID subfield as indicated through the Supports Other_AID field set to 1 within the STA's DMG Capabilities element and the value of the Other_AID subfield within the BRP Request field is different from 0, in which case the STA sets its antenna configuration to the best known receive antenna configuration for receiving from the STA with AID equal to the value of the Other_AID subfield within the BRP Request field. If the STA has not received a BRP frame since the last SLS and the SLS did not include an RXSS, the STA should set its antennas to a quasi-omni antenna pattern.

In a BRP-RX packet, all TRN-R fields shall be transmitted using the same TX AWV configuration as the preamble and data fields of the packet, except if both the transmitting and receiving STAs support the Other_AID subfield as indicated through the Supports Other_AID field set to 1 within the STA's DMG Capabilities element and the value of the Other_AID subfield within the BRP Request field is different from 0, in which case the TRN-R fields shall be transmitted using the best known TX AWV configuration for transmitting to the STA with AID equal to the value of the Other_AID subfield within the BRP Request field.

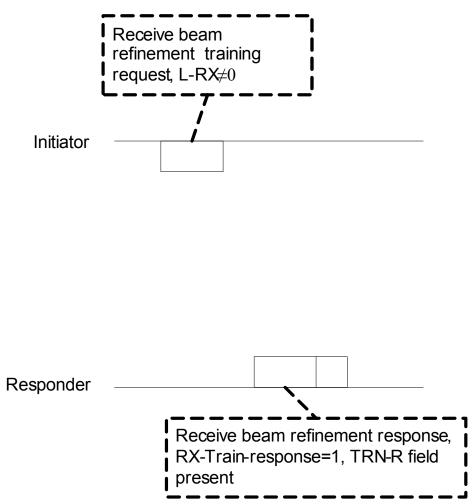


Figure 9-67—Example beam refinement transaction (receive training)

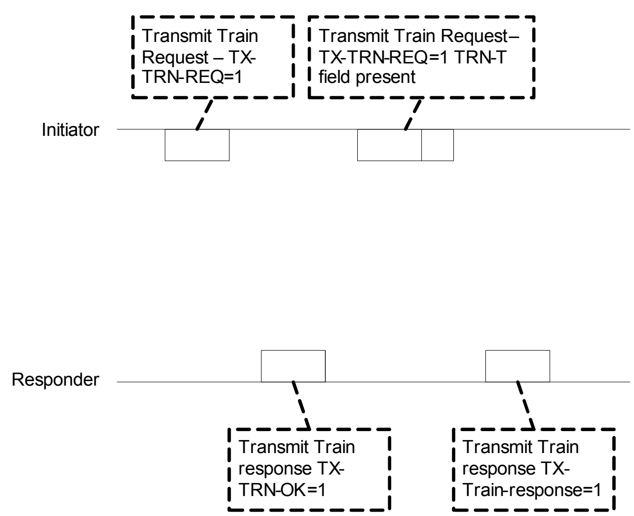


Figure 9-68—Example beam refinement transaction (transmit training)

A STA that has the DMG Antenna Pattern Reciprocity subfield within the DMG STA Capability Information field of the DMG Capabilities element equal to 1 and that has received a BRP-RX packet from a peer STA that also has the DMG Antenna Pattern Reciprocity subfield within the DMG STA Capability Information field of the peer STA's DMG Capabilities element equal to 1 shall use the same AWV that was configured with the BRP-RX packet in subsequent transmissions and receptions with the peer STA during the DTI. This allows STAs that use reciprocity to shorten the beamforming training time.

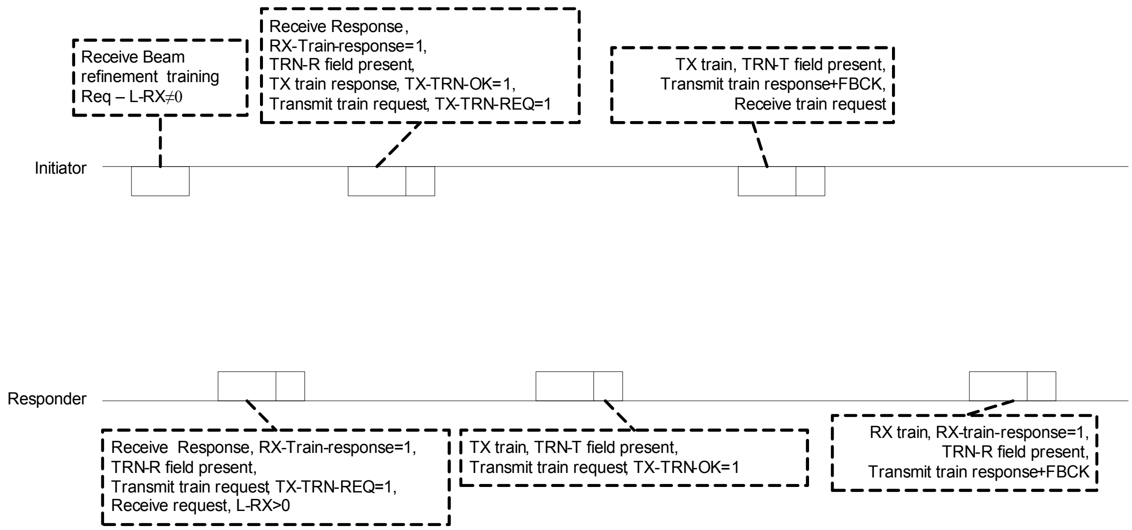


Figure 9-69—Example beam refinement transaction (combination of receive and transmit training)

9.35.7 Beam tracking

A STA (beam tracking initiator) may request a peer STA (beam tracking responder) to perform receive beam tracking by setting, in a transmitted packet, the TXVECTOR parameter BEAM_TRACKING_REQUEST to Beam Tracking Requested, TRN-LEN to the number of requested TRN fields as described in 21.10.2.2.3 and packet type to TRN-R-PACKET. Otherwise, the BEAM_TRACKING_REQUEST parameter shall be set to Beam Tracking Not Requested.

A beam tracking responder that receives a packet with the Beam Tracking Request field in the PLCP header equal to 1 (corresponding to the BEAM_TRACKING_REQUEST parameter in the RXVECTOR set to Beam Track Requested) and the Packet Type field in the PLCP header equal to 0 (corresponding to PACKET-TYPE field in the RXVECTOR set to TRN-R-PACKET) shall follow the rules described in 21.10.2.2 and shall include a beam refinement AGC field and TRN-R subfields appended to the following packet transmitted to the initiator. The value of TRN-LEN in the following packet from the responder to the initiator shall be equal to the value of the TRN-LEN parameter in the RXVECTOR of the packet from the initiator.

A beam tracking initiator requesting transmit beam tracking shall set the BEAM_TRACKING_REQUEST parameter in the TXVECTOR to Beam Tracking Requested, Packet Type to TRN-T-PACKET, TRN-LEN to the number of TRN fields as described in 21.10.2.2.3, and append an AGC field and TRN-T subfields to the packet. The beam tracking responder may append the feedback to any packet from the responder to the initiator. The initiator may allocate time for the feedback through a reverse direction grant, provided the reverse direction protocol is supported by both the initiator and responder. The feedback type shall be the same as the feedback type in the last BRP frame that was transmitted from the initiator to the responder with TX-TRN-REQ equal to 1. If the responder has never received a BRP frame from the initiator with TX-TRN-REQ equal to 1, the responder shall respond with all subfields of the FBCK-TYPE field equal to 0 and set the BS-FBCK field to the best sector.

A beam tracking initiator may also request a beam tracking responder to perform receive beam tracking by setting, in the PLCP header of a transmitted packet, the Beam Tracking Request field to 0, the Training Length field to a nonzero value, the Packet Type field to 0, and append an AGC field and TRN-R subfields to the transmitted packet.

A beam tracking responder that receives a packet with the Beam Tracking Request field in the PLCP header equal to 0, the Training Length field in the PLCP header equal to a nonzero value and the Packet Type field in the PLCP header equal to 0 shall follow the rules described in 21.10.2.2 and may use the beam refinement AGC field and TRN-R subfields appended to the received packet to perform receive beam training.

BRP frames transmitted during beam tracking may be aggregated within A-MPDUs. Figure 9-70 illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-R fields, while Figure 9-71 illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-T fields.

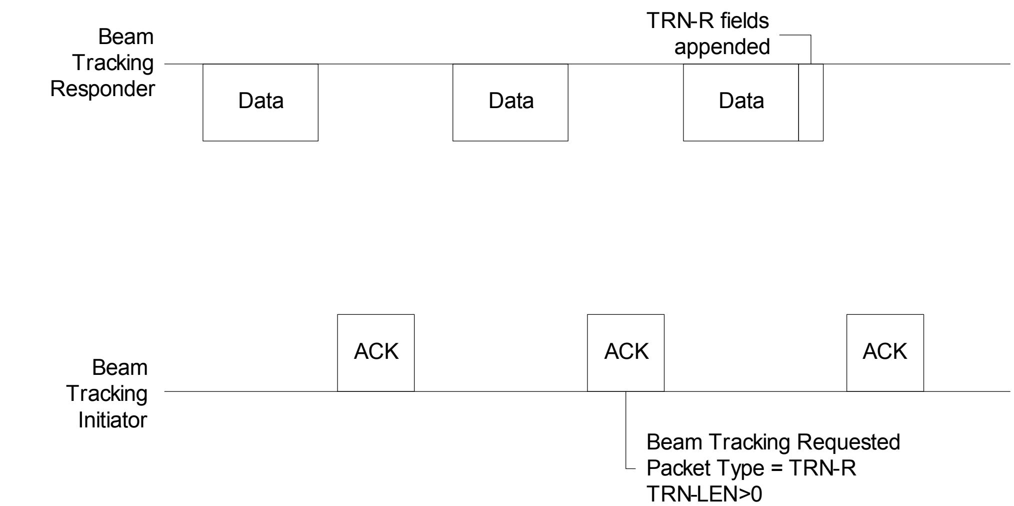


Figure 9-70—Example of a beam tracking procedure with the initiator requesting TRN-R

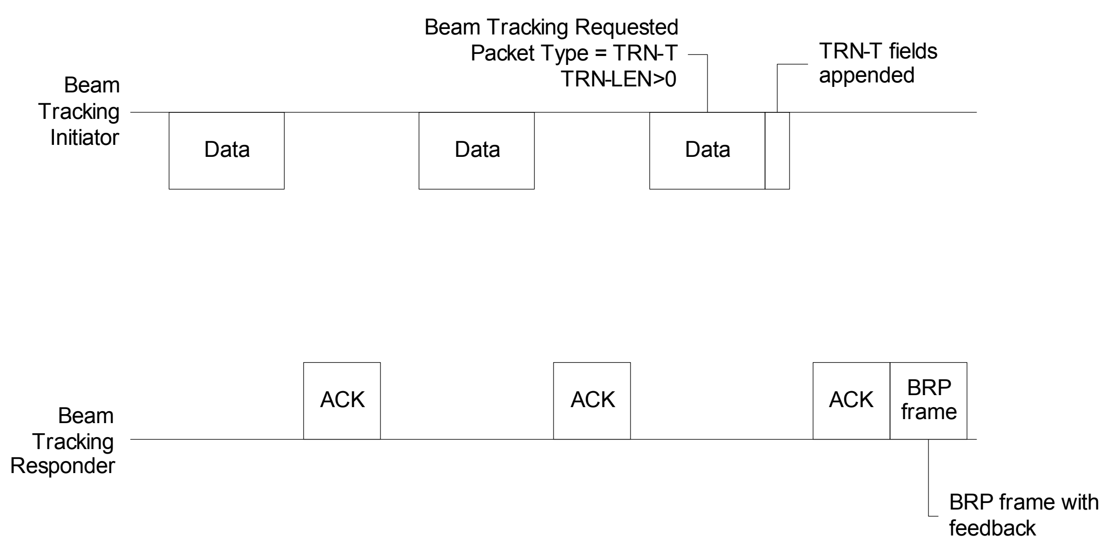


Figure 9-71—Example of a beam tracking procedure with the initiator requesting TRN-T

9.35.8 State machines

Figure 9-72 depicts an example state machine of the SLS phase for the initiator, and Figure 9-73 illustrates an example state machine of the SLS phase for the responder. These state machines describe the behavior of the initiator and responder during BF and are applicable for any period of the beacon interval where BF is performed.

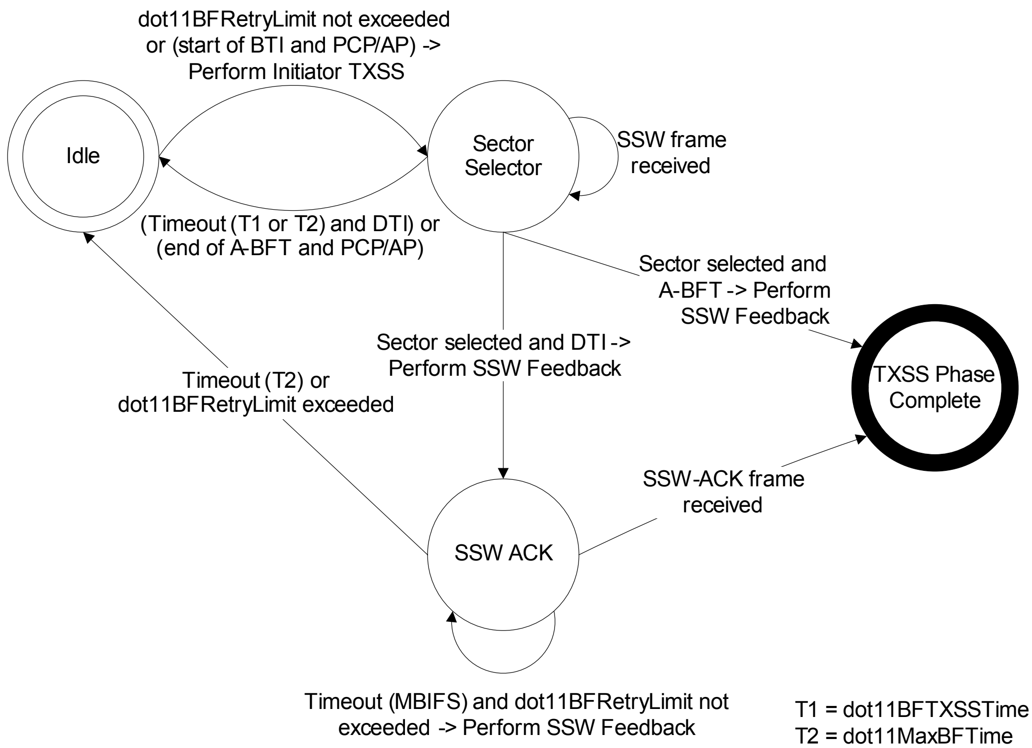


Figure 9-72—SLS phase state machine (initiator)

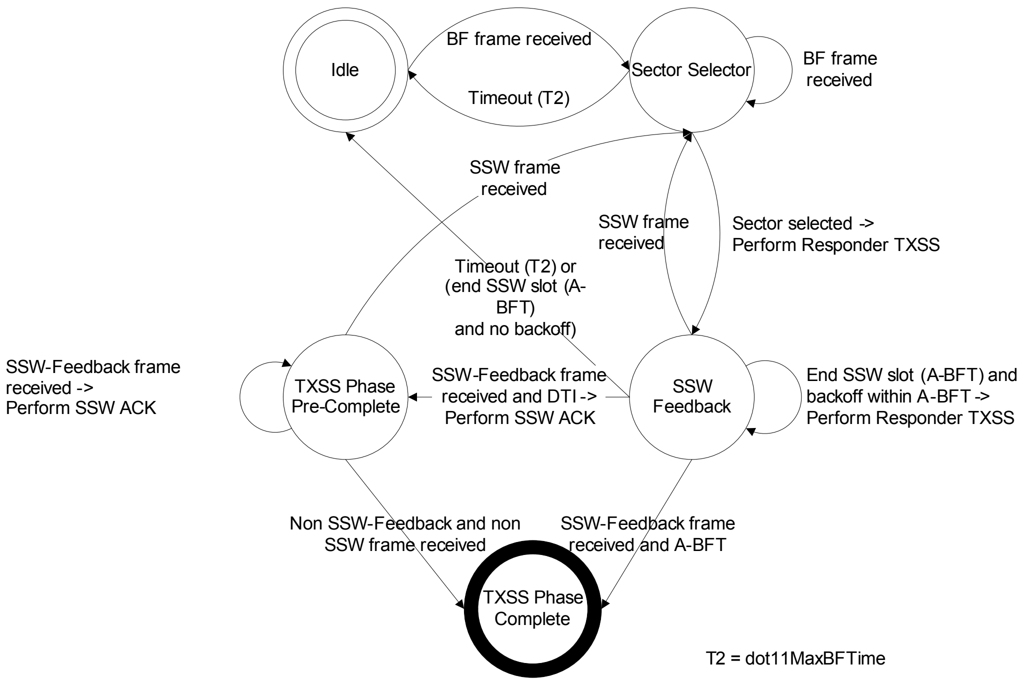


Figure 9-73—SLS phase state machine (responder)

9.36 DMG Block Ack with flow control

9.36.1 General

A DMG STA indicates that it is capable of supporting DMG Block Ack with flow control by setting the BA with Flow Control field to 1 within the DMG STA's DMG Capabilities element. A DMG BlockAck with flow control can be established only when both originator and recipient support this capability.

9.36.2 DMG Block Ack architecture with flow control

The DMG Block Ack rules are explained in terms of the architecture shown in Figure 9-74 and explained in this subclause.

The originator contains a Transmit Buffer Control that uses $WinStart_O$, $BufSize_O$, and $WinLimit_O$ to submit MPDUs for transmission, and releases transmit buffers upon receiving BlockAck frames from the recipient or when it advances the transmit control buffer window.

$WinStart_O$ is the starting sequence number of the transmit range, $WinLimit_O$ is the last sequence number expected to exhaust the receiver buffer capacity, and $BufSize_O$ is the number of buffers negotiated in the Block Ack agreement.

Figure 9-75 shows the DMG Block Ack with flow control and its associated parameters from the Originator perspective.

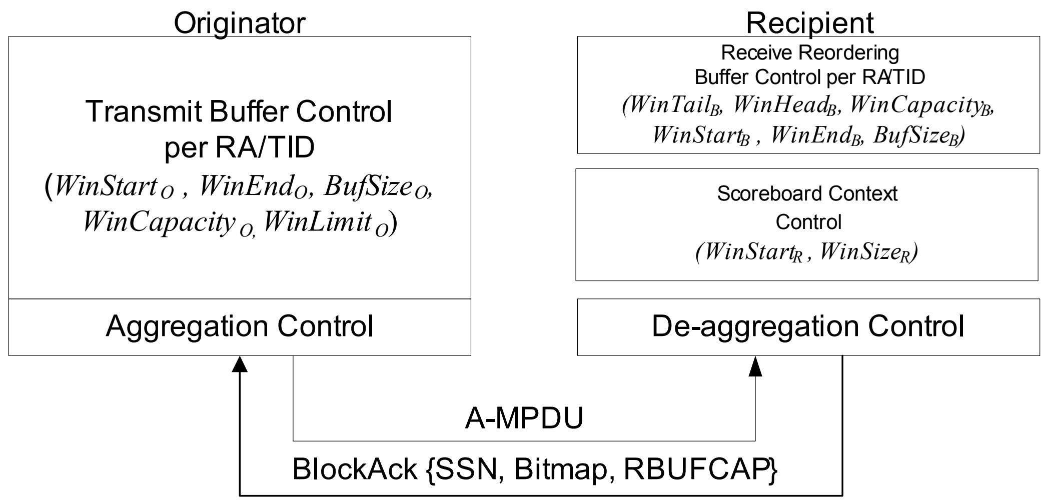


Figure 9-74—DMG Block Ack architecture

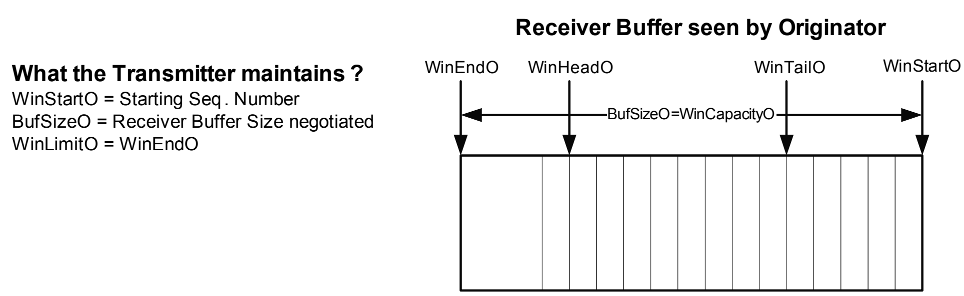


Figure 9-75—Flow control and its associated parameters as a function of receiver buffer size

The Aggregation control creates A-MPDUs. It can adjust the Ack Policy field of transmitted data frames according to the rules defined in 9.21.7.7 in order to solicit Block Ack responses.

The recipient contains a Receive Reordering Buffer Control per TA/TID, which contains related control state.

The receive reordering buffer is responsible for reordering MSDUs or A-MSDUs so that MSDUs or A-MSDUs are eventually passed up to the next MAC process in order of received sequence number (SN). It maintains its own state independent of the Scoreboard Context Control to perform this reordering as specified in 9.21.7.6. The delivery of in order MSDUs or A-MSDUs to the next MAC process is implementation dependent. In some cases, the receiver reordering buffer might be forced to hold on to MSDUs ready for in order delivery due to deferred reception at the next MAC process. This behavior can impose additional buffering requirements on the receiver, causing the actual available buffer capacity to vary dynamically. The reordering buffer is required to manage its lowest and highest (in order) SN, which are marked as $WinTail_B$ and $WinHead_B$, respectively.

The scoreboard context control provides the WinCapacity_B, actually controlled by the Reordering buffer in addition to the bitmap field and the Starting Sequence Number (SSN) field to be sent in BlockAck responses to the originator.

9.36.3 Scoreboard context control with flow control

The scoreboard context control with flow control is defined in 9.21.7.3 and 9.21.7.4.

9.36.4 Receive Reordering Buffer with flow control operation

9.36.4.1 General

A recipient shall maintain a receive reordering buffer for each DMG Block Ack agreement. Each receive reordering buffer includes a record comprising the following:

- Buffered MSDUs or A-MSDUs that have been received, but not yet passed up to the next MAC process
- A $WinStart_B$ parameter, indicating the value of the Sequence Number field (SN) of the first (in order of ascending sequence number) MSDU or A-MSDU that has not yet been received
- A $WinEnd_B$ parameter, indicating the highest SN expected to be received in the current reception range
- A $BufSize_B$ parameter, indicating the size of the reception window
- A $WinTail_B$ parameter, indicating the value of the Sequence Number field (SN) of the first (in order of ascending sequence number) MSDU or A-MSDU that has not yet been delivered to the next MAC process
- A $WinHead_B$ parameter, indicating the highest SN received in the current reception range

$WinStart_B$ is initialized to the Starting Sequence Number field value (SSN) of the ADDBA request frame that elicited the ADDBA response frame that established the DMG Block Ack agreement.

$WinEnd_B$ is initialized to $WinStart_B + BufSize_B - 1$, where $\mathrm{BufSize_B}$ is set to the value of the Buffer Size field of the ADDBA Response frame that established the Block Ack agreement.

Both $WinTail_B$ and $WinHead_B$ are initialized to the preceding Starting Sequence Number field value (SSN – 1), to indicate no MPDU was received, within the current reception window.

Any MSDU or A-MSDU that has been passed up to the next MAC process shall be deleted from the receive reordering buffer, advancing the $WinTail_B$.

The recipient shall pass MSDUs or A-MSDUs up to the next MAC process in order of increasing Sequence Number field value.

9.36.4.2 Operation for DMG Block Ack agreement initialization

At DMG Block Ack agreement establishment:

a) $WinStart_B = SSN$ from the ADDBA Request frame that elicited the ADDBA Response frame that established the DMG Block Ack agreement
b) $WinEnd_B = WinStart_B + BufSize_B - 1$
c) $WinCapacity_B = BufSize_B$
d) $WinHead_B = SSN - 1$, where SSN is taken from the ADDBA Request, similar to $WinStart_B$
e) $WinTail_B = SSN - 1$

9.36.4.3 Operation for each received data MPDU

For each received data MPDU that is related to a specific DMG Block Ack agreement, the receive reordering buffer record is modified as follows, where SN is the value of the Sequence Number field of the received MPDU:

a) If $WinStart_B <= SN <= WinEnd_B$
   1) Store the received MPDU in the buffer.
      i) If $SN > WinHead_B$, Set $WinHead_B = SN$.
      ii) If $SN > (WinTail_B + BufSize_B)$,
         1) All MSDU buffers with sequence numbers from $WinTail_B$ to $SN – BufSize_B$ that were received correctly are passed to the next MAC process.
         2) Set $WinTail_B = SN – BufSize_B$.
      iii) Set $WinCapacity_B = WinTail_B + BufSize_B – WinHead_B$.
   2) Set $WinStart_B$ to the value of the Sequence Number field of the first MSDU or A-MSDU that is missing to allow in-order delivery to the next MAC process.
   3) Set $WinEnd_B = WinStart_B + BufSize_B – 1$.
b) If $WinEnd_B < SN < WinStart_B + 2^{11}$
   1) Store the received MPDU in the buffer.
   2) Set $WinEnd_B = SN$.
   3) Set $WinStart_B = WinEnd_B – BufSize_B + 1$.
   4) All MSDU buffers with sequence numbers from $WinTail_B$ to $SN – BufSize_B$ that were received correctly are passed to the next MAC process.
   5) Set $WinTail_B = SN – BufSize_B$.
   6) Set $WinHead_B = SN$.
   7) Set $WinCapacity_B = WinTail_B + BufSize_B – WinHead_B$.
c) If $WinStart_B + 2^{11} <= SN < WinStart_B$, discard the MPDU (do not store the MPDU in the buffer, do not pass the MSDU or A-MSDU up to the next MAC process).
d) For each received Block Ack Request frame the block acknowledgment record for that agreement is modified as follows, where SSN is the value from the Starting Sequence Number field of the received Block Ack Request frame:
   1) If $WinStart_B < SSN <= WinEnd_B$
      i) Set $WinStart_B = SSN$.
      ii) Set $WinEnd_B = WinStart_B + BufSize_B – 1$.
      iii) If $SSN > WinHead_B$, set $WinHead_B = SSN – 1$.
      iv) If $SSN > (WinTail_B + BufSize_B)$,
         1) All MSDU buffers with sequence numbers from $WinTail_B$ to $SSN – BufSize_B$, are discarded from the buffer.
         2) Set $WinTail_B = SSN – BufSize_B$.
      v) Set $WinCapacity_B = WinTail_B + BufSize_B – WinHead_B$.
   2) If $WinEnd_B < SSN < WinStart_B + 2^{11}$
      i) Set $WinStart_B = SSN$.
      ii) Set $WinEnd_B = WinStart_B + BufSize_B – 1$.
      iii) Set $WinHead_B = SSN – 1$.
      iv) If $SSN > (WinTail_B + BufSize_B)$,

1) All MSDU buffers with sequence numbers from $WinTail_B$ to $SSN - BufSize_B$, are discarded from the buffer.
2) Set $WinTail_B = SSN - BufSize_B$.

v) Set $WinCapacity_B = WinTail_B + BufSize_B - WinHead_B$.

3) If $WinStart_B + 2^{11} <= SSN <= WinStart_B$, make no changes to the record.

9.36.4.4 Operation for ongoing release of received MPDUs

The reordering buffer shall continue to pass MSDUs or A-MSDUs up to the next MAC process that are stored in the buffer in order of increasing value of the Sequence Number field, starting with the MSDU or A-MSDU that has $SN = WinTail_B$ and proceeding sequentially until there is no ready in-order MSDU or A-MSDU buffered for the next sequential value of the Sequence Number field.

a) Set $WinTail_B$ to the value of the Sequence Number field of the last MSDU or A-MSDU that was passed up to the next MAC process plus one.

9.36.5 Generation and transmission of BlockAck by a STA with flow control

In addition to the normative behavior specified in 9.21.7.5 when responding with a BlockAck frame, the RBUFCAP field shall be updated with the value of $WinCapacity_B$.

9.36.6 Originator's behavior with flow control support

If the BA with Flow Control field within a recipient's DMG Capabilities element is equal to 1, the originator shall not transmit an MPDU with a SN that is beyond the current recipient's buffer capacity ($WinLimit_O$).

The BlockAck frame indicates the number of free buffer slots available at the recipient for reception of additional MPDUs.

The originator shall update the variable $WinLimit_O$ upon reception of a valid BlockAck:

— Set $WinCapacity_O$ to the received value of the RBUFCAP field in the BlockAck frame.
— Set *MostSuccSN* to the highest *SN* of positively acknowledged MPDUs
— Set $WinLimit_O = MostSuccSN + WinCapacity_O$

NOTE—Updating the variable $WinLimit_O$ limits the transmission of the following MPDUs.

Originator's support of recipient's partial state is defined in 9.21.7.9.

9.37 DMG link adaptation

9.37.1 General

A STA may transmit a Link Measurement Request frame to request a STA indicated in the RA field of the frame to respond with a Link Measurement Report frame (8.5.7.5). If the Link Measurement Request frame is sent within a PPDU defined in Clause 21, the Link Measurement Report frame shall contain the DMG Link Margin element. The requesting STA may use values of the MCS, of the SNR and of the Link Margin to transmit frames to the STA indicated in the RA field of the Link Measurement Request frame.

The requesting STA may aggregate a Link Measurement Request frame in an A-MPDU as defined in Table 8-284 and Table 8-287.

If the Dialog Token field in the Link Measurement Request frame is equal to a nonzero value, the responding STA shall perform the measurement on the next frame received from the requesting STA and shall send back a Link Measurement Report frame corresponding to the received frame.

The responding STA may aggregate a Link Measurement Report frame in a A-MPDU as defined in Table 8-284 and Table 8-287.

A DMG STA with MAC address that is equal to the value of the Link Measurement Request frame RA field shall transmit a Link Measurement Report frame addressed to the requesting STA. The RA field of the Link Measurement Report frame shall be equal to the TA field of the Link Measurement Request frame.

If the Dialog Token field in the Link Measurement Report frame is equal to the nonzero Dialog Token field of the Link Measurement Request frame, then the MCS, SNR, and Link Margin fields of the Link Measurement Report frame shall be computed using the measurements of the PPDU that is the subsequent frame following the Link Measurement Request frame.

If the Dialog Token field in the Link Measurement Request frame is equal to 0, the responding STA may set the MCS field in the Link Measurement Report frame to the MCS value computed based on any of the received frames from the requesting STA.

The SNR field and Link Margin field in the Link Measurement Report frame shall indicate the corresponding measurements based on the reception of the PPDU that was used to generate the MCS feedback contained in the same Link Measurement Report frame.

The Link Measurement Request and Report frames can be used to obtain Link Margin information, which can be used to determine appropriate action by the requesting STA (e.g., change MCS or control transmit power or initiate FST).

A STA may send an unsolicited Link Measurement Report frame with the Dialog Token field set to 0.

9.37.2 DMG TPC

A DMG STA that receives a Link Measurement Report frame containing a DMG Link Margin element that indicates Increase or Decrease Transmit power behaves according to the following rules:

- If the DMG STA intends to implement the recommendation indicated in the Activity field of the Link Measurement Report, it shall implement the change and send a Link Measurement Report containing a DMG Link Adaptation Acknowledgment element not later than 2×aPPDUMaxTime after it acknowledged the reception of the Link Measurement Report. The Activity field of the DMG Link Adaptation Acknowledgment element shall be set to the value of the Activity field in the received DMG Link Margin Subelement.
- If the DMG STA does not implement the recommendation indicated in the Activity field of the Link Measurement Report, it may send the Link Measurement report containing a DMG Link Adaptation Acknowledgment element no later than 2×aPPDUMaxTime after it acknowledges the reception of the Link Measurement Report. The Activity field of the DMG Link Adaptation Acknowledgment element shall be set to 0, indication the STA prefers to not change transmit power.

A DMG STA shall not include the DMG Link Adaptation Acknowledgment element in a Link Measurement Report unless it is in response to a Link Measurement Report with Activity field set to increase or decrease transmit power.

9.37.3 Fast link adaptation

A STA supports fast link adaptation if the Fast Link Adaptation field in the STA's DMG Capabilities element is 1. Otherwise, the STA does not support fast link adaptation. A STA that supports fast link adaptation shall not use fast link adaptation with a peer STA that does not support fast link adaptation.

A STA that supports fast link adaptation shall support the reverse direction protocol (see 9.25). The STA that transmits a Link Measurement Request frame as part of fast link adaptation shall be the RD initiator and the STA that responds with a Link Measurement Report frame shall be the RD responder. Transmission of Link Measurement Request, Link Measurement Report and the frames defined below shall follow the rules of the reverse direction protocol.

A STA initiates fast link adaptation by transmitting a Link Measurement Request frame of subtype Action No Ack and that has the Dialog Token field set to 0. The PPDU containing the frame shall have the AGGREGATION parameter in the TXVECTOR set to AGGREGATED, shall not contain any other frame that requires immediate response, and shall have a duration (as determined by the PHY-TXTIME.confirm primitive defined in 6.5.8) that is greater than 5.27 µs.

NOTE—The PPDUs have the AGGREGATION parameter in the TXVECTOR set to AGGREGATED to allow padding of the PSDUs with MPDU delimiters of size 0, therefore meeting the transmission duration requirement.

A STA supporting fast link adaptation and that receives a Link Measurement Request frame of subtype Action No Ack, with the Dialog Token field equal to 0 and contained in a PPDU with the AGGREGATION parameter in the RXVECTOR equal to AGGREGATED shall respond with a Link Measurement Report frame in no longer than BRPIFS from the reception of the Link Measurement Request frame. The TPC Report element, DMG Link Margin element and other fields transmitted in the Link Measurement Report frame shall reflect measurements on the PPDU that contained the last received Link Measurement Request frame from the initiating STA.

The STA responding with the Link Measurement Report frame shall keep the IFS not longer than SIFS by transmitting PPDUs that do not contain frames requiring immediate response and that have a duration that is greater than 5.27 µs. All transmitted PPDUs should use the same MCS and the same transmit power.

The transmitted Link Measurement Report frame shall be of subtype Action No Ack, shall be sent using MCS 1, and shall be sent within a PPDU with the AGGREGATION parameter in the TXVECTOR set to AGGREGATED. In addition, the PPDU shall not contain any frame that requires immediate response and shall have a duration that is greater than 5.27 µs.

If at least one of the conditions above for the transmission of the Link Measurement Report frame is not met, the STA may follow the rules in 9.37.1 to respond to the received Link Measurement Request frame.

A STA that supports fast link adaptation and that receives a Link Measurement Report frame should respond with an unsolicited Link Measurement Report frame in no longer than BRPIFS from the reception of the Link Measurement Report frame. The TPC Report element, DMG Link Margin element and other fields transmitted in the unsolicited Link Measurement Report frame shall reflect measurements taken on one or more of the PPDUs received by the STA transmitting the unsolicited Link Measurement Report frame, starting with the received Link Measurement Report frame itself. If the unsolicited Link Measurement Report frame is transmitted longer than SIFS from the reception of the Link Measurement Report frame, the STA transmitting the unsolicited Link Measurement Report frame shall keep the IFS not longer than SIFS by transmitting one or more PPDUs before issuing the unsolicited Link Measurement Report frame.

An example of the fast link adaptation procedure is shown in Figure 9-76.

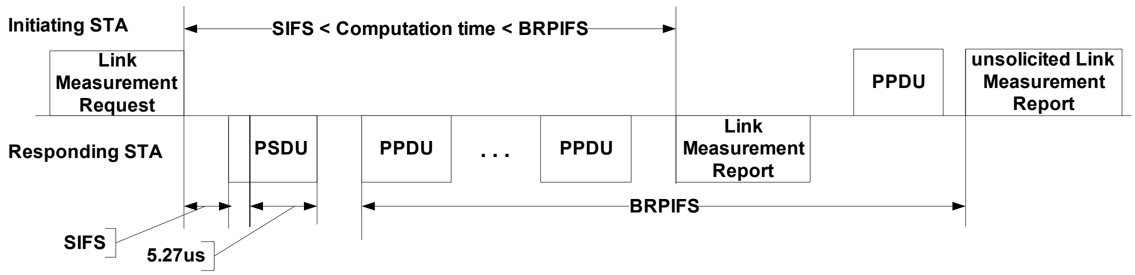


Figure 9-76—Example of the fast link adaptation procedure

9.38 DMG dynamic tone pairing (DTP)

A pair of communicating STAs shall employ DTP modulation only if both STAs support DTP as indicated through the DTP Supported field within the STA's DMG Capabilities element.

A DTP capable STA may use DTP with another DTP capable STA by setting the DTP_TYPE in the TXVECTOR to dynamic; otherwise, the DTP_TYPE is set to static. The transmitting STA may stop using DTP by setting the DTP_TYPE in the TXVECTOR to static.

A transmitting STA requests a DTP report from a receiving STA by sending a DTP Request frame to that STA. Upon receiving a DTP Request frame, the receiving STA shall respond with a DTP Report frame carrying the DTP configuration. The DTP Report frame should be sent no later than dot11BeaconPeriod TUs after the receiving STA transmits an ACK frame in response to the successful reception of the DTP Request frame. If the transmitting STA does not receive a DTP Report frame from the receiving STA within dot11BeaconPeriod TUs from the transmitting STA's reception of the ACK frame corresponding to its most recent DTP Request frame transmission to the receiving STA, the transmitting STA may retransmit the DTP Request frame to the receiving STA. The Dialog Token field of the DTP Report frame is set to the Dialog Token value in the corresponding DTP Request frame.

The transmitting STA should switch to the updated DTP configuration after a DTP Report frame is received.

If a STA transmits a DTP Report frame in response to the reception of a DTP Request frame, the STA shall not send an updated DTP Report frame unless it receives another DTP Request frame.

If a STA transmits an unsolicited DTP Report frame, the STA should not send a new unsolicited updated DTP Report unless the transmitting STA has switched to the DTP configuration last sent.

Both the transmitting and receiving STAs maintain two copies of DTP configurations: the current configuration that is in use for transmission and an updated configuration, if any, received after the current configuration. The transmitting STA determines when to switch from the current to the updated DTP configuration. The transmitting STA shall indicate the switch from the current configuration to the updated configuration by toggling the DTP Indicator bit field in the PLCP header. The value of the DTP Indicator field shall be kept unchanged until the transmitting STA decides to switch to the new DTP configuration. By receiving an ACK frame in response to a data frame from the receiving STA, the switching operation is completed.

The transmitting STA may send another DTP Request frame to a receiving STA even if it decided not to switch to the DTP configuration indicated by the receiving STA's last transmitted, if any, DTP Report frame.

If the Beam link cluster field is 0, then the links within the MMSL cluster that use DTP may maintain independent DTP configurations.

9.39 DMG relay operation

9.39.1 General

The DMG relay procedures are specified in 10.35. This subclause specifies the supported types of DMG relay.

A source REDS, a destination REDS and an RDS can establish two types of relay operation:

— Link switching (9.39.2): If the direct link between the source REDS and destination REDS is disrupted, the source REDS redirects the transmission of frames addressed to the destination REDS via the RDS. The RDS forwards frames received from the source REDS to the destination REDS and from the destination REDS to the source REDS. Direct communication between the source REDS and destination REDS can resume after the direct link between them is recovered.

— Link cooperating (9.39.3): In this case, the RDS is actively involved in the direct communication between the source REDS and the destination REDS. A frame transmission from the source REDS to the destination REDS is simultaneously repeated by the RDS, which can possibly increase the signal quality received at the destination REDS.

9.39.2 Link switching type

9.39.2.1 General

A source REDS that has successfully completed an RLS procedure with a destination REDS for which the value of the Cooperation-Mode subfield within the negotiated Relay Transfer Parameter Set element is 0 may use the selected RDS between the source REDS and destination REDS for the purpose of link switching. This is described in this subclause.

9.39.2.2 SP request and allocation

The source REDS uses the procedures described in 10.4 to request an SP allocation between itself and the destination REDS.

Upon receiving an ADDTS Request frame for which the source AID and the destination AID fields within the DMG TSPEC element are equal to a pair of a source REDS and a destination REDS, respectively, that have successfully completed the RLS procedure defined in 10.35.2.4, the PCP/AP schedules an SP with the source DMG STA as the source REDS and the destination DMG STA as the destination REDS.

An RDS shall check the value of the source AID and the destination AID fields of each SP allocation within an Extended Schedule element it receives in a DMG Beacon or Announce frame from the PCP/AP. If the value of the source AID and the destination AID fields of an SP allocation correspond to a source REDS and a destination REDS, respectively, that have successfully completed the RLS setup procedure (10.35.2), the RDS shall operate as an RDS during that SP allocation.

9.39.2.3 Usage of RDS

In link switching type, an RDS operates either in FD-AF mode or in HD-DF mode. An RDS capable of FD-AF relaying shall be in one of two frame transmission modes:

— **Normal mode**: A pair of source REDS and destination REDS exchange frames via either the direct link or the relay link until this link is determined to become unavailable due to, for example, blockage or channel degradation.

— **Alternation mode**: A source REDS and a destination REDS exchange frames via two separate links, where the use of each link alternates at each Link Change Interval. The Link Change Interval specifies the time instants at which a source REDS is allowed to change the link used for a frame transmission to the destination REDS as specified in 8.4.2.151.

An RDS that supports only HD-DF shall operate in the Normal mode.

The frame transmission mode is indicated in the Relay Transfer Parameter Set element exchanged by the source REDS, destination REDS, and RDS during the RLS procedure. A source REDS or destination REDS may change the transmission mode used in a relay link following a successful exchange of RLS Request and RLS Response frames as described in 10.35.2.4.

An RDS shall start to operate as RDS at the start of an SP for which the value of the source AID and destination AID fields for that SP are equal to the source REDS and destination REDS, respectively, for which the RDS has successfully completed the RLS procedure. The RDS can determine the SPs for which it operates as an RDS upon the reception of an Extended Schedule element.

9.39.2.4 Relay frame exchange rules

9.39.2.4.1 General

Following the completion of the RLS procedure and SP allocation, each of the source REDS, destination REDS, and RDS have a direct link with one another.

The values of Link Change Interval and Data Sensing Time are indicated within the Relay Transfer Parameter Set transmitted by the source REDS to the destination REDS during the RLS procedure. Either the Link Change Interval period or the First Period begins at the start of an SP between the source REDS and the destination REDS, and any transmission by the source REDS, destination REDS, and RDS within a Link Change Interval period shall use the same link that is used at the start of the Link Change Interval period. A new Link Change Interval period starts immediately after another Link Change Interval period, but shall not exceed the end of the SP.

In the normal mode, a source REDS shall use the direct link to initiate frame transmission to the destination REDS at the start of the first SP allocated between the source REDS and destination REDS for a particular TID. At the start of the following SP allocations for that same TID, the source REDS uses the last link in which a frame transmission to the destination REDS via this link was successful. In the alternation mode, the source DMG STA shall alternate the frame transmission to the destination REDS between direct frame transmission to the destination REDS and frame transmission through the RDS. The source REDS shall alternate the link used for a frame transmission at the start of each Link Change Interval.

If a source REDS transmits a frame to the destination REDS via the direct link but does not receive an expected ACK frame or BA frame from the destination REDS during a Link Change Interval period, the source REDS should change the link used for frame transmission at the start of the following Link Change Interval period and use the RDS to forward frames to the destination REDS.

If a source REDS transmits a frame to the destination REDS via the RDS but does not receive an expected ACK frame or BA frame from the RDS during a Link Change Interval period or a First Period, the source REDS should change the link used for frame transmission at the start of the following Link Change Interval period or the following First Period and transmit frames directly to the destination REDS.

9.39.2.4.2 Additional frame exchange rules for FD-AF RDS

If the source REDS decides to change the link at the start of the following Link Change Interval period and the Normal mode is used, the source REDS shall start its frame transmission after Data Sensing Time from the start of the following Link Change Interval period. If the Alternation mode is used, the source REDS alternates the link used for frame transmission at the start of each Link Change Interval period, and the value of Data Sensing Time is ignored.

In the Normal mode, if the destination REDS does not receive a valid frame from the source REDS within Data Sensing Time after the start of a Link Change Interval, the destination REDS shall immediately change the link to attempt to receive frames from the source REDS through the RDS. If the More Data field in the last frame received from the source REDS is equal to 0, then the destination REDS shall not switch to the link in the next Link Change Interval period even if it does not receive a frame during the Data Sensing Time. An example of frame transfer under Normal mode with FD-AF RDS is illustrated in Figure 9-77.

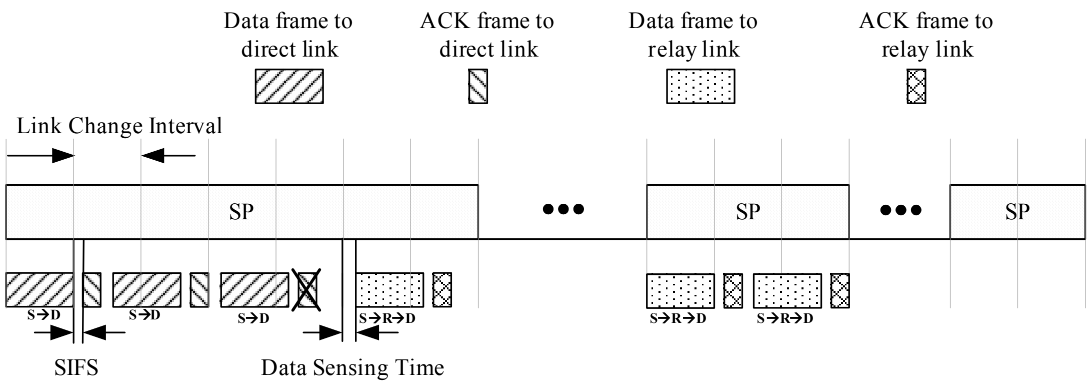


Figure 9-77—Example of Normal mode operation with FD-AF relay

In the Alternation mode, if the destination REDS receives an out of order frame, the destination REDS shall remain at the current link. If the More Data field in the last frame received from the source REDS is equal to 0, then the destination REDS shall not switch links in the next Link Change Interval period. If the source REDS uses either the direct or the relay link and decides to resume alternate frame transmission, the source REDS should transmit a frame to the other link Data Sensing Time after the next Link Change Interval to inform the destination REDS that operation on the other link has been resumed. Note that this is the only situation when Data Sensing Time is used in the Alternation mode.

9.39.2.4.3 Additional frame exchange rules for HD-DF RDS

When the RDS is operating as a HD-DF RDS and the RDS is used in the frame exchange between the source REDS and the destination REDS, the frame exchange is performed in two periods, which are repeated for as long as the RDS is used. In the First Period, the source REDS shall transmit a frame to the RDS and then the RDS responds after SIFS if needed. In the Second Period, the RDS shall forward the frame received from the source REDS to the destination REDS, and then the destination REDS responds after SIFS if needed. The duration of the First Period and the Second Period are specified in the last Relay Transfer Parameter Set element transmitted from the source REDS.

The First Period and Second Period are valid only when the source REDS and destination REDS exchange frames via the RDS. The Link Change Interval is valid only when the source REDS and destination REDS exchange frames via the direct link. The First Period begins at the end of the Link Change Interval when a change to the relay link occurs. The Link Change Interval begins at the end of the Second Period when a change to the direct link occurs.

The source REDS may transmit a Relay ACK Request frame to the RDS to determine whether all frames forwarded through the RDS were successfully received by the destination REDS. Upon reception of a Relay ACK Request frame, the RDS shall respond with a Relay ACK Response frame and set the BlockAck Bitmap field to indicate which frames have been successfully received by the destination REDS.

If the source REDS decides to change to the relay link at the start of the following Link Change Interval period, the source REDS shall start its frame transmission at the start of the following Link Change Interval period. If the current link is the direct link and the destination REDS does not receive a valid frame from the source REDS within Data Sensing Time after the start of each Link Change Interval, the destination REDS shall change the link and consider the First Period to begin at the start of the Link Change Interval.

If a link change to the direct link occurs, the source REDS shall start to transmit a frame using the direct link at the end of the Second Period when the Link Change Interval begins. The destination REDS shall switch to the direct link at each First Period and listen to the medium toward the source REDS. If the destination REDS receives a valid frame from the source REDS, the destination REDS shall remain on the direct link and consider the Link Change Interval to begin at the start of the First Period. Otherwise, the destination REDS shall change the link at the start of the next Second Period and attempt to receive frames from the source REDS through the RDS. If the active link is the relay link and the More Data field in the last frame received from the RDS is equal to 0, then the destination REDS shall not switch to the direct link even if it does not receive any frame during the Second Period.

The source REDS that intends to use the Block Ack mechanism through the RDS shall perform the Block Ack setup procedure with the RDS using the same TID as it is used for the direct communication between the source REDS and the destination REDS. Similarly, the RDS shall perform the Block Ack setup procedure with the destination REDS before transmitting data using the Block Ack mechanism. Upon reception of an ADDBA Request frame from the source REDS, the RDS shall send an ADDBA Request frame to the destination REDS with the same content for all corresponding fields as the ADDBA Request frame received from the source REDS, except for Buffer Size field, which contains the buffer size of the RDS. Following the reception of the ADDBA Response frame from the destination REDS, the RDS shall send an ADDBA Response frame to the source REDS. The ADDBA Response frame shall have the same content for all corresponding fields as the ADDBA Response frame received from the destination REDS, except for the Buffer Size field, which shall be set to the minimum between the buffer size of the RDS and the destination REDS.

An example of frame transfer with HD-DF RDS is illustrated in Figure 9-78.

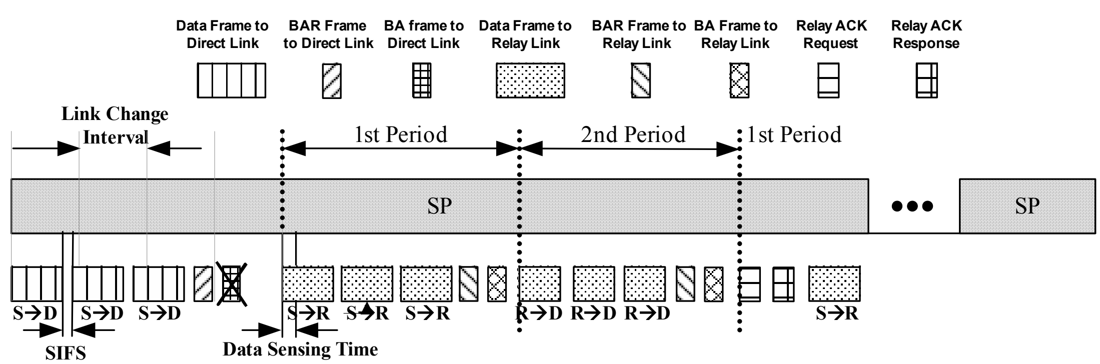


Figure 9-78—Example of the operation with HD-DF relay

9.39.2.4.4 Operation of FD-AF RDS

In an SP allocated for relay operation, a FD-AF RDS operates in an amplify-and-forward manner. This means that for each frame detected at the RF in the receive state within an SP in which it operates as a FD-AF RDS, the RDS amplifies the received signal and simultaneously retransmits it via the RF in transmit state.

At the start of the SP where it operates as a FD-AF RDS, the RDS shall initiate an RF antenna module in the receive state directed toward the source REDS and another RF antenna module in transmit state directed toward the destination REDS.

For each frame received at the RDS during the SP, the RDS shall follow the same rules for frame exchange sequences as described in Annex G and 9.33. This includes switching the state of each RF available to the RDS from receive to transmit, and vice-versa, depending upon the frame type and its ACK policy.

9.39.2.5 Link monitoring

After a link change, the source REDS might periodically monitor the quality of the previous link. To do that, the source REDS can use the link change mechanism described in 9.39.2.4. If the previous link is the relay link, the source REDS can acquire the channel status by using relay link measurement mechanism as described in 9.39.4. If the previous link is the direct link, the source REDS can acquire the channel status via the link adaptation mechanism defined in 9.37. If the channel quality of the previous link is better than the one on the current link, which is an implementation-dependent decision, the source REDS may switch to the previous link.

9.39.3 Link cooperating type

9.39.3.1 TPA procedure

A source REDS, a destination REDS, and an RDS use the common relay setup procedure defined in 10.35.2 to set up a link cooperating relay. In addition, to establish a link cooperating relay, the source REDS, destination REDS, and RDS shall perform the TPA procedure described in this subclause and shown in Figure 9-79.

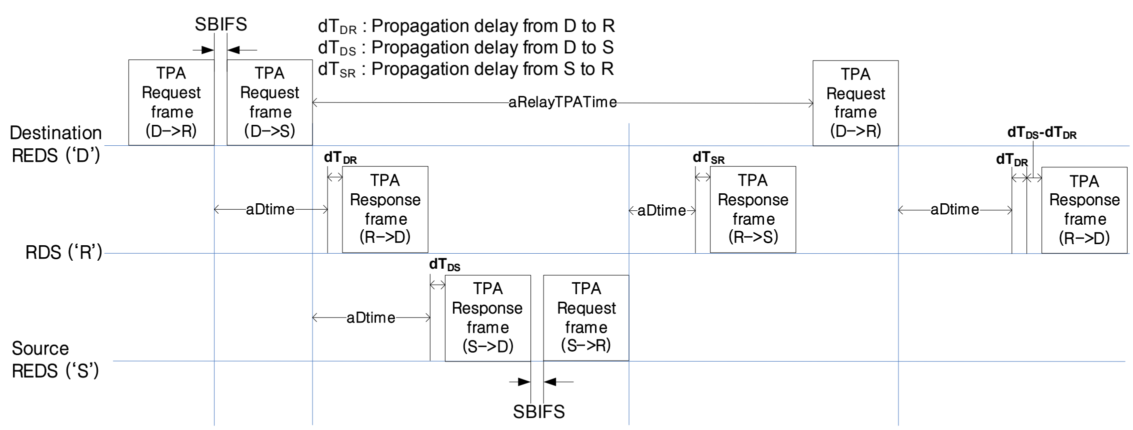


Figure 9-79—TPA mechanism

The TPA procedure is triggered by the destination REDS following the common relay setup procedure with the source REDS and RDS. First, the destination REDS uses the procedures described in 10.4 to request the allocation of an SP to perform TPA, wherein the source of the SP is the destination REDS and the destination of the SP is the source REDS. If the value of a source AID and the destination AID fields of an SP allocation correspond to a destination REDS and a source REDS, respectively, that have successfully completed the RLS setup procedure, the DMG STA that performs as an RDS in that SP allocation shall operate during the allocation as a non-RDS-capable DMG STA.

Within the allocated SP, the destination REDS sends a TPA Request frame to the RDS and sets the Timing Offset field to zero (see Figure 9-79). SBIFS interval following the end of the first TPA Request frame transmission, the destination REDS shall send the second TPA Request frame to the source REDS and set the Timing Offset field to zero. aDtime interval (10.38) following the reception of the first TPA Request frame, the RDS shall transmit a TPA Response frame back to the destination REDS. Upon receiving the TPA Response frame from the RDS, the destination REDS shall estimate the TPA value of the RDS and the time deviation (i.e., $2\times dT_{DR}$) between the expected Dtime and the actual arrival time of the TPA Response frame. aDtime interval following the reception of the second TPA Request frame, the source REDS shall transmit a TPA Response frame back to the destination REDS. The destination REDS shall repeat the same procedure upon reception of the TPA Response frame received from the source REDS.

SBIFS interval following the end of the transmission of the TPA Response frame to the destination REDS, the source REDS shall send a TPA Request frame to the RDS and set the Timing Offset field to zero. aDtime interval following the reception of the TPA Request frame, the RDS shall transmit a TPA Response frame back to the source REDS. Upon reception of the TPA Response frame from the RDS, the source REDS shall estimate the TPA value of the RDS and the time deviation (i.e., $2\times dT_{SR}$) between aDtime and the actual arrival time of the TPA Response frame.

At aRelayTPATime (10.38) from the end of the last TPA Request frame transmitted by the destination REDS to the source REDS, the destination REDS shall send a TPA Request frame to the RDS and set the Timing Offset field to $dT_{DS}–dT_{DR}$. Upon reception of the TPA Request frame, the RDS shall transmit a TPA Response frame to the destination REDS at $aDtime+dT_{DR}+(dT_{DS}–dT_{DR})$ from the end of the TPA Request frame. Upon reception of the TPA Response frame, the destination REDS shall estimate the time deviation (i.e., $2\times dT_{DR}+(dT_{DS}–dT_{DR})$) between aDtime and the actual arrival time of the TPA Response frame. If the destination REDS determines that the estimated deviation is equal to $2\times dT_{DR}+(dT_{DS}–dT_{DR})$, then the destination REDS considers that the TPA procedure was successful. As the last step of the TPA procedure, the destination REDS shall send a TPA Report frame to the source REDS that includes the information regardless of whether the last TPA procedure succeeded.

If it is not successful, the TPA procedure is repeated until it is successful or upon the decision of the destination REDS to stop performing the TPA procedure. The TPA procedure can include the estimation of the sampling frequency-offset (SFO), in order for the source REDS and RDS to adjust their SFOs.

9.39.3.2 Frame exchange operation

9.39.3.2.1 General

A source REDS that has successfully completed an RLS procedure with a destination REDS for which the value of the Cooperation-Mode subfield within the negotiated Relay Transfer Parameter Set element is equal to 1 and has successfully completed the TPA procedure shall use the selected RDS between the source REDS and destination REDS for the purpose of link cooperation. This is described in this subclause.

9.39.3.2.2 Cooperative transmission SP request and allocation

If the source REDS receives a TPA Report frame that indicates the successful completion of the TPA procedure with the RDS and the destination REDS, the source REDS uses the procedure in 10.4 to request an SP allocation with the destination REDS. The source REDS can use the SP allocation for communication with the destination REDS with the assistance of the RDS.

9.39.3.2.3 Data transmission rules

As shown in the example of Figure 9-80, in the allocated SP the first time interval (T1) and the second time interval (T2) for a cooperative data frame transfer are determined by the packet transmission time at each transmission from the source REDS to the destination REDS within the SP.

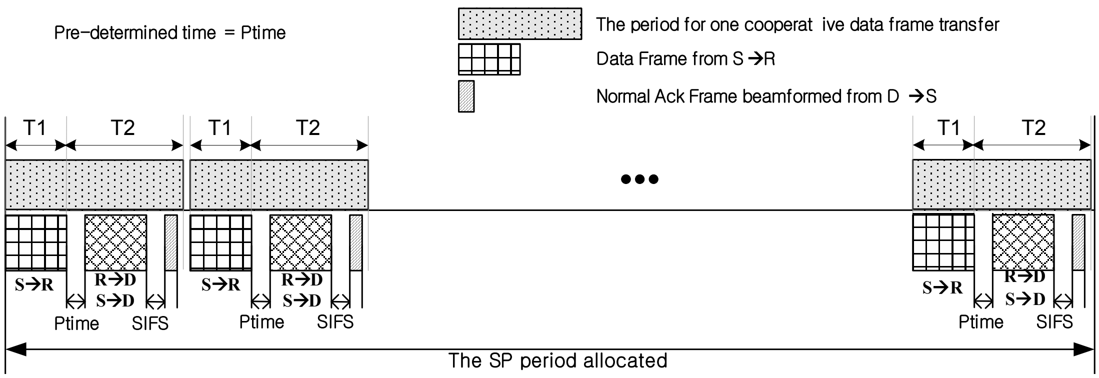


Figure 9-80—Example of data transmission in an SP with link cooperating relay

The data transmission rules are as follows. At the start of each time T1, the source REDS transmits a frame with its transmit antenna pattern directed towards the RDS and with the TA and the RA fields in the MAC header set to the MAC address of the source REDS and destination REDS, respectively. After Ptime+dT_{SR} from the start of T2, the source REDS retransmits the same frame sent to the RDS during the previous time T1 but now with its transmit antenna pattern directed towards the destination REDS. Similarly, after Ptime+(dT_{DS}–dT_{DR}) from the start of T2, the RDS retransmits the same frame it received from the source REDS during the previous time T1. So that the destination REDS can take advantage of the improved received signal level from both of these transmissions, the destination REDS should set its receive antenna pattern during T2 such that it simultaneously covers the links towards both the source REDS and the RDS.

The Ack policy used during an SP where link cooperation is in use is the same as defined in Clause 9.

9.39.4 Relay link adaptation

When a relay link is used for communication between a source REDS and a destination REDS, the link qualities of the S-R link, the R-D link, and the S-D link might be required.

The source REDS, destination REDS, and RDS use the procedure described in 9.37 to request and report the link quality among themselves with the following exception. In the Link Measurement Report frame the RDS transmits to the source REDS, the RDS shall include two Link Margin elements in this order:

- The first Link Margin element shall report the link quality between the source REDS and the RDS.
- The second Link Margin element shall report the link quality between the RDS and the destination REDS.

Upon reception of a Link Measurement Report frame, the source REDS can take several actions including changing the MCS it uses for frame transmission to the RDS and destination REDS.

10. MLME

10.1 Synchronization

10.1.1 General

Insert the following paragraph at the end of 10.1.1:

A multi-band capable device (10.32) shall maintain a local TSF timer for each channel that the STA operates in.

10.1.2 Basic approach

10.1.2.1 TSF for infrastructure networks and PBSS networks

Change 10.1.2.1 as follows:

In an infrastructure BSS or in a PBSS, the AP in the infrastructure BSS or the PCP in the PBSS shall be the timing master for the TSF. A STA that is the AP or the PCP shall initialize its TSF timer independently of any simultaneously started APs or PCPs, respectively, in an effort to minimize the synchronization of the TSF timers of multiple APs or PCPs. In a non-DMG BSS, ~~T~~the AP shall periodically transmit special frames called *Beacon frames*. In a DMG BSS, the PCP/AP shall periodically transmit special frames called *DMG Beacon* and *Announce frames*, which provide a similar function to the Beacon frame in a non-DMG BSS. Beacon, DMG Beacon, and Announce frames ~~that~~ contain the value of ~~its~~ the PCP's or AP's TSF timer to synchronize the TSF timers of other STAs in a BSS. A receiving STA shall accept the timing information in Beacon, DMG Beacon, and Announce frames sent from the AP and PCP servicing its BSS. If a STA's TSF timer is different from the timestamp in the received Beacon, DMG Beacon, or Announce frame, the receiving STA shall set its local TSF timer to the received timestamp value.

In a non-DMG BSS, Beacon frames shall be generated for transmission by the AP once every dot11BeaconPeriod TUs. In a DMG infrastructure BSS, zero or more DMG Beacon frames shall be generated for transmission by the AP every dot11BeaconPeriod TUs (see 10.1.3.2a). The AP shall transmit at least one DMG Beacon frame through each sector available to the AP within a time interval that is not longer than dot11BeaconPeriod $\times$ dot11MaxLostBeacons TUs. The TXSS Span field in the DMG Beacon shall be set to a value that is less than or equal to the dot11MaxLostBeacons attribute.

In a PBSS, the value of the TSF timer is delivered to the DMG STA by the DMG Beacon frames generated at each BTI and by the Announce frames generated during the ATI. In a PBSS, at TBTTs that do not start with a BTI, the PCP begins a beacon interval with an ATI sequence (see 10.1.3.2a.2). The time interval in between two consecutive BTIs shall be an integer multiple of dot11BeaconPeriod TUs. The PCP shall transmit at least one DMG Beacon frame to each associated STA within a time interval that is not longer than dot11BeaconPeriod $\times$ dot11MaxLostBeacons TUs. The PCP shall transmit at least one DMG Beacon frame through each possible antenna configuration in a full-coverage set of antenna configurations within the number of beacon intervals specified within the most recently updated TXSS Span field.

10.1.3 Maintaining synchronization

10.1.3.1 General

Change 10.1.3.1 as follows:

Each STA shall maintain a TSF timer with modulus 2^{64} counting in increments of microseconds. STAs expect to receive Beacon frames at a nominal rate. In a non-DMG infrastructure BSS, t~~T~~he interval between

Beacon frames is defined by the dot11BeaconPeriod parameter of the STA. In a DMG infrastructure BSS, the STAs expect to receive at least one DMG Beacon frame every dot11BeaconPeriod × dot11MaxLostBeacons TUs. In a PBSS, the DMG STAs expect to receive at least one DMG Beacon frame or one Announce frame every dot11BeaconPeriod × dot11MaxLostBeacons TUs.

A STA sending a Beacon frame shall set the value of the Beacon frame's timestamp so that it equals the value of the STA's TSF timer at the time that the data symbol containing the first bit of the timestamp is transmitted to the PHY plus the transmitting STA's delays through its local PHY from the MAC-PHY interface to its interface with the WM [e.g., antenna, light-emitting diode (LED) emission surface]. A STA sending a DMG Beacon or an Announce frame shall set the value of the frame's timestamp field to equal the value of the STA's TSF timer at the time that the transmission of the data symbol containing the first bit of the MPDU is started on the air (which can be derived from the PHY-TXPLCPEND.indication primitive), including any transmitting STA's delays through its local PHY from the MAC-PHY interface to its interface with the WM.

Change the title of 10.1.3.2 as follows:

10.1.3.2 Beacon generation in non-DMG infrastructure networks

Insert the following subclauses, 10.1.3.2a to 10.1.3.2b (including Figure 10-1a), after 10.1.3.2:

10.1.3.2a Beacon generation in a DMG infrastructure BSS and in a PBSS

10.1.3.2a.1 General

A DMG STA acting as a PCP/AP follows the DMG channel access procedures (see 9.33) and the rules described in this subclause to transmit DMG Beacon frames.

Each DMG Beacon frame transmitted by a PCP and by a DMG AP shall have the Discovery Mode field within the DMG Beacon set to 0.

The Duration field of each transmitted DMG Beacon frame shall be set to the time remaining until the end of the current BTI.

A PCP and a DMG AP establish a series of Target Beacon Transmission Times (TBTTs) spaced dot11BeaconPeriod TUs apart. The period between two TBTTs is referred to as the *beacon interval*. The beacon interval length shall be no more than aMaxBIDuration. Time value zero of the TSF is defined to be a TBTT with a DMG Beacon frame transmitted at the beginning of the beacon interval.

The length of the beacon interval is included in the DMG Beacon, Announce, and Probe Response frames, and the DMG STAs shall adopt that beacon interval when joining the BSS.

A PCP and a DMG AP that move the TBTT (10.30.2) or change the beacon interval duration (10.30.3) shall reestablish the TBTT by resetting the TSF to zero at the time the BSS parameter change takes effect in the BSS.

At each BTI, a PCP and a DMG AP schedule DMG Beacon frames for transmission according to the procedure specified in 9.35.4. Subject to this constraint, the PCP/AP may delay the DMG Beacon transmission if the medium is determined by the CCA mechanism to be busy. When delaying a DMG Beacon transmission, the PCP/AP shall check that the BTI, A-BFT, and ATI do not overlap in time with pseudo-static SPs for which the PCP/AP is not the source DMG STA and, if PCP/AP clustering is in use, that the DMG Beacon transmission follows the additional rules described in 9.34.

A PCP/AP may transmit DMG Beacon frames through different antenna configurations during the BTI, but shall not transmit more than one DMG Beacon frame through the same antenna configuration during the BTI of any beacon interval. For any beacon interval that does not include a DMG Beacon transmission in the BTI, the AP shall begin the beacon interval with an ATI, and the PCP begins the beacon interval with an ATI (10.2.5.3).

When the DMG Beacon transmission is performed as multiple directional transmissions, a PCP/AP should change the sequence of directions through which a DMG Beacon is transmitted after it has transmitted a DMG Beacon frame through each direction in the current sequence of directions. When the ECPAC Policy Enforced field is equal to 1 in the DMG Beacon frame most recently transmitted by a PCP/AP, then

— When the PCP/AP transmits a DMG Beacon frame as multiple directional transmissions, the PCP/AP shall change the sequence of directions through which a DMG Beacon frame is transmitted after it has transmitted a DMG Beacon frame through each direction in the current sequence of directions.
— When the PCP/AP transmits a DMG Beacon frame as a single transmission, the PCP/AP shall randomly delay the transmission of the DMG Beacon frame by up to min(4×TXTIME(DMG Beacon), 1024×dot11MinBHIDuration) µs after the TBTT.

This is done to randomize and potentially minimize interference to/from the DMG Beacon. One such example is indicated in Figure 10-1a. If the sequence of directions is changed, the sequence of directions shall be pseudorandomly chosen from a sequence of directions covering the full set of directions available to a PCP/AP.

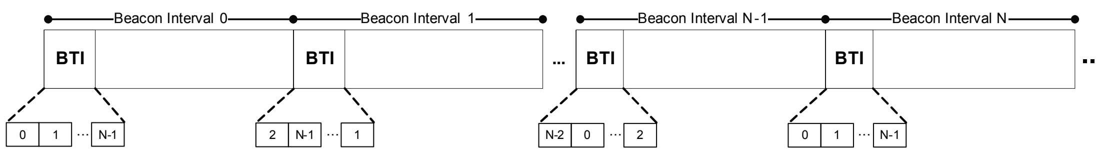


Figure 10-1a—Example of DMG Beacon transmission by PCP/AP during the BTI

NOTE—A PCP/AP operating in a DMG BSS can transmit Announce frames during the ATI (9.33.3). An Announce frame can perform the function of a DMG Beacon frame, can be transmitted as an individually addressed frame directed to a STA, and can provide a much more spectrally efficient access than using a DMG Beacon frame.

A DMG STA that is an AP or a PCP shall include a DMG Operation element within a transmitted DMG Beacon frame if the CBAP Only field within the DMG Beacon frame is equal to 1. A DMG STA that is an AP or a PCP shall include a DMG Operation element within a transmitted DMG Beacon frame if the CBAP Only field within the DMG Beacon frame is equal to 0 and the Extended Schedule element is included in the DMG Beacon frame. A DMG STA that is an AP or a PCP shall include a DMG Operation element within a transmitted Announce frame if the Extended Schedule element is included in the Announce frame.

10.1.3.2a.2 Beacon generation in a PBSS

At TBTTs that do not start with a BTI, the PCP shall begin a beacon interval with an ATI.

A PCP that transmits a DMG Beacon with the CBAP Only field equal to 1 within a BTI shall include a BTI in any following beacon intervals until the completion of the TXSS of which the DMG Beacon is a part.

10.1.3.2a.3 Beacon generation in a DMG infrastructure BSS

The DMG AP shall assert the dot11MaxLostBeacons attribute value equal to the aMinBTIPeriod parameter value.

10.1.3.2b DMG Beacon generation before network initialization

A DMG STA can transmit DMG Beacon frames before network initialization to discover and perform beamforming during the A-BFT with another DMG STA so that the following frame exchanges between these DMG STAs do not have to be done as a sector sweep (see 10.1.4.3.3).

A DMG STA that transmits DMG Beacon frames before network initialization shall set the Discovery Mode field in each transmitted DMG Beacon frame to 1 to indicates that the network initialization procedure defined in 10.1.4.4 has not been performed. In addition, the STA shall set the Next A-BFT field to 0.

Before network initialization, the spacing between TBTTs can change, and the time to the next TBTT is contained in each DMG Beacon transmitted at the last BTI. At each TBTT, the DMG STA should generate a random value for the Beacon Interval field within the DMG Beacon frame from a uniform distribution between [10 TUs, 200 TUs), i.e., 10 TUs inclusive through 200 TUs exclusive. All DMG Beacon frame transmissions within the same BTI shall have the same value for the Beacon Interval field.

The TSF shall be set to 0 at the first TBTT for which the Discovery Mode field within the DMG Beacon frame is equal to 1. After that, the TSF shall be set to 0 at the TBTT of the beacon interval in which the DMG STA changes the value of the Beacon Interval field.

The DMG STA shall transmit the first DMG Beacon frame of the next BTI at the time indicated by the start of the transmission of the first DMG Beacon frame within the last BTI and the value of the Beacon Interval field contained in the DMG Beacon frame transmitted within the last BTI, unless the medium is determined by the CCA mechanism to be busy in which case the DMG STA may delay the transmission of the first DMG Beacon transmission.

A DMG STA that transmits a DMG Beacon frame with the Discovery Mode field equal to 1 may indicate the STA(s) that is allowed to respond in the A-BFT following the BTI where the DMG Beacon frame is transmitted. To do that, in the DMG Beacon the DMG STA shall set the CC Present field to 1 and shall set the A-BFT Responder Address subfield to an individual address or to a group address of a group that includes the STA(s) that is allowed to respond in the A-BFT.

A DMG STA that is transmitting DMG Beacon frames with the Discovery Mode field equal to 1 should configure its receive antenna to a quasi-omni antenna pattern and stay in receiving state during portions of the DTI defined by the DMG Beacon transmissions. This enables the DMG STA to receive frames transmitted by any DMG STA that is covered by this antenna pattern.

A DMG STA that is transmitting DMG Beacon frames with the Discovery Mode field equal to 1 should cease transmitting these beacons when it has received a DMG Beacon frame from another STA, or when it has received acknowledgment of a transmitted Probe Response frame. If a BSS is not initialized as a result of the channel scanning, the DMG STA can resume transmitting DMG Beacon frames with the Discovery Mode field equal to 1.

The procedure of TBTT change described in the preceding paragraph is applicable for DMG Beacon generation before network initialization, whereas the procedures defined in 10.30.2 and 10.30.3 are used to change the DMG BSS parameters after the infrastructure BSS and PBSS are initialized.

The DMG STA shall set the Duration field of each transmitted DMG Beacon frame to the time remaining until the end of the current BTI.

10.1.3.3 Beacon generation in an IBSS

Change the first paragraph in 10.1.3.3 as follows:

Beacon generation in an IBSS is distributed. The beacon period is included in Beacon, Announce, and Probe Response frames, and STAs shall adopt that beacon period when joining the IBSS. All members of the IBSS participate in beacon generation. Each STA shall maintain its own TSF timer that is used for dot11BeaconPeriod timing. The beacon interval within an IBSS is established by the STA at which the MLME-START.request primitive is performed to create the IBSS. This defines a series of TBTTs exactly dot11BeaconPeriod TUs apart. Time zero is defined to be a TBTT. At each TBTT the STA shall

a) Suspend the decrementing of the backoff timer for any pending transmission that is not a ~~non-~~Beacon or DMG Beacon frame ~~transmission~~,

b) Calculate a random delay uniformly distributed in the range between zero and twice aCWmin × aSlotTime when the STA is a non-DMG STA, and between zero and the result of two multiplied by aCWminDMGIBSS multiplied by the duration of the STA's following BTI when the STA is a DMG STA,

c) Wait for the period of the random delay, decrementing the random delay timer using the same algorithm as for backoff,

d) Cancel the remaining random delay and the pending Beacon frame transmission or BTI (DMG only), if a Beacon frame arrives from the IBSS of which the STA is a member before the random delay timer has expired,

e) Send a Beacon frame in a non-DMG BSS or DMG Beacon frame(s) in a DMG BSS if the random delay has expired and no Beacon frame in a non-DMG BSS or no DMG Beacon frame in a DMG BSS has arrived from the IBSS of which the STA is a member during the delay period,

f) If the ATIM Window in use within the IBSS is greater than 0, then

1) Resume decrementing the backoff timer for any pending transmission allowed inside the ATIM window and

2) At the time of the ATIM Window duration, resume the backoff for any pending frames intended for transmission outside the ATIM Window,

g) If the ATIM Window in use within the IBSS is 0, then resume decrementing the backoff timer for any pending transmissions.

10.1.3.5 Beacon reception

Change the second and third paragraphs of 10.1.3.5 as follows:

STAs in an infrastructure network or PBSS shall use information that is not in the CF Parameter Set element in received Beacon frames or DMG Beacon frames or Announce frames only if the BSSID field is equal to the MAC address currently in use by the STA contained in the AP of the BSS or to the MAC address currently in use by the PCP of the PBSS. Non-AP or non-PCP STAs in an infrastructure or PBSS network, respectively, that support the Multiple BSSID capability shall use other information in received Beacon or DMG Beacon frames only if the BSSID field of a non-AP or non-PCP STA is equal to the MAC address currently in use by the STA contained in the AP or PCP, respectively, of the BSS corresponding to the transmitted BSSID or if the BSSID field of a non-AP or non-PCP STA is equal to one of the nontransmitted BSSIDs.

STAs in a~~n~~ non-DMG IBSS shall use information that is not in the CF Parameter Set element in any received Beacon frame for which the IBSS subfield of the Capability field is 1, the content of the SSID element is equal to the SSID of the IBSS, and the TSF value is later than the receiving STA's TSF timer. Use of this information is specified in 10.1.5.

Insert the following paragraphs at the end of 10.1.3.5:

DMG STAs in an IBSS shall use other information in any received DMG Beacon and Announce frames for which the BSS Type subfield is 1, the content of the SSID element is equal to the SSID of the IBSS, and the TSF value is later than the receiving STA's TSF timer. Use of this information is specified in 10.1.5.

A STA shall ignore the BSS Type field contained in a received DMG Beacon frame if the Discovery Mode field within the DMG Beacon is 1.

An active STA operating in a BSS shall be ready to receive a DMG Beacon or a frame from the PCP/AP for a period of time of at least dot11MinBHIDuration following the TBTT or expected ATI start time as specified in the last Next DMG ATI element (8.4.2.137) transmitted by the PCP/AP.

An active DMG STA that is receive beamforming trained with the PCP/AP shall direct its receive antenna pattern toward the PCP/AP or use a quasi-omni antenna pattern during this time.

A non-PCP STA that receives a DMG Beacon frame from a PCP in which the PCP Association Ready field is 0 shall not transmit an Association Request frame addressed to the PCP that transmitted the received DMG Beacon. A non-PCP STA that receives a DMG Beacon frame from a PCP with the PCP Association Ready field set to 1 may transmit an Association Request frame addressed to the PCP that transmitted the received DMG Beacon.

10.1.3.6 Multiple BSSID procedure

Change 10.1.3.6 as follows:

Implementation of the Multiple BSSID capability is optional for a WNM STA and for a DMG STA. A STA that implements the Multiple BSSID capability has dot11MgmtOptionMultiBSSIDImplemented set to true. When dot11MgmtOptionMultiBSSIDImplemented is true, dot11WirelessManagementImplemented shall be set true except for a DMG STA, in which case it may be set to false. A STA that has a value of true for dot11MgmtOptionMultiBSSIDActivated is defined as a STA that supports the Multiple BSSID capability. A STA for which dot11MgmtOptionMultiBSSIDActivated is true shall set the Multiple BSSID field of the Extended Capabilities element to 1.

The nontransmitted BSSID profile shall include the SSID element (see 8.4.2.2) and Multiple BSSID-Index element (see 8.4.2.76) for each of the supported BSSIDs. The PCP/AP may optionally include all other elements in the nontransmitted BSSID profile. The PCP/AP may include two or more Multiple BSSID elements containing elements for a given BSSID index in one Beacon frame or DMG Beacon frame. If two or more are given, the profile is considered to be the complete set of all elements given in all such Multiple BSSID elements sharing the same BSSID index. Since the Multiple BSSID element is also present in Probe Response frames, a~~n~~ PCP/AP may choose to advertise the complete or a partial profile of a BSS corresponding to a nontransmitted BSSID only in the Probe Response frames. In addition, the PCP/AP may choose to include only a partial list of nontransmitted BSSID profiles in the Beacon frame or DMG Beacon frame or to include different sets of nontransmitted BSSID profiles in different Beacon frames or DMG Beacon frames.

When a station receives a Beacon frame or DMG Beacon frame with a Multiple BSSID element that consists of a nontransmitted BSSID profile with only the mandatory elements, it may inherit the complete profile from a previously received Beacon frame, DMG Beacon frame, or Probe Response frame, or it may send a Probe Request frame to obtain the complete BSSID profiles. Each Beacon element not transmitted in a nontransmitted BSSID subelement is inherited from a previous Beacon, DMG Beacon, or Probe Response frame in which the element is present, except for the Quiet element, which shall take effect only in the Beacon frame or DMG Beacon frame that contains it and not carry forward as a part of the inheritance. A~~n~~ PCP/AP is not required to include all supported nontransmitted BSSID profiles in a Probe Response frame and may choose to include only a subset based on any criteria. When a nontransmitted BSSID profile is present in the Multiple BSSID element of the Probe Response frame, the PCP/AP shall include all elements that are specific to this BSS. If any of the optional elements is not present in a nontransmitted BSSID profile, the corresponding values are the element values of the transmitted BSSID.

A non-PCP/non-AP STA derives its nontransmitted BSSID value according to 8.4.2.48 and 8.4.2.76.

The Partial Virtual Bitmap field in the transmitted BSSID Beacon frame or DMG Beacon frame shall indicate the presence or absence of traffic to be delivered to all stations associated to a transmitted or nontransmitted BSSID. The first 2^n bits of the bitmap are reserved for the indication of group addressed frames for the transmitted and all nontransmitted BSSIDs. The AID space is shared by all BSSs, and the lowest AID value that shall be assigned to a station is 2^n (see 8.4.2.7).

Operation in a non-DMG BSS is subject to the following additional rules. If the contention-free period is supported and if the CFPCount of more than one BSS becomes 0 in the same Beacon frame, the AP shall concatenate the contention-free periods of all CFPs that coincide and shall not transmit a CF-End or CF-End+Ack until the end of the concatenated CFP, indicated with a single CF-End or CF-End+Ack, if required. The CF Parameter Set in the transmitted BSSID contains times that are an aggregate of CFP times of the nontransmitted BSSIDs.

Multiple BSSID rate selection is defined in 9.7.7.

10.1.3.7 TSF timer accuracy

Change of 10.1.3.7 as follows:

Upon receiving a Beacon or a DMG Beacon or an Announce frame with a valid FCS and BSSID or SSID, as described in 10.1.3.5, a STA shall update its TSF timer according to the following algorithm:

- Non-DMG STA: The received timestamp value shall be adjusted by adding an amount equal to the receiving STA's delay through its local PHY components plus the time since the first bit of the timestamp was received at the MAC/PHY interface.
- DMG STA: The received timestamp value shall be adjusted by adding an amount equal to the receiving STA's delay through its local PHY components plus the time since the last data symbol of the PLCP header, excluding any guard interval, was received as indicated by PHY_RXSTART.ind.

In the case of an infrastructure BSS or a PBSS, the STA's TSF timer shall then be set to the adjusted value of the timestamp. In the case of an IBSS, the STA's TSF timer shall be set to the adjusted value of the received timestamp, if the adjusted value of the timestamp is later than the value of the STA's TSF timer. The accuracy of the TSF timer shall be no worse than ± 0.01%.

When an STA is associated to a BSS with a nontransmitted BSSID, it shall use the TSF from the transmitted BSSID beacon frame.

10.1.4 Acquiring synchronization, scanning

10.1.4.1 General

Change the third paragraph of 10.1.4.1 as follows:

Upon receipt of the MLME-SCAN.request primitive, a STA shall perform scanning. The SSID parameter indicates the SSID for which to scan. The SSID List parameter indicates one or more SSIDs for which to scan. To become a member of a particular ESS using passive scanning, a STA shall scan for Beacon and DMG Beacon frames containing that ESS's SSID, returning all Beacon and DMG Beacon frames matching the desired SSID in the BSSDescriptionSet parameter of the corresponding MLME-SCAN.confirm primitive with the appropriate bits in the Capabilities Information field or DMG Capabilities field indicating whether the Beacon frame or the DMG Beacon frame came from an infrastructure BSS, PBSS, or IBSS. If the value of dot11RMMeasurementPilotActivated is greater than 1, the STA shall additionally scan for Measurement Pilot frames, returning in the BSSDescriptionFromMeasurementPilotSet parameter all Measurement Pilot frames that equal the requested BSSID of the corresponding MLME-SCAN.request primitive and are not already members of the BSSDescriptionSet. To actively scan, the STA shall transmit Probe request frames containing the desired SSID or one or more SSID List elements, but a DMG STA might also have to transmit DMG Beacon frames or perform beamforming training prior to the transmission of Probe Request frames. When the SSID List element is present in the Probe Request frame, one or more of the SSID elements may include a wildcard SSID (see 8.4.2.2). The exact procedure for determining the SSID or SSID List values in the MLME-SCAN.request primitive is not specified in this standard. When a STA scans for a BSS whose AP does not support the SSID List element, or for a BSS for which AP support of the SSID List element is unknown, the SSID element with an SSID or wildcard SSID shall be included in the MLME-SCAN.request primitive. Upon completion of scanning, an MLME-SCAN.confirm primitive is issued by the MLME indicating all of the BSS information received.

Insert the following paragraph after the third paragraph of 10.1.4.1 as follows:

In DMG BSSs, the Active Scan procedure (10.1.4.3) can be used for device discovery prior to initializing or joining a BSS.

Change the now sixth paragraph of 10.1.4.1 as follows:

Upon receipt of an MLME-SCAN.request primitive with the SSID parameter set to the wildcard SSID, the STA shall passively scan for any Beacon or DMG Beacon or Meassurement Pilot frames, or actively transmit Probe Request or DMG Beacon frames containing the wildcard SSID, as appropriate depending upon the value of ScanMode. Upon completion of scanning, an MLME-SCAN.confirm primitive is issued by the MLME indicating all of the BSS information received.

Change the now ninth paragraph of 10.1.4.1 as follows:

When a STA starts a BSS, that STA shall determine the BSSID of the BSS. If the BSSType indicates an infrastructure BSS, then the STA shall start an infrastructure BSS, and the BSSID shall be equal to the STA's dot11StationID. If the BSSType indicates a PBSS, then the STA shall start a PBSS. For both the infrastructure BSS and the PBSS, ~~T~~the value of the BSSID shall remain unchanged, even if the value of dot11StationID is changed after the completion of the MLME-START.request primitive. If the BSSType indicates an IBSS, the STA shall start an IBSS, and the BSSID shall be an individual locally administered IEEE MAC address as defined in 9.2 of IEEE Std 802-2001. The remaining 46 bits of that MAC address shall be a number selected in a manner that minimizes the probability of STAs generating the same number, even when those STAs are subjected to the same initial conditions. The value SSID parameter shall be used as the SSID of the new BSS. It is important that designers recognize the need for statistical independence among the random number streams among STAs.

10.1.4.2 Passive scanning

Change 10.1.4.2 as follows:

10.1.4.2.1 Passive scanning for non-DMG STAs

If the ScanType parameter indicates a passive scan, the STA shall listen to each channel scanned for no longer than a maximum duration defined by the MaxChannelTime parameter.

Insert the following subclause, 10.1.4.2.2, after 10.1.4.2.1:

10.1.4.2.2 Passive scanning for DMG STAs

Upon receipt of the MLME-SCAN.request primitive with the ScanType parameter set to Passive, a DMG STA shall passively scan for transmissions on each channel specified within the ChannelList parameter of the MLME-SCAN.request primitive. The channel traversal order during passive scanning is implementation specific.

That is, the DMG STA shall be in the receive state scanning for a period of time in a channel no less than MinChannelTime and return information on all DMG Beacon frames received matching a particular BSSID or SSID parameters specified in the MLME-SCAN.request primitive. If no DMG Beacon scan parameters are specified in the request, then the DMG STA shall return information on all received DMG Beacon frames.

If at any time during the scan the DMG STA detects a non-DMG Beacon frame, the DMG STA shall continue to scan the current channel until the scanning timer expires. After scanning one channel, the DMG STA shall initiate scanning in another channel if at least one channel within the ChannelList parameter has not yet been scanned.

When the DMG STA has completed scanning all indicated channels, it returns the scan results via the MLME-SCAN.confirm primitive.

10.1.4.3 Active scanning

10.1.4.3.2 Sending a probe response

Change the third and fourth paragraphs of 10.1.4.3.2 as follows:

Only DMG STAs that are not members of a PBSS but that have transmitted at least one DMG Beacon frame with the Discovery Mode field set to 1, multi-band capable non-AP STAs for which the last received probe request included a Multi-band element, APs, PCPs, and STAs in an IBSS or in an MBSS respond to probe requests. A result of the procedures defined in this subclause is that in each infrastructure BSS, except in DMG BSSs, and IBSS, there is at least one STA that is awake at any given time to receive and respond to probe requests. In an MBSS, STAs might not be awake at any given time to respond to probe requests. In an infrastructure BSS or in an IBSS, a STA that sent a Beacon frame shall remain in the Awake state and shall respond to probe requests, subject to criteria in the next paragraph, until a Beacon frame with the current BSSID is received. If the STA is contained within an AP, it shall remain in the Awake state and always respond to probe requests, subject to criteria in the next paragraph. There may be more than one STA in an IBSS that responds to any given probe request, particularly in cases where more than one STA transmitted a Beacon/DMG Beacon frame following the most recent TBTT, either due to not receiving successfully a previous Beacon/DMG Beacon frame or due to collisions between beacon transmissions.

In an infrastructure BSS or in an IBSS, STAs receiving Probe Request frames shall respond with a probe response when the SSID in the probe request is the wildcard SSID or matches the specific SSID of the STA or when the specific SSID of the STA is included in the SSID List element. Furthermore, a STA with dot11RadioMeasurementActivated true receiving a probe request with a DSSS Parameter Set element containing a Current Channel field value that is not the same as the value of dot11CurrentChannel shall not respond with a probe response. A DMG STA that is not member of a PBSS but that has transmitted at least one DMG Beacon with the Discovery Mode field set to 1, ~~A~~an AP, and a PCP shall respond to all probe requests meeting the above criteria. In an IBSS, a STA that transmitted a Beacon or DMG Beacon frame since the last TBTT shall respond to group addressed Probe Request frames. A STA in an IBSS shall respond to Probe Request frames sent to the individual address of the STA.

10.1.4.3.3 Active scanning procedure

Change the second and third paragraphs in 10.1.4.3.3 as follows:

For each channel to be scanned:

a) Wait until the ProbeDelay time has expired or a PHYRxStart.indication primitive has been received.

b) Perform the Basic Access procedure as defined in 9.3.4.2 if the STA is a non-DMG STA.

c) If the STA is a DMG STA:

  1) Start generation of DMG Beacon frames according to the rules described in 10.1.3.2b if the STA intends to transmit DMG Beacon frames with the Discovery Mode field set to 1.

  2) Otherwise, proceed to step (e).

d) If a DMG Beacon frame is received, perform the beamforming training defined in 9.35.5.

e) If the STA is a DMG STA, perform the basic access procedure defined in 9.3.4.2.

f) ~~c)~~ Send a probe request to the broadcast destination address or, in the case of a DMG STA only, (i) following the transmission of an SSW-Feedback frame, send a probe request to the MAC address of the DMG STA addressed by the SSW-Feedback frame or (ii) optionally, following the reception of an SSW-Feedback frame, send a probe request to the MAC address of the DMG STA that transmitted the SSW-Feedback frame. In all these cases, the probe request is sent with the SSID and BSSID from the MLME-SCAN.request primitive. When transmitted by a DMG STA, the probe request includes the DMG Capabilities element. When the SSID List is present in the MLME-SCAN.request primitive, send one or more probe request~~ frames~~s, each with an SSID indicated in the SSID List and the BSSID from the MLME-SCAN.request primitive.

g) ~~d)~~ Set to 0 and start a ProbeTimer.

h) ~~e)~~ If PHY-CCA.indication (busy) has not been detected before the ProbeTimer reaches MinChannelTime, then

  1) If the STA is a non-DMG STA, set the NAV to 0 and scan the next channel~~,~~.

  2) Otherwise, ~~else~~ when ProbeTimer reaches MaxChannelTime, process all received probe responses.

i) ~~f)~~ Set the NAV to 0 and scan the next channel.

See Figure 10-3 for non-DMG STAs.

Insert the following paragraph (including Figure 10-3a) after Figure 10-3:

See Figure 10-3a for DMG STAs that generate DMG Beacon frames with the Discovery Mode field set to 1.

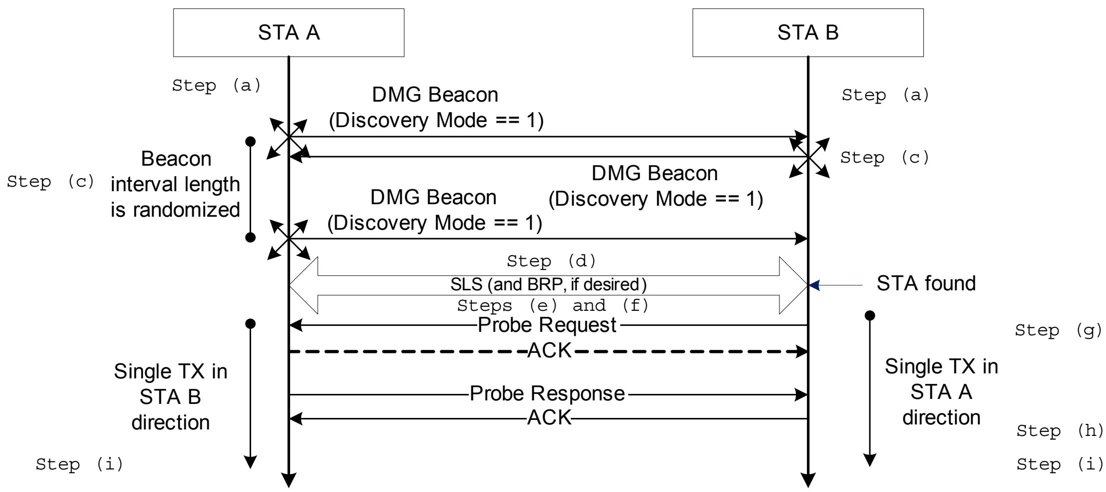


Figure 10-3a—Active scanning for DMG STAs

Insert the following subclause, 10.1.4.3.4 (including Figure 10-3b), after 10.1.4.3.3:

10.1.4.3.4 PCP selection in a PBSS

The PCP selection procedure is performed by the SME in the following cases:

- At the reception of an MLME-SCAN.confirm primitive that was received in response to an MLME-SCAN.request primitive with the value of the ScanType parameter equal to ACTIVE and BSSType parameter equal to PERSONAL
- As part of a PCP handover (see 10.28.2).

The decision whether the STA performs in the role of PCP is done by comparing the value of the STA's PCP Factor (self_PCP_factor) and the PCP Factor of the peer STA (peer_PCP_factor) that is indicated in the peer STA's DMG Capabilities element.

The PCP Factor of a STA is constructed by concatenating the value of select fields present in the STA's DMG Capabilities element defined in 8.4.2.130. The PCP Factor is defined in Figure 10-3b.

NOTE—According to the convention, the least significant bit is the leftmost bit (B0).

	B0 B6	B7 B14	B15 B21	B22	B23	B24	B25	B26 B31
	Reserved (set to 0)	MAX Associated STA Number	Total Number of Sectors	Pseudo-Static Allocations	TDDTI	Decentralized PCP/AP Clustering	Power Source	Reserved (set to 0)
Bits:	7	8	7	1	1	1	1	6

Figure 10-3b—PCP Factor for a DMG STA

For each peer STA reported as part of an MLME-SCAN.confirm primitive or considered as part of a PCP handover, the STA proceeds as follows. If the STA's value of self_PCP_factor is greater than the value of peer_PCP_factor or if the values are equal and the MAC address of the STA is greater than the MAC address of the peer STA contained in the peer STA's DMG Capabilities element, the STA becomes a candidate PCP. Otherwise, the STA does not become a candidate PCP. For the purpose of this MAC address comparison, the first transmitted octet shall be interpreted as the most significant octet (i.e., big endian).

The rules the SME of a candidate PCP follows to initialize a PBSS are described in 10.1.4.4.2.

10.1.4.4 Initializing a BSS

Change 10.1.4.4 as follows:

10.1.4.4.1 General

Upon receipt of an MLME-START.request primitive, a STA shall determine the BSS's BSSID (as described in 10.1.4), select channel synchronization information, select a beacon period, select the operational rate set, initialize and start its TSF timer, and begin transmitting Beacon frames if the STA is a non-DMG STA or DMG Beacon frames if the STA is a DMG STA.

A STA shall include a Country element in the transmission of Beacon frames and DMG Beacon frames if dot11MultiDomainCapabilityActivated, dot11SpectrumManagementRequired, or dot11RadioMeasurementActivated is true. See 8.3.3.2 for the description of a properly formed Beacon frame, and see 8.3.4.1 for the description of a properly formed DMG Beacon frame.

Insert the following subclause, 10.1.4.4.2, after 10.1.4.4.1:

10.1.4.4.2 Initializing a DMG BSS

Prior to choosing a suitable operating channel and starting a BSS, the SME of a DMG STA should perform a channel scan to ascertain the quality of each channel that the STA supports. The rules for choosing a suitable operating channel are implementation specific and might be subject to regulatory requirements.

Upon receipt of an MLME-START.request primitive from the SME, the MAC entity of the DMG STA shall try to start a BSS. The DMG STA may listen for a duration of aMinChannelTime, the listening duration, in the channel specified by the SME in the request. If the DMG STA determines the channel is suitable for BSS operation at the end of this listening duration, the DMG STA initializes the BSS by commencing transmission of DMG Beacon frames according to 10.1.3.2a in the case of a PBSS or an infrastructure BSS and according to 10.1.3.3 in the case of an IBSS. If PCP/AP clustering is in use on the selected channel, the DMG Beacon transmission by a PCP/AP commences following the additional rules described in 9.34.

If the DMG STA determines that no channels are suitable or available, it responds with an MLME-START.confirm primitive with a ResultCode of NOT_SUPPORTED. Otherwise, the MLME shall respond with an MLME-START.confirm primitive with a ResultCode of SUCCESS.

The SME should issue an MLME-START.request primitive with BSSType parameter equal to PERSONAL for at least one network in which the STA becomes a candidate PCP as defined in 10.1.4.3.4. If the STA becomes a candidate PCP of more than one network, the SME may issue an MLME-START.request primitive with BSSType parameter equal to PERSONAL for any of the remaining networks. In either case, the MLME-START.request primitive should be issued no later than 4×aMaxBIDuration since the reception of an MLME-SCAN.confirm primitive.

The SME should not issue an MLME-START.request primitive with BSSType parameter equal to PERSONAL for networks in which the STA does not become a candidate PCP as defined in 10.1.4.3.4. If the SME issues the MLME-START.request primitive under this circumstance, it shall not be issued if less than 4×aMaxBIDuration has elapsed since the reception of the MLME-SCAN.confirm primitive.

10.1.4.5 Synchronizing with a BSS

Insert the following paragraph at the end of 10.1.4.5:

A DMG STA shall be capable of transmitting DMG Beacon frames. A DMG STA shall adopt the operational parameters transmitted by its PCP/AP within the DMG Operation Information field of the DMG Operation element. A DMG STA shall update the value of its local MIB variables with the corresponding field value transmitted by its PCP/AP within the DMG BSS Parameter Configuration field of the DMG Operation element (8.4.2.131). Except for the predicate "dot11" used in the MIB variable naming convention, the name of the field is the same as the name of the corresponding MIB variable.

10.1.5 Adjusting STA timers

Change 10.1.5 as follows:

In an infrastructure BSS or PBSS, STAs shall adopt the TSF timer value in a Beacon,~~ frame or~~ P~~p~~robe R~~r~~esponse, DMG Beacon, or Announce frame coming from the PCP/AP in their BSS by using the algorithm in 10.1.3.7.

In response to an MLME-JOIN.request primitive, a STA joining an IBSS shall initialize its TSF timer to 0 and shall not transmit a Beacon,~~ frame or~~ P~~p~~robe R~~r~~esponse, or DMG Beacon frame until it hears a Beacon, ~~frame or~~ P~~p~~robe R~~r~~esponse, or DMG Beacon frame from a member of the IBSS with a matching SSID. Consequently, the STA joining an IBSS adopts the timer from the next Beacon,~~ frame or~~ P~~p~~robe R~~r~~esponse, or DMG Beacon frame from its IBSS.

All Beacon, DMG Beacon, Announce, and Probe Response frames carry a Timestamp field. A STA receiving such a frame from another STA in an IBSS with the same SSID shall compare the Timestamp field with its own TSF time. If the Timestamp field of the received frame is later than its own TSF timer, the non-DMG STA in the IBSS shall adopt each parameter contained in the Beacon frame according to the rule for that parameter found in the "IBSS adoption" column of the matching row of the BSSDescription table found in 6.3.3.3.2. A DMG STA in an IBSS shall adopt each parameter contained in the DMG Beacon or Announce frames. Parameters adopted by a STA due to the receipt of a later timestamp shall not be changed by the STA except when adopting parameters due to a subsequently received Beacon, DMG Beacon, or Announce frame with a later timestamp.

10.1.7 Terminating a network

Change 10.1.7 as follows:

An infrastructure BSS or a PBSS may be terminated at any time. A STA may cease support for an IBSS that it formed at any time. Upon receipt of an MLME-STOP.request primitive, a STA shall stop transmitting Beacon, DMG Beacon, Announce, and Probe Response frames and deauthenticate all associated STAs.

10.2 Power management

Change the title of 10.2.1 as follows:

10.2.1 Power management in a~~n~~ non-DMG infrastructure network

10.2.1.2 STA Power Management modes

Insert the following paragraph at the end of 10.2.1.2:

To change Power Management mode, a STA that is coordinated by an MM-SME shall inform the AP through a successful frame exchange initiated by the STA. The Power Management bit in the Frame Control field of the frame sent by the STA in this exchange indicates the Power Management mode that the STAs coordinated by the MM-SME and advertised in the MMS element sent by the STA shall adopt upon successful completion of the entire frame exchange. To change the Power Management mode of the coordinated STA, the frame may be sent using any of the MMSLs within the MMSL cluster established with the AP.

10.2.4 SM power save

Insert the following subclauses, 10.2.5 to 10.2.5.3 (including Figure 10-1a to Figure 10-1c, Table 10-1a, and Table 10-1b), after 10.2.4:

10.2.5 Power management in a PBSS and DMG infrastructure BSS

10.2.5.1 General

To enable non-PCP/non-AP STAs and PCPs to sleep for one or more beacon intervals or part of a beacon interval, a non-PCP/non-AP STA power save mechanism and a PCP power save mechanism are defined in this subclause.

Non-PCP/non-AP STA power save mode, as described in 10.2.5.2, allows a non-PCP/non-AP STA to sleep at intervals negotiated with the PCP/AP. Each non-PCP/non-AP STA can choose an independent wakeup schedule that fits its own power consumption and traffic delivery requirements.

PCP Power Save (PPS) mode, as described in 10.2.5.3, allows a PCP to sleep at intervals to minimize the energy consumption. The PCP operating in PPS mode can choose an independent wakeup schedule to sleep for one or more consecutive beacon intervals and does not transmit DMG Beacons during this time.

The Wakeup Schedule element is used to schedule the wakeup and sleeping of STAs. The Wakeup Schedule element defines two types of beacon intervals:

- Doze BI: a beacon interval that is explicitly defined as a Doze BI in the last, if any, Wakeup Schedule element successfully negotiated with the PCP/AP in the case of non-PCP/non-AP power save mode or transmitted by the PCP in the case of PCP power save mode.
- Awake BI: a beacon interval that is not defined as a Doze BI.

A STA may operate in one of two power states:

- Awake: STA is fully powered.
- Doze: STA is not able to transmit or receive and consumes very low power.

The manner in which a STA transitions between these two power states shall be determined by the STA's Power Management mode:

- Active mode: A STA is in the Awake state, except that the STA can switch to Doze state in an Awake BI when the STA is allowed to doze as indicated in Table 10-1a.
- Power Save (PS) mode: A STA alternates between the Awake and the Doze states, as determined by the rules defined in this subclause.

A PCP/AP keeps track of the wakeup schedules of all associated non-PCP/non-AP STAs. Each STA delivers traffic to a peer STA only when the peer STA is in Awake state.

An AP shall buffer MPDUs addressed to non-AP STAs in Doze state. The buffered data shall be transmitted only at designated times (10.2.5.2). A non-AP STA shall defer delivering of MPDUs addressed to other non-AP STA in Doze state. The MPDUs shall be transmitted only at designated times (10.2.5.2).

If a PCP sets the BSS Type field within a transmitted DMG Beacon frame to PBSS or the PCP/AP includes a Nontransmitted BSSID Capability element in a transmitted DMG Beacon, Announce, or Probe Response frames and the BSS Type field within the Nontransmitted BSSID Capability element is equal to PBSS, then the PCP/AP shall follow the PCP power management rules described in 10.2.5.3 if the PCP/AP chooses to employ power management.

A PCP/AP may include an Antenna Sector ID Pattern element in Power Save Configuration Response and Probe Response frames transmitted to a non-PCP/non-AP STA. If a non-PCP/non-AP STA uses the information contained in the Antenna Sector ID Pattern element received from its PCP/AP, then during the BTI of an Awake BI, the STA might stay awake just to receive DMG Beacon frames transmitted through specific DMG antenna and sector and switch to Doze state during other periods in the BTI.

Table 10-1a lists the power states for a non-PCP/non-AP STA in PS mode and a PCP in PS mode during an Awake BI. Each entry indicates the state, either Awake or Doze, for the non-PCP/non-AP STA or the PCP in PS mode at various times during the Awake BI.

Table 10-1a—Power management states for an Awake BI

Portion of the beacon interval		PPS PCP	PS non-PCP/ non-AP STA
BTI	BTI	Awake	Awake or Doze
A-BFT	A-BFT	Awake	Awake or Doze
ATI	ATI	Awake	Awake
DTI	CBAP marked as PCP available in the schedule	Awake	Awake or Doze
	CBAP marked as PCP unavailable in the schedule	Doze	Awake or Doze
	SP with broadcast AID as Destination AID	Awake	Awake
	Nontruncatable or nonextensible SP with non-PCP STA as Source AID or Destination AID	Awake or Doze	Awake or Doze
	Truncatable SP or extensible SP with non-PCP/non-AP STA (excluding the PS STA) as Source AID or Destination AID	Awake	Awake or Doze
	SPs allocated to itself	Awake or Doze	Awake or Doze
	All other SPs	Awake or Doze	Awake or Doze

Table 10-1b lists the power states for a non-PCP/non-AP STA in PS mode and a PCP in PS mode during a Doze BI. Each entry indicates the state, either Awake or Doze, for the non-PCP/non-AP STA or the PCP in PS mode at various times during the Doze BI.

Table 10-1b—Power management states for a Doze BI

Portion of the beacon interval		PPS PCP	PS non-PCP/ non-AP STA
BTI	BTI	N/A	Awake or Doze
A-BFT	A-BFT	N/A	Awake or Doze
ATI	ATI	Awake	Awake
DTI	CBAP marked as PCP available in the schedule	Awake	Doze
	CBAP marked as PCP unavailable in the schedule	Doze	Doze
	SP with broadcast AID as Destination AID	Doze	Doze
	SP with individually addressed destination AID	Doze	Awake
	Nontruncatable or nonextensible SP with non-PCP STA as Source AID or Destination AID	Doze	Doze
	Truncatable SP or extensible SP with non-PCP/non-AP STA (excluding the PS STA) as Source AID or Destination AID	Doze	Doze
	SPs allocated to itself	Doze	Doze
	All other SPs	Doze	Doze

The source DMG STA and the destination DMG STA of a nontruncatable SP or allocated CBAP with individually addressed destination AID may go to Doze state within the SP or within the CBAP, respectively, after the source DMG STA transmitted a frame to the destination DMG STA of the SP or the CBAP, respectively, with the EOSP field set to 1 and successfully received the following response frame from the destination DMG STA of the SP or the CBAP, respectively.

If the MM-SME Power Mode field within the MMS element sent by an MM-SME coordinated STA is 1, all STAs advertised in the MMS element shall switch to the Doze state when the wakeup schedule of any one STA or a successful frame exchange as described in Annex G brings the STA to the Doze state.

If the MM-SME Power Mode field within the MMS element sent by an MM-SME coordinated STA is 0, all STAs advertised in the MMS element shall switch to the Awake state when the wakeup schedule of any one STA or a successful frame exchange as described in Annex G brings the STA to the Awake state.

10.2.5.2 Non-PCP/non-AP STA power management mode

10.2.5.2.1 General

The power management mode of a non-PCP/non-AP STA is selected by the PowerManagementMode parameter of the MLME-POWERMGT.request primitive. Once the STA updates its Power Management mode, the MLME shall issue an MLME-POWERMGT.confirm primitive indicating the result of the operation. A STA that acknowledges the reception of a PSC-RSP frame with Status Code indicating success shall update the STA’s power management mode at the instant indicated by the value of the BI Start Time field of the corresponding Wakeup Schedule element.

Figure 10-5a illustrates a finite state machine that shows the state transition of a STA in active and PS mode, and also the transition between active and Power Save Mode when the non-PCP/non-AP STA has set up a wakeup schedule.

NOTE—In Figure 10-5a, the notations PSC-REQ(X) and PSC-RSP(Y) indicate that the PSC-REQ and PSC-RSP frames, respectively, are transmitted with the setting as indicated by their corresponding X and Y parameters.

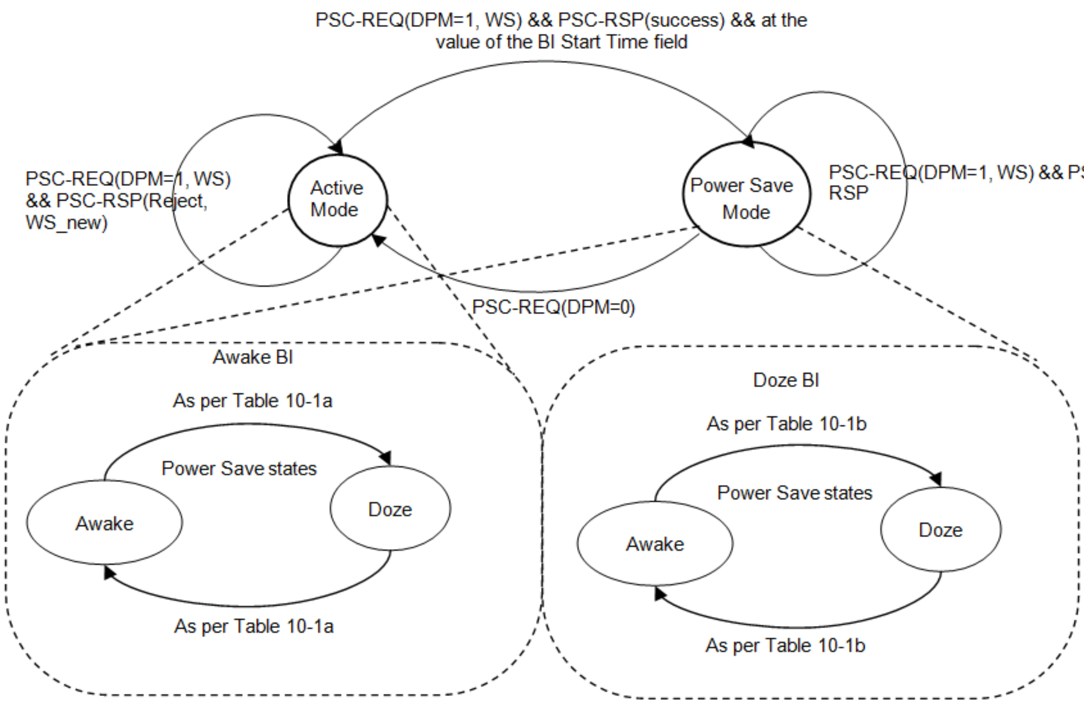


Figure 10-5a—State transition diagram of non-PCP/non-AP STA in Active and Power Save Mode

10.2.5.2.2 Power management mode operation of a non-PCP/non-AP STA with no wakeup schedule

A non-PCP/non-AP STA that has not set up a wakeup schedule with the PCP/AP is in Active mode and every beacon interval is an Awake BI. The non-PCP/non-AP STA shall enter PS mode only after a successful frame exchange as described in Annex G, initiated by the non-PCP/non-AP STA and that includes an acknowledgment from the PCP/AP. The Power Management field set to 1 in the Frame Control field of the frame sent by the STA is used to indicate such a transition.

When a non-PCP/non-AP STA that has not set up a wakeup schedule with the PCP/AP enters PS mode, every beacon interval shall be an Awake BI for that STA. A non-PCP/non-AP STA that has not set up a wakeup schedule with the PCP/AP and that is in PS mode shall be awake during any allocated SP for which the STA is either the source DMG STA or destination DMG STA during an Awake BI. During an Awake BI, a non-PCP/non-AP STA that has not set up a wakeup schedule with the PCP/AP and that is in PS mode shall be awake during any allocated CBAP for which the STA is the source DMG STA or destination DMG STA, or the source AID of the CBAP is equal to the broadcast AID or the destination AID of the CBAP is equal to the broadcast AID.

10.2.5.2.3 Power management mode operation of a non-PCP/non-AP STA with a wakeup schedule

To transition from Active mode to PS mode, a non-PCP/non-AP STA that is associated with a PCP/AP shall establish a wakeup schedule with the PCP/AP. A wakeup schedule (WS) is established with the PCP/AP following the successful transmission of a PSC-REQ frame to the PCP/AP with the DPM field set to 1 and an acknowledged receipt of the corresponding PSC-RSP from the PCP/AP provided that the PSC-RSP contained a status code indicating success. After receiving a PSC-RSP frame from the PCP/AP with a status code indicating success and responding with an acknowledgment, the STA switches to the PS mode at the instant specified by the BI Start Time field of the Wakeup Schedule element transmitted to the PCP/AP and follows the WS established with the PCP/AP.

If a non-PCP/non-AP STA has not established a pseudo-static SP with the PCP/AP, a WS element shall be included in any PSC-REQ frame that the STA transmits to the PCP/AP as an explicit request for a wakeup schedule. If the PCP/AP accepts the proposed WS, it shall reply with a PSC-RSP frame indicating a status code of SUCCESS. Otherwise, it shall respond with a PSC-RSP frame with a nonzero status code indicating the reason for rejecting the request. The PCP/AP may suggest an alternative schedule in the PSC-RSP frame and set the status code to REJECT_WITH_SCHEDULE. If the STA accepts the alternative schedule, it shall include this WS in a subsequently transmitted PSC-REQ frame. If the non-PCP/non-AP STA does not accept the alternative schedule, it shall not send a PSC-REQ frame for dot11PSRequestSuspensionInterval beacon intervals following the receipt of the PSC-RSP frame.

NOTE—Providing recommended schedules enables the PCP/AP to align sleep intervals from different non-PCP/non-AP STAs.

If a non-PCP/non-AP STA has established a pseudo-static SP schedule with the PCP/AP, it may omit the WS in the PSC-REQ frames that it sends to the PCP/AP. In this case, all outstanding pseudo-static SPs for the non-PCP/non-AP STA become an implicit WS request. When no WS element is specified in a PSC-REQ, the PCP/AP shall reply with a PSC-RSP frame indicating a status code of SUCCESS and shall adopt all outstanding pseudo-static service period schedules (9.33.6.4) as the wakeup schedule for that STA.

If a non-PCP/non-AP STA has explicitly established a WS with the PCP/AP and the non-PCP/non-AP STA is in PS mode, the non-PCP/non-AP STA shall have *m* successive Awake BIs repeating every *n* beacon interval, where *n* is the value of the Sleep Cycle field of the WS element contained in the PSC-RSP frame received from the PCP/AP during the frame exchange that established the WS, and *m* is the value of the Number of Awake/Doze BIs field in that PSC-RSP frame. The non-PCP/non-AP STA shall be awake during allocated SPs in which it is either the source or destination DMG STA during each Awake BI.

If a non-PCP/non-AP STA has implicitly established a WS with the PCP/AP and the non-PCP/non-AP STA is in PS mode, every beacon interval that includes an SP for which the non-PCP/non-AP STA is either the source or the destination shall be an Awake BI for the non-PCP/non-AP STA. The non-PCP/non-AP STA shall be awake during the Awake Window within the CBAPs and during allocated SPs in which it is either the source or destination DMG STA during each of its Awake BIs.

The WS established by a non-PCP/non-AP STA might contain one part that is explicitly negotiated with the PCP/AP and another part that is inferred from the non-PCP/non-AP STA's pseudo-static SPs. The portion of the WS that is explicitly negotiated between the non-PCP/non-AP STA and the PCP/AP remains valid until the non-PCP/non-AP STA updates or deletes the explicit portion of the WS through a successful PSC-REQ/PSC-RSP exchange or until the non-PCP/non-AP STA's association with the PCP/AP times out. The portion of the WS that is inferred from the non-PCP/non-AP STA's pseudo-static SPs changes with the changing allocation of the non-PCP/non-AP STA's pseudo-static SPs and is deleted when the association with the PCP/AP times out or when an explicit deletion request for the SP is successful.

A PCP/AP may send an unsolicited PSC-RSP frame without a WS and indicating a status code of success to a non-PCP/non-AP STA in PS mode. Upon receiving the unsolicited PSC-RSP frame meeting these conditions, the non-PCP/non-AP STA shall switch to Active mode.

10.2.5.2.4 Power management mode operation of a non-PCP/non-AP STA with or without a wakeup schedule

A non-PCP/non-AP STA in PS mode shall stay awake for dot11MinBHIDuration starting from the beginning of each Awake BI and may switch to the Doze state after the expiration of this time. The only exception is when the Power Save Configuration Response or Probe Response frame received from the PCP/AP includes an Antenna Sector ID Pattern element, in which case the non-PCP/non-AP STA may use the Antenna Sector ID Pattern element to receive DMG Beacon frames transmitted through a specific DMG antenna and sector, and may switch to Doze state during other periods in the BTI.

A PCP/AP shall transmit SP allocation announcements for STAs in PS mode during each of the STAs' Awake BIs and may transmit those SP allocation announcements in other beacon intervals. New SPs shall be allocated to begin either within or after the later Awake BI of the source DMG STA and destination DMG STA of the SP.

To transition from PS mode to Active mode, a non-PCP/non-AP STA that has an established WS with the PCP/AP shall send a PSC-REQ frame with the DPM field set to 0 to the PCP/AP and enter Active mode following the reception of the ACK response. The PCP/AP shall not send a PSC-RSP frame if the DPM field is 0 in the PSC-REQ frame.

In order for a STA to learn the WS of another STA within the BSS, the STA may send an Information Request frame to the other STA or to the PCP/AP as defined in 10.29.1.

If the Information Request frame is transmitted to the PCP/AP and the STA indicated in the Information Request's Subject Address field does not have an established WS with the PCP/AP, the PCP/AP shall set the length of the Wakeup Schedule element to 0 in the Information Response frame. Every time the STA indicated in the Information Request's Subject Address field changes its WS with the PCP/AP, the PCP/AP shall inform the STA that requested the information by transmitting an unsolicited Information Response frame with the updated Wakeup Schedule element.

There might be one or more CBAPs in a beacon interval. An Awake window is present within the first CBAP of a beacon interval if the Awake Window field in the Awake Window element (8.4.2.139) has a value that is nonzero. The Awake window starts from the beginning of the first CBAP and has a duration that is defined by the value of the Awake Window field in the Awake Window element. During the Awake window, a STA shall transmit only ATIM frames. A DMG STA in PS mode shall be in the Awake state during each Awake window that lies within each Awake BI for that STA.

Group addressed MSDUs, individually addressed MSDUs and MMPDUs that are to be transmitted to a STA that is in PS mode are first announced through ATIM frames during the Awake window. A STA in PS mode that is awake during an Awake window shall listen for these announcements to determine if it needs to remain in the Awake state. If during the Awake window the STA does not receive or transmit an ATIM frame with BSSID equal to the BSSID of the BSS the STA is a member, then it may enter the Doze state at the end of the Awake window. If a STA receives an ATIM frame during the Awake Window, it shall acknowledge the ATIM frame. Any two STAs that successfully complete an ATIM frame exchange with each other during the Awake Window become peer STAs. If a STA receives or transmits an ATIM frame during the Awake Window, it shall be awake during the CBAP(s) within the current beacon interval that have the source AID or destination AID described by the ATIM frame to wait for the announced MSDU(s) and/or MMPDU(s) to be received and/or to transmit announced MSDU(s) and/or MMPDU(s). A STA that receives or transmits an ATIM frame during the Awake Window may enter the Doze state when it has successfully transmitted to and received from all corresponding peer STAs for this beacon interval a QoS data frame with the EOSP subfield set to 1. ATIM frame transmissions and MSDU transmissions follow the rules defined in 10.2.2.5.

The ATIM frame transmission result and EOSP notification result between a MAC address pair can be used for other MAC pairs that are members of the same MMSL cluster.

10.2.5.3 PCP Power management mode

A PCP in PPS mode (PPS PCP) may enter the Doze state for one or more consecutive beacon intervals in order to minimize its energy consumption. Figure 10-5b illustrates a finite state machine that shows the state transition of the PCP power management mode.

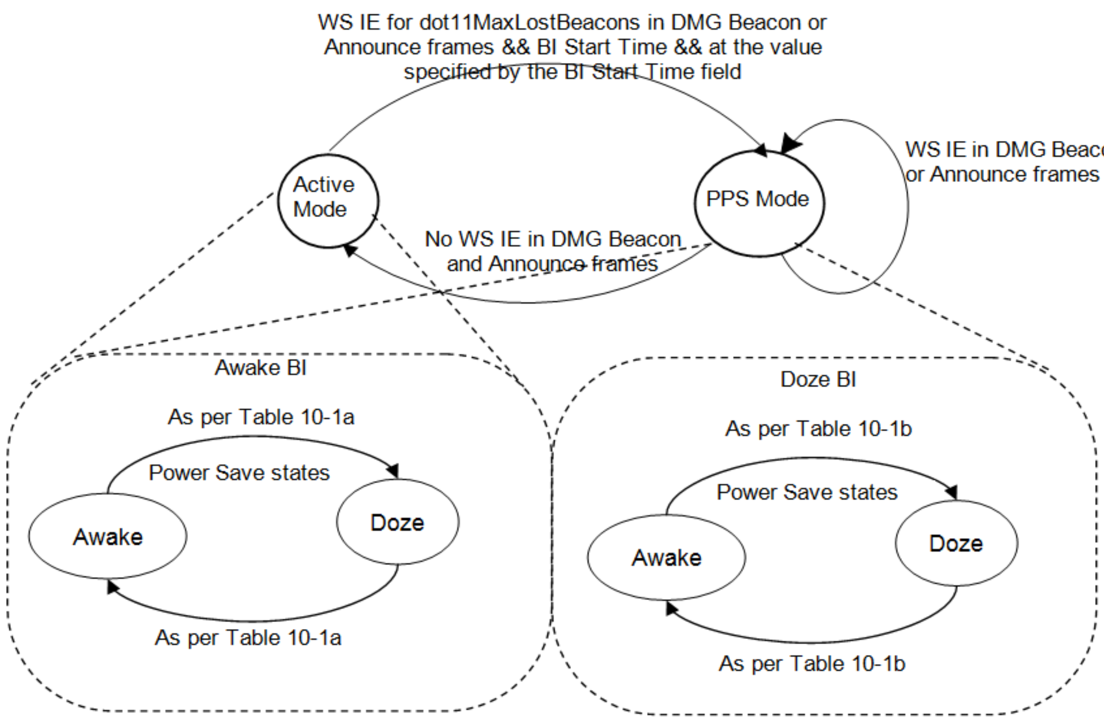


Figure 10-5b—State Transition Diagram of PCP Power Management Mode

To enter PS mode, the PCP shall announce the start of the first PCP Doze BI and the length of the PCP sleep interval through the Wakeup Schedule element (8.4.2.133) and include this element within DMG Beacon or Announce frames. The Wakeup Schedule element shall be transmitted at least dot11MaxLostBeacons times before the PCP goes into PS mode. The PCP enters PS mode at the instant specified by the value of the BI Start Time field of the corresponding Wakeup Schedule element. In order to transition from PS mode to active mode, the PCP shall stop including Wakeup Schedule elements in DMG Beacon and Announce frames.

In a PCP Doze BI, the PCP shall transmit an Announce frame during the ATI to each associated STA.

The PCP may include in the Extended Schedule element the schedule for the beacon intervals during the PCP Doze BIs. The PCP may schedule a SP or CBAP within a Doze BI by setting the Allocation Start field of the new SP or CBAP in the Extended Schedule element to a value within a Doze BI. If the Extended Schedule element is transmitted, the PCP shall transmit it at least dot11MaxLostBeacons times before the PPS PCP enters the Doze state.

The PCP shall check that the schedule of pseudo-static allocations transmitted in the last Extended Schedule element before the PCP entered PS mode is valid during the PCP Doze BIs. Thus, a STA participating in such a pseudo-static allocation assumes that the allocation is present during the following consecutive PCP Doze BIs.

The PCP may enter and remain in the Doze state for any portion of an SP if it is not a source or a destination of the SP. The PCP shall remain in the Awake state for any portion of a truncatable or extendable SP (8.4.2.134). The availability of the PCP during a CBAP in the Awake BI shall be announced by setting the PCP Active subfield within the Allocation Control field to one for a CBAP allocation made through the Extended Schedule element.

Figure 10-5c shows an example of the basic operation of a PCP in PPS mode when the PCP sleep interval equals one beacon interval (i.e., PCP sleeps every other beacon interval) and the PCP sleep interval starts right after the first beacon interval. In this example, the first beacon interval and the second beacon interval have the same schedule, but the third beacon interval and the fourth beacon interval have different schedules. The first beacon interval is the Awake BI in which the PPS PCP is in the Awake state to serve non-PCP STAs. In the first beacon interval, the PCP transmits the Extended Schedule element for the current beacon interval with the pseudo-static subfield set to 1 for all allocations within the Extended Schedule element to indicate that the schedule of the first beacon interval also applies to the second beacon interval. In addition, the PCP transmits the Wakeup Schedule element with the information of the start time and the length of the PCP sleep interval, and the STA Availability element to indicate the availability of the PCP for the CBAP of the Awake BI. Following the CBAP of the first beacon interval, the PCP enters the Doze state and sleeps for more than one beacon interval. The PCP switches from the Doze state to the Awake state after sleeping through the remainder of the first beacon interval and through the entire second beacon interval, which is the start of the third beacon interval in Figure 10-5c. Since in this example the schedule of the third beacon interval and the fourth beacon interval are different, the PCP transmits the Extended Schedule element containing the individual allocations for the third beacon interval and fourth beacon interval. The PCP enters the Doze state after it completes all exchanges in the third beacon interval and wakes up at the start of the fifth beacon interval.

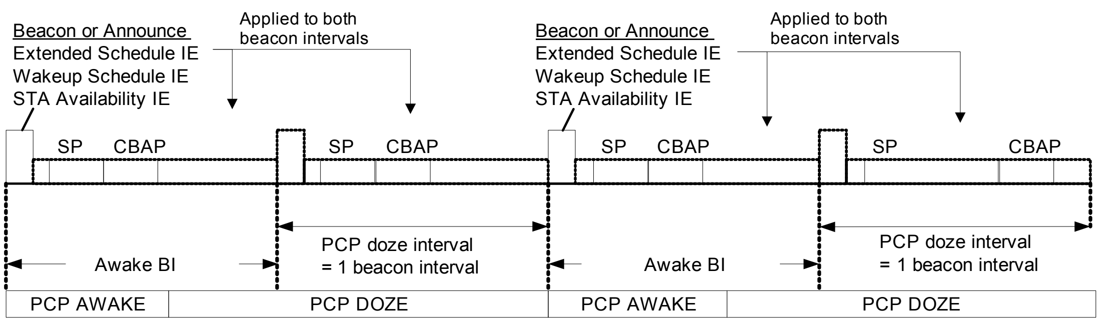


Figure 10-5c—Example operation of PPS mode

10.3 STA authentication and association

10.3.1 State variables

Change the fourth paragraph of 10.3.1, and insert a new fifth paragraph as follows:

For nonmesh STAs, this state variable expresses the relationship between the local STA and the remote STA. It takes on the following values:

— State 1: Initial start state~~,~~ for non-DMG STAs. U~~u~~nauthenticated, unassociated. State 1 is not used by DMG STAs.

— State 2: Initial start state for DMG STAs. Authenticated (non-DMG STAs only), not associated.
— State 3: Authenticated (non-DMG STAs only) and associated (Pending RSN Authentication).
— State 4: For Infrastructure BSS and PBSS only, RSNA Established or Not Required ~~Authenticated and associated~~.

State 1 is not used by DMG STAs, and the state machine starts in State 2.

10.3.2 State transition diagram for nonmesh STAs

Replace Figure 10-6 with the following figure:

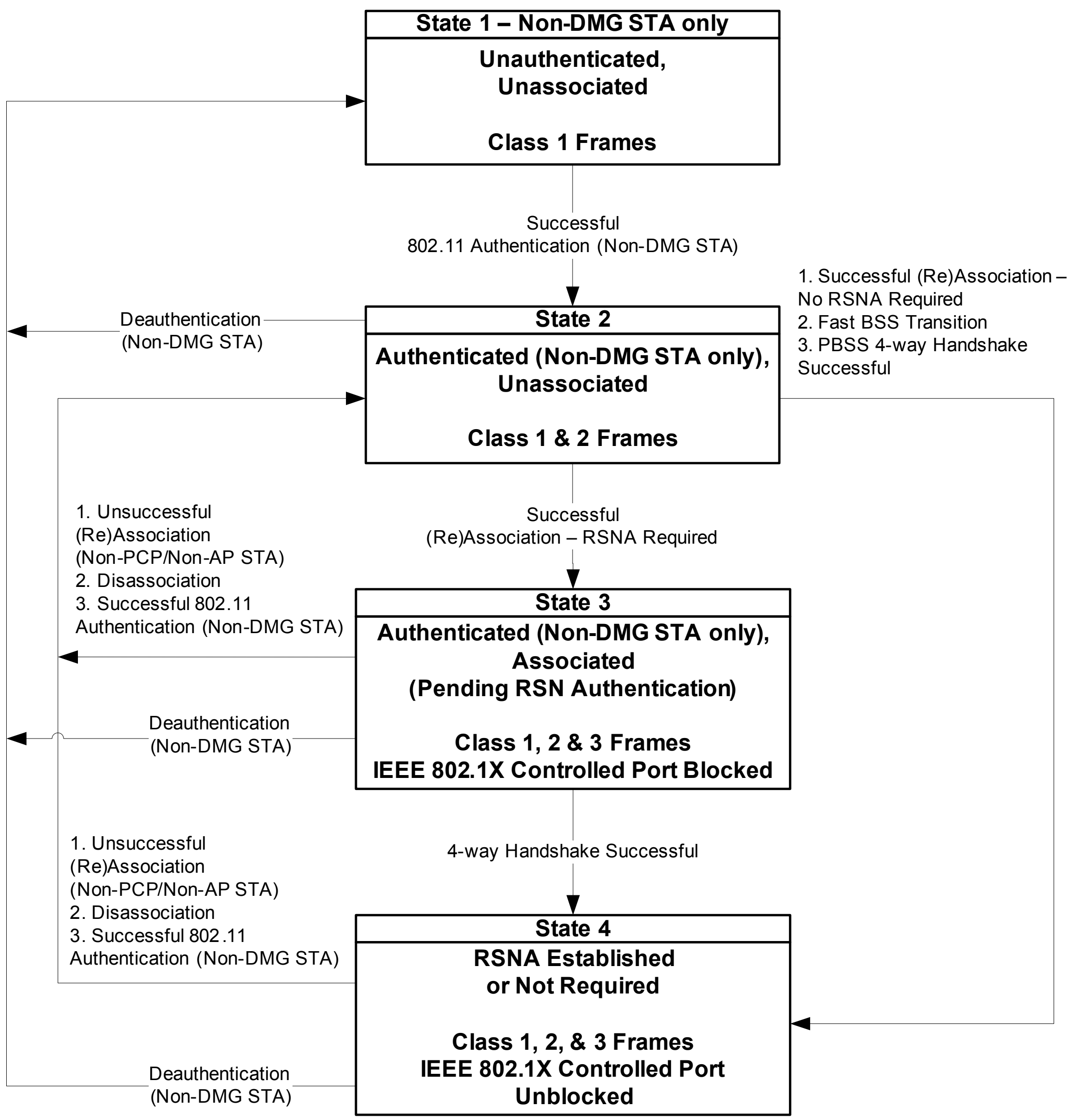


Figure 10-6—Relationships between state and services

10.3.3 Frame filtering based on STA state

Change 10.3.3 as follows:

The current state existing between the transmitter and receiver STAs determines the IEEE 802.11 frame types that may be exchanged between that pair of STAs (see Clause 8). A unique state exists for each pair of transmitter and receiver STAs. The allowed frame types are grouped into classes, and the classes correspond to the STA state. In State 1, only Class 1 frames are allowed. In State 2, either Class 1 or Class 2 frames are allowed. In State 3 and State 4, all frames are allowed (Classes 1, 2, and 3).

In the definition of frame classes, the following terms are used:

- *Within an infrastructure BSS:* both the transmitting STA and the recipient STA participate in the same infrastructure BSS
- *Within a PBSS:* both the transmitting STA and the recipient STA participate in the same PBSS
- *Within an IBSS:* both the transmitting STA and the recipient STA participate in the same IBSS
- *dot11RSNAEnabled:* reference to the setting of dot11RSNAEnabled at the STA that needs to determine whether a transmission or reception is permitted.

NOTE—The phrase “within a BSS” comprises “within a PBSS,” “within an IBSS,” “within a MBSS,” or “within an infrastructure BSS.”

STA A participates in the same infrastructure BSS as STA B if at least one of the following conditions is met:

- STA A is associated with STA B, and either STA A or STA B is an AP.
- STA A receives a frame with the value of its TA field equal to the MAC address of STA B and with the value of its BSSID field equal to the BSSID of the BSS with which STA A is associated.
- STA A receives an Information Response frame from the AP with which it is associated containing an explicit indication that STA B is a member of the BSS with which STA A is associated.

STA A participates in the same PBSS as STA B if at least one of the following conditions is met:

- STA A is associated with STA B, and either STA A or STA B is a PCP.
- STA A receives a frame with the value of its TA field equal to the MAC address of STA B and with the value of its BSSID field equal to the BSSID of the PBSS that STA A has joined or started.
- STA A receives a frame, i.e. an Information Response frame, from its PCP containing an explicit indication that STA B is a member of the PBSS that STA A has joined.

STA A participates in the same IBSS as STA B if STA A receives a frame with the value of its TA field equal to the MAC address of STA B and with the value of its BSSID field equal to the BSSID of the IBSS that STA A has joined or started.

The frame classes are defined as follows:

a) Class 1 frames
  1) Control frames
    i) RTS
    ii) DMG Clear to send (DMG CTS)
    iii) ~~ii)~~ CTS
    iv) ~~iii)~~ ACK
    v) Grant
    vi) SSW
    vii) SSW-Feedback

- viii) SSW-ACK
- ix) Grant ACK
- x) ~~iv)~~ CF-End+ACK
- xi) ~~v)~~ CF-End
- xii) ~~vi)~~ Within an IBSS and within a PBSS when dot11RSNAEnabled is false, Block Ack (BlockAck)
- xiii) ~~vii)~~ Within an IBSS and within a PBSS when dot11RSNAEnabled is false, Block Ack Request (BlockAckReq)

2) Management frames
- i) Probe Request/Response
- ii) Beacon
- iii) Authentication
- iv) Deauthentication
- v) ATIM
- vi) Public Action
- vii) Self-protected Action
- viii) Within an IBSS, all Action frames and all Action No Ack frames
- ix) Unprotected DMG Action frames
- x) DMG: Link Measurement Request and Link Measurement Report frames
- xi) Within a PBSS when dot11RSNAEnabled is false, all Action and Action No Ack frames except the following frames:
  1) ADDTS Request
  2) ADDTS Response
  3) DELTS frame

3) Data frames
- i) Data frames between STAs in an IBSS
- ii) Data frames between peers using DLS
- iii) Data frames within a PBSS

4) Extension frames
- i) DMG Beacon

b) Class 2 frames

1) Management frames
- i) Association Request/Response
- ii) Reassociation Request/Response
- iii) Disassociation

c) Class 3 frames

1) Data frames
- i) Data frames between STAs in an infrastructure BSS or in an MBSS

2) Management frames
- i) Within an infrastructure BSS or an MBSS or a PBSS, all Action and Action No Ack frames except those that are declared to be Class 1 or Class 2 frames (above)

3) Control frames
- i) PS-Poll
- ii) Poll

iii) SPR

iv) DMG DTS

v) ~~ii) Within an infrastructure BSS or an MBSS,~~ Block Ack (BlockAck), except those that are declared to be Class 1 (above)

vi) ~~iii) Within an infrastructure BSS or an MBSS,~~ Block Ack Request (BlockAckReq), except those that are declared to be Class 1 (above)

Class 2 and Class 3 frames are not allowed in an IBSS. If a STA in an IBSS receives a Class 2 or Class 3 frame, it shall ignore the frame.

A STA shall not transmit Class 2 frames unless in State 2 or State 3 or State 4.

A STA shall not transmit Class 3 frames unless in State 3 or State 4.

A multi-band capable device that uses OCT to move from State 2 to either State 3 or State 4 shall not transmit frames before the transmitting STA becomes on-the-air enabled (see 10.32.4).

The use of the word “receive” in 10.3 refers to a frame that meets all of the filtering criteria specified in Clause 11 and Clause 9.

10.3.4 Authentication and deauthentication

10.3.4.1 General

Change 10.3.4.1 as follows:

This subclause describes the procedures used for IEEE 802.11 authentication and deauthentication. The states used in this description are defined in 10.3.1.

Successful authentication sets the STA’s state to State 2, if it was in State 1. Unsuccessful authentication leaves the STA’s state unchanged. ~~The STA shall not transmit Class 2 frames unless in State 2 or State 3 or State 4. The STA shall not transmit Class 3 frames unless in State 3 or State 4.~~

Deauthentication notification sets the STA’s state to State 1. ~~The STA shall become authenticated again prior to sending Class 2 frames.~~ Deauthentication notification when in State 3 or State 4 implies disassociation as well. A STA may deauthenticate a peer STA at any time, for any reason.

If non-DMG STA A in an infrastructure BSS receives a Class 2 or Class 3 frame from STA B that is not authenticated with STA A (i.e., the state for STA B is State 1), STA A shall discard the frame. If the frame has an individual address in the Address 1 field, the MLME of STA A shall send a Deauthentication frame to STA B.

Authentication is optional in ~~an~~ non-DMG IBSS. In ~~an~~ non-DMG infrastructure BSS, authentication is required. APs do not initiate authentication. Authentication and deauthentication are not supported by DMG STAs.

10.3.4.2 Authentication—originating STA

Insert the following paragraph at the beginning of 10.3.4.2:

Upon receipt of an MLME-AUTHENTICATE.request primitive that is part of an on-channel tunneling (see 10.32.4), the originating STA shall follow the rules in 10.32.4 in addition to the authentication procedure described below.

10.3.5 Association, reassociation, and disassociation

Change 10.3.5.1 to 10.3.5.9 as follows:

10.3.5.1 General

Subclause 10.3.5 describes the procedures used for IEEE 802.11 association, reassociation, and disassociation.

The states used in this description are defined in 10.3.1.

Successful association enables a STA to exchange Class 3 frames. Successful association sets the STA's state to State 3 or State 4.

Successful reassociation enables a STA to exchange Class 3 frames. Unsuccessful reassociation when not in State 1 leaves the STA's state unchanged (with respect to the PCP/AP that was sent the Reassociation Request (which may be the current STA)). Successful reassociation sets the STA's state to State 3 or State 4 (with respect to the PCP/AP that was sent the Reassociation Request). Successful reassociation when not in State 1 sets the STA's state to State 2 (with respect to the current PCP/AP, if this is not the PCP/AP that was sent the Reassociation Request). Reassociation shall be performed only if the originating STA is already associated in the same ESS.

Disassociation notification when not in State 1 sets the STA's state to State 2. The STA shall become associated again prior to sending Class 3 frames. A STA may disassociate a peer STA at any time, for any reason.

If non-DMG STA A in an infrastructure BSS receives a Class 3 frame from STA B that is authenticated but not associated with STA A (i.e., the state for STA B is State 2), STA A shall discard the frame. If the frame has an individual address in the Address 1 field, the MLME of STA A shall send a Disassociation frame to STA B.

If DMG STA A in an infrastructure BSS receives a Class 3 frame from STA B that is not associated with STA A (i.e., the state for STA B is State 2), STA A shall discard the frame. If the frame has an individual address in the Address 1 field, the MLME of STA A shall send a Disassociation frame to STA B.

If an MM-SME coordinated STA receives an Association Response frame with a result code equal to SUCCESS and with the value of the Single AID field within MMS element equal to 1, then

- For each of its MAC entities advertised within the MMS element and for which dot11RSNAEnabled is true, the state is set to State 3. Progress from State 3 to State 4 occurs independently in each such MAC entity.
- For each of its MAC entities advertised within the MMS element and for which dot11RSNAEnabled is false, the state is set to State 4.

If the MM-SME coordinated STA in State 3 is assigned an AID for only the MAC entity identified by the RA field of the Association Response with result code equal to SUCCESS, the MM-SME may repeat the association procedure for any other MAC entity coordinated by the MM-SME.

Association is not applicable in an IBSS. In an infrastructure BSS, association is required. In a PBSS, association is optional. APs do not initiate association.

10.3.5.2 Non-PCP/Non-AP STA association initiation procedures

The SME shall delete any PTKSA and temporal keys held for communication with the PCP/AP by using MLME-DELETEKEYS.request primitive (see 11.5.15) before invoking MLME-ASSOCIATE.request primitive.

If dot11InterworkingServiceActivated is true, the STA does not have credentials for the AP, and the STA is initiating an emergency services association procedure, the SME shall submit the MLMEASSOCIATE.request with EmergencyServices parameter set to true.

The MM-SME of a non-PCP/non-AP STA may include an MMS element in an MLME-ASSOCIATE.request primitive. The MM-SME shall include in the MMS element the MAC address associated with the MLME SAP instance to which the primitive is submitted.

Upon receipt of an MLME-ASSOCIATE.request primitive that is part of an on-channel tunneling (see 10.32.4), a non-PCP/non-AP STA shall follow the rules in 10.32.4 in addition to the association procedures described below.

Upon receipt of an MLME-ASSOCIATE.request primitive, a non-PCP/non-AP STA shall associate with ~~an~~ PCP/AP using the following procedure:

a) If the state for the AP is State 1, the MLME shall inform the SME of the failure of the association by issuing an MLME-ASSOCIATE.confirm primitive, and this procedure ends.
b) The MLME shall transmit an Association Request frame to the PCP/AP. If the MLME-ASSOCIATE.request primitive contained an RSNE with only one pairwise cipher suite and only one authenticated key suite, this RSNE shall be included in the Association Request frame. If the MLME-ASSOCIATE.request primitive contained the EmergencyServices parameter set to true, an Interworking element with the UESA field set to 1 shall be included in the Association Request frame.
c) If an Association Response frame is received with a status code of Successful, the state for the PCP/AP shall be set to State 4 or State 3 if RSNA Establishment is required. The state for any other PCP/AP which is State 3 or State 4 prior to the association request shall be set to State 2, and the MLME shall issue an MLME-ASSOCIATE.confirm primitive to inform the SME of the successful completion of the association.
d) An MM-SME coordinated STA that receives an Association Response frame with a status code of Successful containing an MLME element with the Single AID field equal to 1, all the STAs coordinated by the MM-SME are associated with the PCP/AP (i.e., shall be set to State 4 or State 3 if RSNA Establishment is required).
e) ~~d)~~ If an Association Response frame is received with a status code other than Successful or the AssociateFailureTimeout expires, the state for the PCP/AP shall be set to State 2, and the MLME shall issue an MLME-ASSOCIATE.confirm primitive to inform the SME of the failure of the association. The status code returned in the Association Response frame indicates the cause of the failed association attempt. Any misconfiguration or parameter mismatch, e.g., data rates required as basic rates that the STA did not indicate as supported in the STA's Supported Rates element, shall be corrected before the SME issues an MLME-ASSOCIATE.request primitive for the same PCP/AP. If the status code indicates the association failed because of a reason that is not related to configuration (e.g., the PCP/AP is unable to support additional associations) and the Association Response frame does not include a Timeout Interval element with Timeout Interval Type equal to 3, the SME shall not issue an MLME-ASSOCIATE.request primitive for the same PCP/AP until a period of at least 2 s has elapsed. If the status code indicates the association failed and the Association Response frame contains a Timeout Interval element with Timeout Interval Type equal to 3, the SME shall not issue an MLME-ASSOCIATE.request primitive for the same PCP/AP until the period specified in the Timeout Interval element has elapsed.

f) ~~e)~~ If an MLME-ASSOCIATE.confirm primitive is received with a ResultCode of SUCCESS and if RSNA is required, then the SME shall perform a 4-way handshake to establish an RSNA. As a part of a successful 4-way handshake, the SME enables protection by invoking an MLME-SETPROTECTION.request(Rx_Tx) primitive.

g) ~~f)~~ Upon receipt of the MLME-SETPROTECTION.request(Rx_Tx) primitive, the MLME shall set the state of the STA to State 4.

10.3.5.3 PCP/AP association receipt procedures

Upon receipt of an Association Request frame from a non-AP STA for which the state is State 1, the AP's MLME shall transmit an Association Response frame with an appropriate status code.

Upon receipt of an Association Request frame from a non-PCP/non-AP STA for which the state is State 2, State 3, or State 4, the PCP/AP's MLME shall associate with the non-PCP/non-AP STA using the following procedure:

a) The MLME shall issue an MLME-ASSOCIATE.indication primitive to inform the SME of the association request.

b) At an AP having dot11InterworkingServiceActivated equal to true, subsequent to receiving an MLME-ASSOCIATE.indication primitive with EmergencyServices set to true that does not include an RSNE, the SME shall accept the association request even if dot11RSNAActivated is true and dot11PrivacyInvoked is true thereby granting access, using unprotected frames (see 8.2.4.1.9), to the network for emergency services purposes.

c) Upon receiving an MLME-ASSOCIATE.indication primitive, when management frame protection is not in use, the SME shall delete any PTKSA and temporal keys held for communication with the STA by using the MLME-DELETEKEYS.request primitive (see 11.5.15).

d) In an RSNA, the PCP/AP shall check the values received in the RSNE to see whether the values received match the PCP/AP's security policy. If not, the association shall not be accepted.

e) If the PCP/AP's state for the non-PCP/non-AP STA is State 4, the PCP/AP has a valid security association for the non-PCP/non-AP STA and has negotiated management frame protection with the non-PCP/non-AP STA, and an earlier, timed-out SA Query procedure with the non-PCP/non-AP STA has not allowed a new association process to be started without an additional SA Query procedure, then

   1) The SME shall reject the Association Request by generating an MLME-ASSOCIATE.response primitive with ResultCode "Association request rejected temporarily; try again later."

   2) The SME shall not modify any association state for the non-PCP/non-AP STA and shall include in the MLME-ASSOCIATE.response primitive a Timeout Interval element with Timeout interval type set to 3 (Association Comeback time), specifying a comeback time when the PCP/AP would be ready to accept an association with this STA.

   3) Following this, if the SME is not already engaging in an SA Query with the STA, the SME shall issue one MLME-SAQuery.request primitive addressed to the STA every dot11AssociationSAQueryRetryTimeout TUs until a matching MLME-SAQuery.confirm primitive is received or dot11AssociationSAQueryMaximumTimeout TUs from the beginning of the SA Query procedure have passed.

   4) The SME shall specify a TransactionIdentifier parameter value in the MLME-SAQuery.request primitive, increment the value by 1 for each subsequent MLME-SAQuery.request primitive, and roll over the value to 0 after the maximum allowed value is reached.

   5) The MLME may interpret reception of a valid protected frame as an indication of a successfully completed SA Query and thereby generate an MLME-SAQuery.confirm primitive.

6) If an MLME-SAQuery.confirm primitive with an outstanding transaction identifier is not received within dot11AssociationSAQueryMaximumTimeout period, the SME shall allow the association process to be started without starting an additional SA Query procedure.

f) The SME shall refuse an association request from a STA that does not support all the rates in the BSSBasicRateSet parameter

g) The SME shall refuse an association request from an HT STA that does not support all the MCSs in the BSSBasicMCSSet parameter.

h) The SME shall generate an MLME-ASSOCIATE.response primitive addressed to the non-PCP/non-AP STA. When the association is not successful, the SME shall indicate a specific reason for the failure to associate in the ResultCode parameter as defined in 6.3.7.5.2. If the ResultCode is SUCCESS, the SME has an existing SA with the non-PCP/non-AP STA, and an SA Query procedure with that non-PCP/non-AP STA has failed to receive a valid response, then the SME shall send an MLME-DISASSOCIATE.request primitive to the STA with Reason Code "Previous Authentication no longer valid."[40] If the ResultCode is SUCCESS, the association identifier assigned to the STA shall be included in the MLME-ASSOCIATE.response primitive, and the SME shall delete any PTKSA and temporal keys held for communication with the STA by using the MLME-DELETEKEYS.request primitive (see 11.5.15). In the case of a DMG PCP/AP, the association identifier shall be in the range of 1 to 254.

i) If the MLME-ASSOCIATE.indication primitive includes an MMS parameter, the PCP/AP shall generate the MLME-ASSOCIATE.response primitive directed to the MLME of the STA identified by the PeerSTAAddress parameter of the MLME-ASSOCIATE.request primitive and take the following additional action, as appropriate:

   1) If the Single AID field in the MMS parameter of the MLME-ASSOCIATE.indication primitive is equal to 1, the PCP/AP may allocate a single AID for all the STAs included in the MMS element. If the PCP/AP allocates the same AID to each STA whose MAC address was included in the MMS element, it shall include the MMS element received from the MM-SME coordinated STA in the MLME-ASSOCIATION.response primitive.

   2) If the Single AID field is 0, the AP shall allocate a distinct AID for each STA specified in the MMS element.

j) ~~i)~~ Upon receipt of an MLME-ASSOCIATE.response primitive, the MLME shall transmit an Association Response frame to the STA.

k) ~~j)~~ When the ResultCode of the MLME-ASSOCIATE.response primitive is not SUCCESS, if management frame protection is in use, the state for the STA shall be left unchanged and, if management frame protection is not in use, set to State 3 if it was in State 4.

l) ~~k)~~ When the Association Response frame with a status code of Successful is acknowledged by the STA, the state for the STA shall be set to State 4 or to State 3 if RSNA establishment is required.

m) ~~l)~~ If RSNA establishment is required, the SME shall attempt a 4-way handshake. Upon a successful completion of a 4-way handshake, the SME shall enable protection by invoking an MLME-SETPROTECTION.request(Rx_Tx) primitive. Upon receipt of the MLME-SETPROTECTION.request(Rx_Tx) primitive, the MLME shall set the state for the STA to State 4.

n) ~~m)~~ AP only: The SME shall inform the DS of any changes in the association state.

10.3.5.4 Non-PCP/Non-AP STA reassociation initiation procedures

Except when the association is part of a fast BSS transition, the SME shall delete any PTKSA and temporal keys held for communication with the PCP/AP by using the MLME-DELETEKEYS.request primitive (see 11.5.15) before invoking an MLME-REASSOCIATE.request primitive.

[40] This MLME-DISASSOCIATE.request primitive generates a protected Disassociation frame addressed to the STA.

If dot11InterworkingServiceActivated is true and the STA was associated to the ESS for unsecured access to emergency services, the SME shall submit the MLME-REASSOCIATE.request with EmergencyServices parameter set to true.

The MM-SME of a non-PCP/non-AP STA may include an MMS element in an MLME-REASSOCIATE.request primitive. The MM-SME shall include in the MMS element the MAC address associated with the MLME SAP instance to which the primitive is submitted.

Upon receipt of an MLME-REASSOCIATE.request primitive that is part of an on-channel tunneling (see 10.32.4), a non-PCP/non-AP STA shall follow the rules in 10.32.4 in addition to the reassociation procedures described below.

Upon receipt of an MLME-REASSOCIATE.request primitive, a non-PCP/non-AP STA shall reassociate with a PCP/AP using the following procedure:

a) If the STA is not associated in the same ESS or the state for the new AP is State 1, the MLME shall inform the SME of the failure of the reassociation by issuing an MLME-REASSOCIATE.confirm primitive, and this procedure ends.
b) The MLME shall transmit a Reassociation Request frame to the new PCP/AP. If the MLME-REASSOCIATE.request primitive contained an RSNE with only one pairwise cipher suite and only one authenticated key suite, this RSNE shall be included in the Reassociation Request frame. If the MLME-REASSOCIATE.request primitive contained the EmergencyServices parameter set to true, an Interworking element with the UESA field set to 1 shall be included in the Reassociation Request frame.
c) If a Reassociation Response frame is received with a status code of Successful, the state variable for the new PCP/AP shall be set to State 4 or to State 3 if RSNA establishment is required and the FT Protocol is not used with respect to the new PCP/AP and, unless the old PCP/AP and new PCP/AP are the same, to State 2 with respect to the old PCP/AP, and the MLME shall issue an MLME-REASSOCIATE.confirm primitive to inform the SME of the successful completion of the reassociation.
d) An MM-SME coordinated STA that receives a Reassociation Response frame with a status code of Successful containing an MLME element with the Single AID field equal to 1, all the STAs coordinated by the MM-SME are reassociated with the PCP/AP (i.e., shall be set to State 4 or State 3 if RSNA Establishment is required).
e) ~~d)~~ If a Reassociation Response frame is received with a status code other than Successful or the ReassociateFailureTimeout expires,
    1) Except when the association is part of a fast BSS transition, the state for the PCP/AP shall be set to State 2 with respect to the new PCP/AP.
    2) The MLME shall issue an MLME-REASSOCIATE.confirm primitive to inform the SME of the failure of the reassociation. The ResultCode returned in the MLME-REASSOCIATE.confirm primitive indicates the cause of the failed reassociation attempt. Any misconfiguration or parameter mismatch, e.g., data rates required as basic rates that the STA did not indicate as supported in the STA's Supported Rates element, shall be corrected before the SME issues an MLME-REASSOCIATE.request primitive for the same PCP/AP. If the status code indicates the reassociation failed because of a reason that is not related to configuration (e.g., the PCP/AP is unable to support additional associations) and the Reassociation Response frame does not include a Timeout Interval element with Timeout Interval Type equal to 3, the SME shall not issue an MLME-REASSOCIATE.request primitive for the same PCP/AP until a period of at least 2 s has elapsed. If the status code indicates the reassociation failed and the Reassociation Response frame contains a Timeout Interval element with Timeout Interval Type equal to 3, the SME shall not issue an MLME-REASSOCIATE.request primitive for the same PCP/AP until the period specified in the Timeout Interval element has elapsed.

f) ~~e)~~ If an MLME-REASSOCIATE.confirm primitive is received with a ResultCode of SUCCESS, RSNA is required, and the STA is in State 3, then the SME shall perform a 4-way handshake to establish an RSNA. As a part of a successful 4-way handshake, the SME shall enable protection by invoking an MLME-SETPROTECTION.request(Rx_Tx) primitive.

g) ~~f)~~ Upon receipt of the MLME-SETPROTECTION.request(Rx_Tx) primitive, the MLME shall set the state of the STA to State 4.

10.3.5.5 PCP/AP STA reassociation receipt procedures

Upon receipt of an Reassociation Request frame from a non-AP STA for which the state is State 1, the AP's MLME shall transmit an Reassociation Response frame with an appropriate status code.

Upon receipt of a Reassociation Request frame from a STA for which the state is State 2, State 3, or State 4, the PCP/AP's MLME shall reassociate with the STA using the following procedure:

a) The MLME shall issue an MLME-REASSOCIATE.indication primitive to inform the SME of the reassociation request.

b) At an AP having dot11InterworkingServiceActivated equal to true, subsequent to receiving a MLME-REASSOCIATE.indication primitive with EmergencyServices set to true that does not include an RSN parameter, the SME shall accept the reassociation request even if dot11RSNAActivated is true and dot11PrivacyInvoked is true thereby granting access, using unprotected frames (see 8.2.4.1.9), to the network for emergency services purposes.

c) In an RSNA, the SME shall check the values received in the RSNE to see whether the values received match the AP's security policy. If not, the association shall not be accepted.

d) If the PCP/AP's state for the non-PCP/non-AP STA is State 4, the non-PCP/non-AP STA has a valid security association, the non-PCP/non-AP STA has negotiated management frame protection, the reassociation is not a part of a Fast BSS Transition, and an earlier, timed-out SA Query procedure with the non-PCP/non-AP STA has not allowed a new association process to be started without an additional SA Query procedure, then

    1) The SME shall reject the Reassociation Request by generating an MLME-REASSOCIATE.response primitive with ResultCode "Association request rejected temporarily; Try again later."

    2) The SME shall not modify any association state for the non-PCP/non-AP STA and shall include in the MLME-REASSOCIATE.response primitive a Timeout Interval element with type set to 3 (Association Comeback time), specifying a comeback time when the PCP/AP would be ready to accept an association with this STA.

    3) Following this, if the SME is not in an ongoing SA Query with the STA, the SME shall issue one MLME-SAQuery.request primitive addressed to the STA every dot11AssociationSAQueryRetryTimeout TUs until a matching MLME-SAQuery.confirm primitive is received or dot11AssociationSAQueryMaximumTimeout TUs from the beginning of the SA Query procedure have passed.

    4) The SME shall insert the TransactionIdentifier in MLME-SAQuery.request primitive, increment this by 1 for each subsequent MLME-SAQuery.request primitive, and roll it over to 0 after the maximum allowed value in this field.

    5) An MLME may interpret reception of a valid protected frame as an indication of a successfully completed SA Query and thereby generate an MLME-SAQuery.confirm primitive.

    6) If an MLME-SAQuery.confirm primitive with an outstanding transaction identifier is not received within dot11AssociationSAQueryMaximumTimeout period, the SME shall allow the association process to be started without starting an additional SA Query procedure.

e) The SME shall refuse a reassociation request from a STA that does not support all the rates in the BSSBasicRateSet parameter.

f) The SME shall refuse a reassociation request from an HT STA that does not support all the MCSs in the BSSBasicMCSSet parameter.

g) The SME shall generate an MLME-REASSOCIATE.response primitive addressed to the non-PCP/non-AP STA. If the reassociation is not successful, the SME shall indicate a specific reason for the failure to reassociate in the ResultCode parameter as defined in 6.3.7.5.2.

h) If the ResultCode is SUCCESS, the SME has an existing SA with the non-PCP/non-AP STA, and an SA Query procedure with that non-PCP/non-AP STA has failed to receive a valid response, then the SME shall issue an MLME-DISASSOCIATE.request primitive with Reason Code "Previous Authentication no longer valid."

NOTE—This MLME-DISASSOCIATE.request primitive generates a protected Disassociation frame addressed to the STA.

i) If the ResultCode is SUCCESS, the association identifier assigned to the STA shall be included in this primitive. If the association is not part of a fast BSS transition and management frame protection is not in use, the SME shall delete any PTKSA and temporal keys held for communication with the STA by using MLME-DELETEKEYS.request primitive (see 11.5.15). In the case of a DMG PCP/AP, the association identifier shall be in the range of 1 to 254.

j) If the MLME-REASSOCIATE.indication primitive includes an MMS parameter, the PCP/AP shall generate the MLME-REASSOCIATE.response primitive directed to the MLME of the STA identified by the PeerSTAAddress parameter of the MLME-REASSOCIATE.request primitive and take the following additional action, as appropriate:

1) If the Single AID field in the MMS parameter of the MLME-REASSOCIATE.indication primitive is equal to 1, the PCP/AP may allocate a single AID for all the STAs included in the MMS element. If the PCP/AP allocates the same AID to all STAs whose MAC address was included in the MMS element, it shall include the MMS element received from the MM-SME coordinated STA in the MLME-REASSOCIATE.response primitive.

2) If the Single AID field is 0, the AP shall allocate a distinct AID for each STA specified in the MMS element.

k) ~~j)~~ Upon receipt of an MLME-REASSOCIATE.response primitive, the MLME shall transmit a Reassociation Response frame to the STA.

l) ~~k)~~ When the Reassociation Response frame with a status value of Successful is acknowledged by the STA, the state variable for the STA shall be set to State 4 or to State 3 if RSNA establishment is required on the new PCP/AP and the FT Protocol is not used on the new PCP/AP.

m) ~~l)~~ When the ResultCode of the reassociation is not SUCCESS~~,~~ and if Management Frame Protection is in use, the state for the STA shall be left unchanged on the PCP/AP to which the Reassociation Request frame was sent. When the ResultCode is not SUCCESS, Management Frame Protection is not in use, and the association is not part of a fast BSS transition, then the state for the STA is set to State 3 if it was in State 4.

n) ~~m)~~ If RSNA establishment is required and FT is not in use, the SME shall attempt a 4-way handshake. Upon a successful completion of a 4-way handshake, the SME shall enable protection by invoking an MLME-SETPROTECTION.request(Rx_Tx) primitive. Upon receipt of the MLME-SETPROTECTION.request(Rx_Tx) primitive, the MLME shall set the state for the STA to State 4.

o) ~~n)~~ AP only: The SME shall inform the DS of any changes in the association state.

10.3.5.6 Non-PCP/Non-AP STA disassociation initiation procedures

The SME shall issue an MLME-DISASSOCIATE.request primitive that includes an appropriate Reason Code as defined in Table 8-36 of 8.4.1.7.

Upon receipt of an MLME-DISASSOCIATE.request primitive, a non-PCP/non-AP STA's MLME shall disassociate from a PCP/AP using the following procedure:

a) If the state for the PCP/AP is State 3 or State 4, the MLME shall transmit a Disassociation frame to the PCP/AP.

b) The state for the PCP/AP shall be set to State 2 if it was not State 1. In the case of an MM-SME coordinated STA, the MLME shall perform this for each STA whose address was included in the MMS parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive that established the association.

c) The MLME shall issue an MLME-DISASSOCIATE.confirm primitive to inform the SME of the successful completion of the disassociation.

d) Upon receiving a MLME-DISASSOCIATE.confirm primitive, the SME shall delete any PTKSA and temporal keys held for communication with the PCP/AP by using the MLME-DELETEKEYS.request primitive (see 11.5.15) and by invoking an MLME-SETPROTECTION.request(None) primitive. In the case of an MM-SME coordinated STA, the MLME shall perform this for each STA whose address was included in the MMS parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive that established the association.

10.3.5.7 Non-PCP/Non-AP STA disassociation receipt procedures

Upon receipt of a Disassociation frame from ~~an~~ PCP/AP for which the state is State 3 or State 4, if Management Frame Protection was not negotiated when the PTKSA(s) were created, or if MFP is in use and the frame is not discarded per MFP processing, a non-PCP/non-AP STA shall disassociate from the PCP/AP using the following procedure:

a) The state for the PCP/AP shall be set to State 2.

b) The MLME shall issue an MLME-DISASSOCIATE.indication primitive to inform the SME of the disassociation.

c) Upon receiving the MLME-DISASSOCIATE.indication primitive, the SME shall delete any PTKSA and temporal keys held for communication with the PCP/AP by using the MLME-DELETEKEYS.request primitive (see 11.5.15) and by invoking an MLME-SETPROTECTION.request(None) primitive. The MM-SME shall perform this process for each STA whose address was included in the MMS parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive that established the association.

d) If the reason code indicates a configuration or parameter mismatch as the cause of the disassociation, the SME shall not attempt to associate or reassociate with the PCP/AP until the configuration or parameter mismatch has been corrected.

e) If the reason code indicates the STA was disassociated for a reason other than configuration or parameter mismatch, the SME shall not attempt to associate or reassociate with the PCP/AP until a period of 2s has elapsed.

10.3.5.8 PCP/AP disassociation initiation procedure

The SME shall issue an MLME-DISASSOCIATE.request primitive that includes an appropriate Reason Code as defined Table 8-36 of 8.4.1.7.

Upon receipt of an MLME-DISASSOCIATE.request primitive, ~~an~~ PCP/AP shall disassociate a STA using the following procedure:

a) If the state for the STA is State 3 or State 4, the PCP/AP shall generate a Disassociation frame to be transmitted to the indicated STA.

NOTE—As the Disassociation frame is a bufferable MMPDU, the transmission of this frame might be delayed by the operation of a power-saving protocol. The AID and the PTKSA are maintained (when applicable) until the frame is acknowledged or attempts to transmit the frame are abandoned.

b) The state for the STA shall be set to State 2, if it was not State 1. The MM-SME shall perform this process for each STA whose address was included in the MMS parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive that established the association.

c) Once the Disassociation frame is acknowledged or attempts to transmit the frame are abandoned, the MLME shall issue an MLME-DISASSOCIATE.confirm primitive to inform the SME of the disassociation.

d) Upon receiving a MLME-DISASSOCIATE.confirm primitive, the SME shall delete any PTKSA and temporal keys held for communication with the STA by using the MLME-DELETEKEYS.request primitive (see 11.5.15) and by invoking an MLME-SETPROTECTION.request(None) primitive. The MM-SME shall perform this process for each STA whose address was included in the MMS parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive that established the association.

e) Upon receiving an MLME-DISASSOCIATE.confirm primitive, the SME shall release the AID assigned for the indicated STA, if the state for the indicated STA was State 3 or State 4.

f) The SME of an AP shall inform the DS of the disassociation.

10.3.5.9 PCP/AP disassociation receipt procedure

Upon receipt of a Disassociation frame from a STA for which the state is State 3 or State 4, if management frame protection was not negotiated when the PTKSA(s) were created, or if MFP is in use and the frame is not discarded per MFP processing, the PCP/AP shall disassociate the STA using the following procedure:

a) The state for the STA shall be set to State 2. The MM-SME shall perform this process for each STA whose address was included in the MMS parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive that established the association.

b) The MLME shall issue an MLME-DISASSOCIATE.indication primitive to inform the SME of the disassociation.

c) Upon receiving a MLME-DISASSOCIATE.indication primitive the SME shall delete any PTKSA and temporal keys held for communication with the STA by using the MLME-DELETEKEYS.request primitive (see 11.5.15) and by invoking an MLME-SETPROTECTION.request(None) primitive. The MM-SME shall perform this process for each STA whose address was included in the MMS parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive that established the association.

d) The SME of an AP shall inform the DS of the disassociation.

e) The SME shall release the AID assigned for the indicated STA.

Insert the following subclause, 10.3.5.10, after 10.3.5.9:

10.3.5.10 PBSS procedures for nonassociated STAs

In a PBSS, there are four types of relationships between a PCP and the members of a PBSS:

— Nonassociated, non-RSNA (when dot11RSNAEnabled is false)
— Associated, non-RSNA (when dot11RSNAEnabled is false)
— Associated, RSNA (when dot11RSNAEnabled is true)
— Nonassociated, RSNA (when dot11RSNAEnabled is true)

The following rules apply in the last case:

a) In a PBSS, when in State 2 and dot11RSNAEnabled is set to true, successful RSNA establishment changes to State 4. Unsuccessful RSNA establishment leaves state unchanged.

b) In a PBSS when in State 4, disassociation notification changes the state to State 2.

10.3.6 Additional mechanisms for an AP collocated with a mesh STA

Insert the following subclause, 10.3.7, after 10.3.6:

10.3.7 Communicating PBSS information

Following the association or security association of a STA with a PCP, the PCP shall send the PBSS information using an unsolicited Information Response frame (8.5.20.5). The PCP shall set the Subject Address field of the Information Response frame to the broadcast address and shall include in the Information Response frame an entry for each STA associated with the PBSS including the PCP.

The PCP shall distribute the PBSS information for each of the STAs that are associated with the PBSS, including the PCP, at least once every dot11BroadcastSTAInfoDuration beacon intervals.

10.4 TS operation

10.4.1 Introduction

Change 10.4.1 as follows:

There are three types of traffic specifications: the TSPEC, the DMG TSPEC, and the PTP TSPEC.

A TSPEC describes the traffic characteristics and the QoS requirements of a TS. The main purpose of the TSPEC is to reserve resources within the HC and, in the case of HCCA and HEMM access policies, to modify the HC's scheduling behavior. It also allows other parameters to be specified that are associated with the TS, such as a traffic classifier and acknowledgment policy.

The DMG TSPEC (8.4.2.136) describes an allocation (also known as DMG allocation) within either a PBSS or a DMG infrastructure BSS. The purpose of the DMG TSPEC is to create or modify an allocation for the transmission of frames between DMG STAs that are members of a PBSS or that are members of an infrastructure BSS (9.33.6).

When transmitted between DMG STAs of a PBSS or DMG STAs of an infrastructure BSS, the TSPEC defined in 8.4.2.32 is used to create or modify a TS between members. When transmitted between DMG STAs of a PBSS or between DMG STAs of an infrastructure BSS, the TSPEC is referred to as a PTP TSPEC.

In a DMG BSS, a TSPEC includes parameters that are associated with the TS such as maximum MSDU size, delay bound, and optionally the allocation carrying the TS. A single allocation can carry multiple TSs. Each TS is carried in one allocation, except when

- The TS has an access policy of EDCA, where it can use all CBAP allocations with Source AID equal to the broadcast AID, all CBAP allocations with Source AID matching the source STA of the TS, and all CBAP allocations with Destination AID matching the destination STA of the TS; or
- The TS has an access policy of SEMM, where it can use exactly one SP allocation as well as all CBAP allocations with Source AID equal to the broadcast AID, all CBAP allocations with Source AID matching the source STA of the TS, and all CBAP allocations with Destination AID matching the destination STA of the TS.

A TS may have one or more TCLAS (within the discretion of the STA that sets up the stream) associated with it. The DMG STA or AP uses the parameters in the TCLAS elements to filter the MSDUs belonging to this TS for delivery as part of the TS. An Intra-Access Category Priority element may be associated with a TS by the inclusion of an Intra-Access Category Priority element in an ADDTS Request frame. The User Priority subfield of the Intra-Access Category Priority element shall be set to the same UP as specified in the

User Priority subfield of the TS Info field. If dot11AlternateEDCAActivated is true, the Alternate Queue subfield is used to select the appropriate EDCA transmit queue when the Access Policy subfield of the TS Info field in the TSPEC is EDCA or HEMM. When an Intra-Access Category Priority element is associated with a TS, the Drop Eligibility subfield is used to indicate the drop eligibility of the MSDUs of this TS.

TS may have zero or one Expedited Bandwidth Request (EBR) element associated with it. An AP uses the parameters in the EBR to understand the precedence level requested by a non-AP STA (see V.5.4). For example, the precedence level may be used to convey to the AP that the requested TS is for the purposes of placing an emergency call. Support for precedence levels greater than 18 is optional for STAs.

TSPEC, PTP TSPEC, optional TCLAS, optional EBR, and optional Intra-Access Category Priority elements are transported on the air by the ADDTS Request frame and the ADDTS Response frame and across the MLME SAP by the MLME-ADDTS primitives. In addition, a TS could be created if a STA sends a resource request to a~~n~~ PCP/AP prior to initiating a transition to that PCP/AP, as part of performing FST (10.32), or in the Reassociation Request frame to that PCP/AP.

DMG TSPEC is transported over the air within the DMG ADDTS and across the MLME SAP by the MLME-ADDTS primitives.

Following a successful negotiation, a TS is created, identified within the non-AP STA by its TSID and direction, and identified within the HC by a combination of TSID, direction, and STA address.

Following a successful negotiation of a DMG TSPEC in a PBSS or in a DMG infrastructure BSS, a new allocation is created, or an existing allocation is modified. Within a PBSS or infrastructure BSS, each allocation is uniquely identified by a combination of Allocation ID, source AID, and destination AID.

Following a successful negotiation of a PTP TSPEC or a TSPEC in a DMG BSS, the frames corresponding to the PTP TSPEC or TSPEC are identified within the DMG STA by the combination of TSID, requesting non-AP DMG STA address, and responding non-AP DMG STA address and direction.

It is always the responsibility of the non-AP STA to initiate the creation of a TS regardless of its direction. A STA that is not a DMG STA shall not transmit a PTP TSPEC or a DMG TSPEC. A non-AP DMG STA that is not the source DMG STA of a specific TS shall not initiate the exchange of a TSPEC to the AP DMG STA or PCP DMG STA to create that TS. Any non-AP DMG STA can issue a PTP TSPEC to any other non-AP DMG STA to create a TS.

In the direct-link or TDLS direct-link case, it is the responsibility of the STA that is going to send the data to create the TS. In this case, the STA negotiates with the HC to gain TXOPs that it uses to send the data. There is no negotiation between the originator and recipient STAs concerning the TS: the originator can discover the capabilities of the recipient (rates, BlockAck) using the DLS.

In the case of traffic relayed by a~~n~~ PCP/AP, the sending and receiving non-PCP/non-AP STAs may both create individual TSs for the traffic. In an infrastructure BSS, a~~A~~ny traffic classifier created for the downlink TS applies equally regardless of whether the source is in the same BSS or reached through the DS.

In a non-DMG infrastructure BSS, a~~A~~ non-AP STA may simultaneously support up to eight TSs from the HC to itself and up to eight TSs from itself to other STAs, including the HC. The actual number it supports may be less due to implementation restrictions.

In a non-DMG infrastructure BSS, a~~A~~n HC may simultaneously support up to eight downlink TSs and up to eight uplink TSs per associated STA. The actual number it supports may be less due to implementation restrictions.

Within a DMG BSS there may be up to 16 TSs from a source DMG STA to a destination DMG STA. An additional 16 TSs may be created between the two DMG STAs by reversing the roles of source and destination. The actual number supported in any direction may be less due to implementation restrictions in either the source or destination DMG STA.

In a non-DMG BSS, t~~T~~he traffic admitted in context of a TSPEC can be sent using EDCA, HCCA, or HEMM. This depends on the access policy set in the TS Info field in the TSPEC. A TSPEC request may be set so that both HCCA and EDCA mechanisms (i.e., HEMM) are used.

In a DMG BSS, the traffic admitted in the context of a PTP TSPEC or TSPEC is sent according to the access policy set in the TS Info field of the PTP TSPEC or TSPEC, respectively. Specifically, the traffic is sent during one or more CBAP allocations if the access policy is EDCA, during an SP allocation if the access policy is SPCA, and during one SP allocation as well as zero or more CBAP allocations if the access policy is SEMM.

A DMG STA transmitting a DMG TSPEC shall set the LP SC Used subfield within the DMG TSPEC to 1 to indicate that the low-power SC PHY described in 21.7 is used during the allocation. All frames sent during such an allocation shall use the low-power SC PHY. The DMG STA shall set the LP SC Used subfield to 1 only if the DMG STA identified in the Destination AID field within the DMG TSPEC supports the low-power SC PHY (8.4.2.130.2). In all other cases, the LP SC Used subfield shall be set to 0.

When dot11SSPNInterfaceActivated is true, TSPEC processing by the HC may be subject to limitations received from the SSPN interface. The SSPN may limit access to certain QoS priorities, and further restrict the data rate and delay used with any priority.

10.4.2 TSPEC Construction

Change the first paragraph in 10.4.2 as follows:

DMG TSPECs and TSPECs are constructed at the SME, from application requirements supplied via the SME, and with information specific to the MAC layer. Except as described in this subclause, there are no normative requirements on how any TSPEC is to be generated. However, N.3.2 describes parameter choice for the TSPEC. There are no normative requirements on how any DMG TSPEC is to be generated.

10.4.3 TS life cycle

Insert the following paragraph after the third paragraph ("A TS may be established ….") of 10.4.3:

Unless stated otherwise, in a DMG BSS, the owner of an SP is the source DMG STA for that SP, and the owner of a TXOP is the TXOP holder. A STA that owns an SP or a TXOP is said to have the ownership of the SP or the TXOP, respectively. The rules applicable to an SP or TXOP owner are defined in 9.33 and 10.4.

Change the now sixth, seventh, and eighth paragraphs of 10.4.3 as follows:

While the TS is active, the parameters of the TSPEC characterizing the TS or the parameters of the DMG TSPEC characterizing the allocation carrying the TS can be renegotiated, when the renegotiation is initiated by the non-AP STA. This negotiation might succeed, resulting in a change to the TSPEC or DMG TSPEC, or might fail, resulting in no change to the TSPEC or DMG TSPEC.

An active TS becomes inactive following a TS deletion process initiated at either non-AP STA or HC. It also becomes inactive following a TS timeout detected at the HC, or if the HC within an AP when dot11SSPNInterfaceActivated is true determines as defined in 10.24.5 that the non-AP STA's TS has exceeded the transmitted MSDU limit for the access category in which the TS was admitted. In a DMG BSS, a TS timeout is detected at a non-AP STA and causes the TS deletion process to be initiated at the non-AP STA. When an active TS becomes inactive, all the resources allocated for the TS are released.

An active TS may become suspended if no activity is detected for a duration of a suspension interval. Upon detection of activity, the TS may be reinstated. While the TS is in the suspended state, the HC shall not reclaim the resources assigned to the TS. In a DMG BSS, a TS in which both the source and destination are non-PCP/non-AP STAs shall not be suspended.

10.4.4 TS Setup

10.4.4.2 Non-Ap-STA-initiated TS setup

In Figure 10-8, replace "HC" by "HC/non-AP STA" (in two places).

10.4.4.4 TS setup procedures for both AP and non-AP STA initiation

Change 10.4.4.4 as follows:

The non-AP STA's SME decides that a TS needs to be created. How it does this, as well as how it selects the TSPEC or DMG TSPEC parameters, is beyond the scope of this standard. The SME generates an MLME-ADDTS.request primitive containing a TSPEC or DMG TSPEC. A TSPEC or DMG TSPEC may also be generated autonomously by the MAC without any initiation by the SME. However, if a TSPEC or DMG TSPEC is generated subsequently by the SME and the responding MLME-ADDTS.confirm primitive contains ResultCode=SUCCESS, the TSPEC or DMG TSPEC containing the same TSID generated autonomously by the MAC shall be overridden. If one or more TSPECs or DMG TSPECs are initiated by the SME, the autonomous TSPEC or DMG TSPEC shall be terminated.

The STA's MLME transmits the TSPEC or DMG TSPEC in an ADDTS Request frame to the HC/non-AP STA and starts a response timer called *ADDTS timer* of duration dot11ADDTSResponseTimeout. If the non-AP STA's MLME is in power save mode, the STA shall include its Wakeup Schedule element in the ADDTS Request frame variant and in the DMG ADDTS Request frame variant.

The HC/non-AP's MLME receives this management frame and generates an MLME-ADDTS.indication primitive to its SME containing the TSPEC or DMG TSPEC.

The SME in the HC/non-AP STA decides whether to admit the TSPEC or DMG TSPEC with its associated TCLAS element(s) (if present) and TCLAS processing element (if present), as specified, refuse the TSPEC or DMG TSPEC, or not admit but suggest an alternative TSPEC or TCLAS element(s) or TCLAS processing element or DMG TSPEC.

If the TSPEC or DMG TSPEC is received from a non-AP STA by an AP when dot11SSPNInterfaceActivated is true, the HC shall use the permissions stored in dot11InterworkingEntry for that STA in the decision to admit or deny the request (see 10.24.5.3). The SME then generates an MLME-ADDTS.response primitive containing the TSPEC or DMG TSPEC, zero or more TCLAS element(s) (only if present in the request) and TCLAS processing element (only if present in the request), and a ResultCode value. The contents of the TSPEC or DMG TSPEC field, TCLAS element(s) (if present), TCLAS processing element (if present), and ResultCode field contain values specified in 6.3.26.5.2. The SME may include fewer TCLAS elements in the MLME-ADDTS.response primitive than were present in the request; when the SME's response includes a single TCLAS element, it shall not include a TCLAS processing element. If the SME changes a TCLAS element's Classifier Type field in the MLME-ADDTS.response primitive but is unable to suggest a value for the Classifier Mask field, it shall set that field to 0. If the SME changes a TCLAS element's Classifier Type field or Classifier Mask field in the MLME-ADDTS.response primitive but is unable to suggest values for one or more Classifier Parameter subfields, it shall set those subfields to 0.

When the HC in an AP that has dot11SSPNInterfaceActivated equal to true receives a TSPEC, the AP shall inspect it to determine the requested access policy, user priority, and mean data rate as follows:

a) The access category shall be determined from the user priority according to Table 9-1. For a TS to be admitted when the requested access policy is EDCA, both of the following shall be true:
   1) The field corresponding to this access category in dot11NonAPStationAuthAccessCategories from the non-AP STA's dot11InterworkingEntry is equal to 1.
   2) The sum of the mean data rate of all the requesting STA's active TSs in this access category plus the mean data rate in the TSPEC is less than or equal to the non-AP STA's dot11InterworkingEntry for dot11NonAPStationAuthMaxVoiceRate, dot11NonAPStationAuthMaxVideoRate, dot11NonAPStationAuthMaxBestEffortRate, or dot11NonAPStationAuthMaxBackgroundRate depending on whether the derived access category is AC_VO, AC_VI, AC_BE or AC_BK, respectively.
b) For a TS to be admitted when the requested access policy is HCCA, all of the following shall be true:
   1) The dot11NonAPStationAuthHCCAHEMM value is true.
   2) The sum of the mean data rate of all the requesting STA's active TSs having access policy set to HCCA plus the mean data rate in the TSPEC is less than or equal to dot11NonAPStationAuthMaxHCCAHEMMRate in the non-AP STA's dot11InterworkingEntry.
   3) The delay bound that will be provided by the HC in the TSPEC response is less than or equal to dot11NonAPStationAuthHCCAHEMMDelay in the non-AP STA's dot11InterworkingEntry.

If the DMG TSPEC is admitted, the PCP/AP shall set the ResultCode to SUCCESS_STA_IN_DOZE_MODE if the STA identified by destination AID is in power save mode and shall include in the ADDTS Response frame the Wakeup Schedule element of the destination DMG STA if one is established. In this case, the PCP/AP should defer including the TS schedule in the Extended Schedule element until both source DMG STA and destination DMG STA are in active mode.

The HC/non-AP's MLME transmits an ADDTS Response frame containing this TSPEC or DMG TSPEC and status. The encoding of the ResultCode values to Status Code field values is defined in Table 8-37. The PCP/AP shall transmit the ADDTS Response frame to the STAs identified as source and destination AID of the DMG TSPEC contained in the ADDTS Request frame if the ADDTS Request it is sent by a non-PCP/non-AP STA. If the ResultCode is SUCCESS, the PCP/AP shall announce the creation of the allocation by setting the Allocation ID field in the TSPEC element sent in the ADDTS Response frame to a nonzero value and also by including the allocation schedule in the Extended Schedule element transmitted in the DMG Beacon frame or Announce frame.

The STA's MLME receives this management frame and cancels its ADDTS timer. It generates an MLME-ADDTS.confirm primitive to its SME containing the TSPEC or DMG TSPEC and status.

The SME decides whether the response meets its needs. How it does this is beyond the scope of this standard. A SME receiving a modified TCLAS element having a Classifier Mask field equal to 0 or Classifier Parameter subfields equal to 0 should regard these values as meaning that no suggested value has been provided by the HC.

— If the result code is SUCCESS, the TS enters into an active state.
— If the result code is REJECTED_WITH_SUGGESTED_BSS_TRANSITION, the non-AP STA may try to transition to other BSSs. In the case that the non-AP STA is recommended to transition to other BSSs, it should do so according to the process defined in 10.23.6. Once the transition is completed, it should proceed with a TS setup process with the new HC.
— Otherwise, the whole process can be repeated using the same TSID and direction, a modified TSPEC or DMG TSPEC, optional TCLAS element(s), and an optional TCLAS processing element

until the SME decides that the granted medium time is adequate or inadequate and cannot be improved.

The above rules also apply to the negotiation of the PTP TSPEC and to the negotiation of the DMG TSPEC.

The parameters that are set for a TS may be renegotiated in a similar manner, when such a request is generated by the SME through ADDTS.request primitive. When a request for the modification of the TS parameters is accepted by the HC, it shall reset both the suspension interval and the inactivity interval timers.

When a request for the modification of the TS parameters is accepted by a non-AP STA, it shall reset the inactivity interval timers.

If the HC/PCP grants medium time for an ADDTS Request frame with the Ack Policy subfield equal to Block Ack and the Direction field equal to either downlink or bidirectional, then it shall initiate a Block Ack negotiation by sending an ADDBA Request frame to the STA that originated the ADDTS Request frame. If a non-DMG STA is granted medium time for an ADDTS Request frame with the Ack Policy subfield equal to Block Ack and the Direction field equal to other than downlink, then it shall initiate a Block Ack negotiation by sending an ADDBA Request frame to the recipient of the TS.

In a non-DMG BSS, t~~T~~he combination of the TSID and Direction subfields identifies the TS, in the context of the STA, to which the TSPEC applies. A bidirectional link request is equivalent to a downlink TS and an uplink TS, each with the same TSID and parameters. In a DMG BSS, the combination of the TSID, source DMG STA AID, destination DMG STA AID, and Direction subfields identifies the TS, in the context of the non-AP STA, to which the TSPEC applies.

The same TSID may be used for multiple TSs at different STAs. A STA can use the same TSID subfield value for a downlink TSPEC and either an uplink or a direct-link TSPEC at the same time. In a non-DMG BSS, a~~A~~ non-AP STA shall not use the same TSID for both uplink and direct-link TS. In a DMG BSS, a non-AP STA as a source DMG STA can use the TSID subfield value for an uplink PTP TSPEC, and at the same time the non-AP STA as a destination DMG STA can use the same TSID subfield value for a downlink PTP TSPEC.

If the TS Info Ack Policy subfield of a TSPEC element is Block Ack and the type of Block Ack policy is unknown to the HC, the HC assumes, for TXOP scheduling, that the immediate Block Ack policy is being used (see 9.21).

An HC shall be capable of receiving an ADDTS request frame that contains a TCLAS element and capable of generating an indication that contains this as a parameter.

When a STA requests service at a higher priority than authorized by its dot11InterworkingTableEntry, the HC may optionally provide a suggested TSPEC with a data rate and lower priority that would be authorized. Usage of the TSPEC in an Interworking environment is described in Annex N.

A STA may include a U-PID element in ADDTS Request and ADDTS Response frames transmitted by the STA. The U-PID element is used to indicate the protocol responsible for handling MSDUs corresponding to the TID indicated within the frame carrying the U-PID element. If a U-PID element is not included in an ADDTS Request frame, MSDUs corresponding to the TID contain an LLC protocol header that is used for upper layer protocol selection. A U-PID element shall not be included in an ADDTS Response frame if a U-PID element was not included in the corresponding ADDTS Request frame. If a U-PID element was included in an ADDTS Request frame, the value of the LLC header copy field within a U-PID element included in the ADDTS Response frame that has a Status Code of success and is transmitted in response to the received ADDTS Request frame shall be the same as the LLC header copy field contained in the ADDTS Request frame. The STA shall set the Status Code field to REJECT_U-PID_SETTING in the

ADDTS Response frame if it rejects the ADDTS Request frame due to the setting of the U-PID element received within the ADDTS Request frame.

All MSDUs corresponding to a TID that was successfully negotiated through the ADDTS exchange with a U-PID element shall have their LLC header stripped before transmission and the agreed LLC header added before delivery at the peer MAC-SAP.

10.4.7 Failed TS Setup

Change 10.4.7 as follows:

There are two possible types of failed TS setup:

a) The transmission of ADDTS Request frame failed.
b) No ADDTS Response frame is received from the HC/non-AP STA (e.g., because of delay due to congestion or because the response frame cannot be transmitted).

Figure 10-9 summarizes the remaining two cases. The MLME shall issue an MLME-ADDTS.confirm primitive, with a result code of TIMEOUT. In either case and for a non-DMG BSS, if the request is not for an existing TS, the MLME shall send a DELTS to the HC specifying the TSID and direction of the failed request just in case the HC had received the request and it was the response that was lost. In both cases and for a DMG BSS, if the request is not for an existing allocation or TS, the MLME shall send a DELTS to the non-AP STA specifying the Allocation ID or TSID and destination DMG STA of the failed request just in case the PCP/AP had received the request and it was the response that was lost.

In Figure 10-9, replace "HC" by "HC or non-AP STA" (in four places).

10.4.8 Data Transfer

Change the first paragraph in 10.4.8 as indicated below:

After the setup of a TSPEC or PTP TSPEC, MSDUs are classified above the MAC and are sent to the MAC through the MAC_SAP using the MA-UNITDATA.request primitive with the priority parameter encoded to the TSID.

Insert the following paragraphs after the first paragraph of 10.4.8:

In a DMG BSS, MSDUs are transmitted using QoS data frames. During each CBAP allocation, the MAC delivers MSDUs based on the priority of the transmitted QoS data frames. The MAC can transmit all MSDUs having a TSID with an associated TSPEC with an access policy of EDCA or SEMM, provided that the source AID of the CBAP allocation is equal to the source AID of the TS, or the source AID of the CBAP allocation is equal to broadcast AID, or the destination AID of the CBAP matches the destination AID of the TS.

NOTE—MSDUs having a TSID with no associated TSPEC are not transmitted.

During each SP allocation, the MAC delivers MSDUs whose TSIDs identify TSPECs that have been set up to use the SP allocation. Relative prioritization of multiple TSPECs mapped to the same SP allocation is implementation dependent and outside the scope of this standard.

When an MSDU arrives from the MAC_SAP with a TSID for which there is no associated TSPEC, the MSDUs shall be sent using EDCA with the access category AC_BE.

10.4.9 TS Deletion

Change 10.4.9 as indicated below:

There are two types of TS deletion: non-PCP/non-AP STA-initiated and HC/PCP-initiated. In both cases, the SME entity above the MAC generates an MLME-DELTS.request primitive specifying either the TS or the allocation ~~TSID and direction of the TS~~ to be deleted and the reason for deleting the TS or allocation, respectively. This causes the MAC to send a DELTS Action frame.

In a PBSS and DMG infrastructure BSS, an SP or CBAP allocation can be deleted at any point in time. A PCP/AP can delete any allocation. A non-PCP/non-AP STA can delete only allocations for which either the Source AID or Destination AID of the allocation is equal to the STA's AID. Deleting an allocation also deletes any TS that is dependent on that allocation as follows:

- Deleting an SP allocation shall also delete any TS with access policy SPCA or SEMM using the allocation.
- Deleting a CBAP allocation with Source AID different from the broadcast AID shall also delete any TS with access policy EDCA using the allocation.
- Deleting a CBAP allocation with Source AID equal to the broadcast AID shall also delete any TS with access policy EDCA using the allocation, unless there is another CBAP allocation the TS could use.

A DMG STA that receives an MLME-DELTS.request primitive for an allocation causes the MAC to send a DELTS Action frame to the PCP/AP. If the Destination AID of the allocation is different from the broadcast AID, the PCP/AP shall send a DELTS Action frame to the STA identified by the Destination AID of the allocation. The PCP/AP shall also delete the scheduling information corresponding to the allocation and contained in the Extended Schedule element.

A DMG STA that receives an MLME-DELTS.request primitive for a TS causes the MAC to send a DELTS Action frame to the peer STA of the TS.

The encoding of ReasonCode values to Reason Code field (see 8.4.1.7) values is defined in Table 8-36.

The TS or allocation is considered inactive within the initiating MAC when the ACK frame to the Action frame is received. No Action frame response is generated.

Figure 10-10 shows the case of TS deletion initiated by the non-PCP/non-AP STA and the case of TS deletion initiated by the HC/PCP.

In Figure 10-10, replace "HC" by "HC or non-AP STA" (in five places).

An HC should not delete a TSPEC without a request from the SME except due to inactivity (see 10.4.10) or an HC service change that precludes the HC from continuing to meet the requirements of the TSPEC.

All TSPECs or DMG TSPECs that have been set up shall be deleted upon disassociation and reassociation. Reassociation causes the non-PCP/non-AP STA and PCP/AP to clear their state, and the non-PCP/non-AP STA has to reinitiate the setup.

10.4.10 TS Timeout

Change 10.4.10 as indicated below:

TS timeout is detected within the HC/non-AP STA's MAC when no traffic is detected on the TS within the inactivity timeout specified when the TS was created.

For an uplink TS in a non-DMG BSS or for a TS that has the PCP/AP as the destination DMG STA in a DMG BSS, the timeout is based on the arrival of correctly received MSDUs that belong to the TS after any decryption and reassembly.

For a downlink TS in a non-DMG BSS or for a TS that has the PCP/AP as the source DMG STA in a DMG BSS, the timeout is based on the following:

— Arrival of valid MA-UNITDATA.request primitives using this TS at the MAC_SAP when the QoS data frames are sent with the Ack Policy subfield set to No Ack.
— Confirmation of correctly sent MSDUs that belong to the TS within the MAC when the QoS data frames are sent with the Ack Policy subfield set other than to No Ack.

In a DMG BSS and in the case of a TS that is established between non-AP STAs (PTP TSPEC), the timeout of the recipient is based on the arrival of correctly received MSDUs that belong to the TS within the MAC after any decryption, A-MSDU unpacking, and reassembly.

For a TS established between non-AP STAs (PTP TSPEC), the timeout of the originator is based on the following:

— Arrival of valid MA-UNITDATA.request primitives using this TS at the MAC_SAP when the QoS data frames are sent with the Ack Policy subfield set to No Ack.
— Confirmation of correctly sent MSDUs that belong to the TS within the MAC when the QoS data frames are sent with the Ack Policy subfield set other than to No Ack.

For a direct-link TS in a non-DMG BSS, inactivity is considered to have happened if one of the two following events occurs:

— The HC transmits a QoS CF-Poll frame and the polled STA returns a QoS Null immediately after a SIFS interval that contains a QoS Control field in which the Queue Size subfield contains 0.
— The HC transmits a QoS CF-Poll frame, and no QoS Null frame is received within the granted TXOP duration that indicates the queue size for related TSID. This is to ensure that the STA is actually using the assigned TXOP for the given TSID.

In a non-DMG BSS, A~~a~~ny other use of a polled TXOP delivered to the STA is considered to be activity on all direct-link TSs associated with that STA. Detection of inactivity of this type is optional.

In response to an inactivity timeout, the HC shall send a DELTS frame to the STA with the result code set to TIMEOUT and inform its SME using the MLME-DELTS.indication primitive. In response to an inactivity timeout, the AP DMG STA shall send a DELTS frame to the non-AP DMG STA with the result code set to TIMEOUT and inform its SME using the MLME-DELTS.indication primitive. In response to an inactivity timeout, the PCP DMG STA shall send a DELTS frame to the non-PCP DMG STA with the result code set to TIMEOUT and inform its SME using the MLME-DELTS.indication primitive.

In a DMG BSS when a TS is established between non-AP STAs (PTP TSPEC), then in response to a TS timeout detected within the originator non-AP STA the non-AP STA shall send a DELTS frame to the recipient non-AP STA with the result code set to TIMEOUT and inform its SME using the MLME-DELTS.indication primitive. If the TS timeout is detected within the recipient non-AP STA, the STA shall send a DELTS frame to the originator non-AP STA with the result code set to TIMEOUT and inform its SME using the MLME-DELTS.indication primitive.

The case of uplink TS timeout in which the PCP/AP is the destination DMG STA of the TS is shown in Figure 10-11.

In Figure 10-11, replace "HC" by "HC or non-AP STA" (in four places).

Insert the following subclauses, 10.4.13 to 10.4.14, after 10.4.12:

10.4.13 DMG allocation formats

10.4.13.1 General

A DMG STA manages allocations and TSs as described in 10.4.1 to 10.4.14. Using the DMG TSPEC, a DMG STA can indicate two types of allocation scheduling: isochronous and asynchronous. It should establish an isochronous allocation if it needs periodic access to the channel and does not expect to change the amount of time allocated frequently. It should establish an asynchronous allocation if it expects to make requests for channel time and wishes to reserve a minimum amount of channel time to satisfy for those requests when they occur.

10.4.13.2 Isochronous allocations

In order to request the setup of an isochronous allocation, a DMG STA shall set the Allocation Format field in the DMG TSPEC element to 1.

Following the successful admittance of a DMG TSPEC with an isochronous allocation, the PCP/AP should allocate time in the beacon interval to meet the periodicity and minimum allocation requirements specified in the DMG TSPEC element.

Referring to fields in the DMG TSPEC element, the PCP/AP should check that over each Allocation Period the sum of the time allocations is at least the Minimum Allocation. In addition, the PCP/AP should check that each individual allocation has a minimum duration of at least Minimum SP Duration. See 8.4.2.136, 9.33.6, and 9.33.6.4.

With an isochronous DMG TSPEC, the allocation period defines the period over which the channel time allocation repeats. The scheduler should check that at least the minimum allocation is made within each allocation period. The allocation may be composed of multiple SPs. The scheduler also checks that each SP making up the allocation is no shorter than the minimum SP duration. The scheduler is free to position the SPs that make up the allocation anywhere in the allocation period. The scheduler may allocate up to the maximum allocation each allocation period if resources permit.

10.4.13.3 Asynchronous allocations

A DMG STA uses the SPR frame to request channel time for asynchronous traffic.

For each TID, source DMG STA, and destination DMG STA tuple, the PCP/AP can maintain the amount of outstanding channel time that needs to be allocated. Each time it receives an SPR frame, the amount of outstanding channel time is set to the value received in the SPR frame from the source DMG STA for the identified TID and destination DMG STA. The amount of outstanding channel time is decreased by the amount allocated when channel time is schedule for that TID, source DMG STA, and destination DMG STA tuple.

A DMG STA may also use a DMG TSPEC to reserve resources for asynchronous traffic. In this case, the STA shall set the Allocation Format field in the DMG TSPEC element to 0. The PCP/AP should admit an asynchronous DMG TSPEC only if it is able to meet the minimum allocation requirements specified in the DMG TSPEC element.

With an asynchronous DMG TSPEC, the DMG STA registers the minimum allocation it expects within the allocation period while an SP request is in effect that is greater than the minimum allocation specified. In addition, the STA expects that each allocation is at least Minimum Duration microseconds in duration provided the outstanding SP request is at least that much. In admitting a DMG TSPEC, the PCP/AP should check that there are sufficient resources available to meet the TSPEC requirements.

10.4.14 PTP TS Operation

The ADDTS Request frame containing the PTP TSPEC may be sent to the peer non-AP DMG STA directly or through PCP/AP DMG STA.

A non-AP DMG STA may add TSs to an existing allocation. To do this, the non-AP DMG STA transmits an ADDTS Request frame to peer non-PCP/non-AP DMG STA to include the additional TS. The ADDTS Request frame shall contain a PTP TSPEC with the Allocation ID field set to indicate the desired allocation to carry the additional TS. A TS with EDCA access policy does not need to be added to any CBAP allocation and can use any CBAP allocation as long as the source AID of the CBAP allocation matches the source AID of the TS, or the source AID of the CBAP allocation is equal to the broadcast AID, or the destination AID of the CBAP matches the destination AID of the TS.

A non-AP DMG STA transmits an ADDTS Request frame to a peer non-AP DMG STA to add a TS to an existing allocation and to possibly communicate traffic-specific parameters such as A-MSDU subframe and Maximum MSDU Size with the peer non-AP DMG STA. The non-AP DMG STA may transmit the ADDTS Request frame directly to the peer DMG STA or to the PCP/AP. In the latter case, the ADDTS Request frame shall contain a TCLAS element with the classifier type set to Ethernet parameters; the Source Address field shall contain the address of the DMG STA that sends the ADDTS Request frame; and the Destination Address field shall contain the address of the peer DMG STA, which is used by PCP/AP to forward to the peer DMG STA.

The AP DMG STA or PCP DMG STA shall forward the received ADDTS Request frame to the DMG STA with Address equal to the Destination Address field of the Classifier. If an ADDTS Response frame is received by the AP DMG STA or PCP DMG STA in response to the forwarded ADDTS Request frame, then the AP DMG STA or PCP DMG STA shall forward the ADDTS Response frame to the DMG STA with Address equal to the Source Address field of the Classifier. The AP DMG STA and the PCP DMG STA shall not change the content of the elements included in the ADDTS Request and ADDTS Response frames.

If the DMG STA asserts the direction field to a value equal to Downlink in the PTP TSPEC included in the ADDTS Request frame, the parameters apply to the DMG STA as the receiving station. For example, in this case, the Maximum MSDU Size field indicates that the DMG STA is not able to receive MSDUs longer than the value presented in the MSDU Size field. Similarly, if the direction field indicates uplink, the DMG STA that issued the ADDTS Request frame does not send MSDUs longer than the value of the Maximum MSDU Size field.

10.5 Block Ack operation

10.5.2 Setup and modification of the Block Ack parameters

10.5.2.2 Procedure at the originator

Change list item b) in 10.5.2.2 as follows:

b) If the peer STA is a non-DMG STA, ~~C~~check whether the intended peer STA is capable of participating in the Block Ack mechanism by discovering and examining its “Delayed Block Ack” and “Immediate Block Ack” capability bits. If the recipient is capable of participating, the originator sends an ADDBA frame indicating the TID and the buffer size. If the recipient is capable of participating and the GCRGroupAddress parameter of the MLME-ADDBA.request primitive is present, the originator sends an ADDBA Request frame that includes a GCR Group Address element. All DMG STAs are capable of participating in the Block Ack mechanism.

10.5.2.4 Procedure common to both originator and recipient

Change the text in 10.5.2.4 as follows:

Once a Block Ack agreement has been successfully established between two STAs, the type of agreement thus established is dependent on the capabilities of the STAs and the contents of the ADDBA frames used to establish this agreement as defined in Table 10-2 for non-DMG STAs and in Table 10-2a for DMG STAs.

Table 10-2 remains unchanged.

Insert the following table, Table 10-2a, and note at the end of 10.5.2.4:

Table 10-2a—Types of Block Ack agreement based on capabilities and ADDBA conditions for DMG STAs

Capabilities condition	ADDBA condition	Type of BAR and BA variant	Type of Block Ack agreement
Both STAs are DMG STAs, and both DMG STAs have the BA with Flow Control field in the DMG Capabilities element equal to 1.	Block Ack Policy subfield set to 0	Compressed	HT-Immediate
Both STAs are DMG STAs, and at least one of the DMG STAs has the BA with Flow Control field in the DMG Capabilities element equal to 0.	Block Ack Policy subfield set to 0	Compressed	HT-Immediate
Both STAs are DMG STAs, and at least one of the DMG STAs has the BA with Flow Control field in the DMG Capabilities element equal to 0.	Block Ack Policy subfield set to 1	Extended Compressed	HT-Immediate
Both STAs are DMG STAs, and both DMG STAs have the BA with Flow Control field in the DMG Capabilities element equal to 1.	Block Ack Policy subfield set to 1	Extended Compressed	HT-Immediate + flow control

NOTE—If the BAR and BA variant is Extended Compressed and the Type of Block Ack agreement is HT-Immediate, use of the RBUFCAP field is implementation dependent.

10.7 DLS operation

10.7.1 General

Insert the following paragraph after the first paragraph ("DLS is a protocol ….") of 10.7.1:

Since the channel access in a DMG BSS allows DMG STAs to send frames directly to each other, DMG STAs shall not use the DLS protocol.

10.8 TPC procedures

10.8.1 General

Change the first bullet in the third paragraph of 10.8.1 as follows:

— Association of STAs with a~~n~~ PCP/AP in a BSS based on the STAs' power capability (see 10.8.2).

Change the first sentence in the fourth paragraph of 10.8.1 as follows:

If dot11SpectrumManagementRequired is true, a non-DMG STA shall not join an infrastructure BSS, MBSS, or IBSS unless the Spectrum Management bit is 1 in the Capability Information field in Beacon frames and Probe Response frames or in the Condensed Capability Information field in Measurement Pilot frames received from other STAs in the BSS, with the following exceptions:

10.8.2 Association based on transmit power capability

Change 10.8.2 as follows:

A STA shall provide a~~n~~ PCP/AP with its minimum and maximum transmit power capability for the current channel when associating or reassociating, using a Power Capability element in Association Request frames or Reassociation Request frames.

A~~n~~ PCP/AP may use the minimum and maximum transmit power capability of associated STAs as an input into the algorithm used to determine the local transmit power constraint for any BSS it maintains. The specification of the algorithm is beyond the scope of this standard.

A~~n~~ PCP/AP may reject an association or reassociation request from a STA if it considers the STA's minimum or maximum transmit power capability to be unacceptable. For example, a STA's power capability might be unacceptable if it violates local regulatory constraints or increases the probability of hidden STAs by a significant degree. The criteria for accepting or rejecting an association or reassociation on the basis of transmit power capability are beyond the scope of this standard.

10.8.4 Specification of regulatory and local maximum transmit power levels

Change the first and second paragraphs of 10.8.4 as follows:

A STA shall determine a regulatory maximum transmit power for the current channel. The STA shall use the minimum of the following:

— Any regulatory maximum transmit power received in a Country element from the AP in its BSS, PCP in its PBSS, another STA in its IBSS, or a neighbor peer mesh STA in its MBSS and
— Any regulatory maximum transmit power for the channel in the current regulatory domain known by the STA from other sources.

A STA shall determine a local maximum transmit power for the current channel by selecting the minimum of the following:

— Any local maximum transmit power received in the combination of a Country element and a Power Constraint element from the AP in its BSS, PCP in its PBSS, another STA in its IBSS, or a neighbor peer mesh STA in its MBSS and
— Any local maximum transmit power for the channel regulatory domain known by the STA from other sources.

Insert a new paragraph before the last paragraph of 10.8.4 as follows:

In a PBSS, the PCP should advertise the regulatory maximum transmit power for its operating channel in DMG Beacon frames and shall advertise it in Announce and Probe Response frames using a Country element. A PCP in a PBSS should advertise the local maximum transmit power for its operating channel in DMG Beacon frames and shall advertise it in Announce and Probe Response frames using the combination of a Country element and a Power Constraint element.

Change the last paragraph of 10.8.4 as follows:

Where TPC is being used for radio measurement without spectrum management, the inclusion of a Power Constraint element in Beacon<u>, DMG Beacon, Announce,</u> and Probe Response frames shall be optional.

10.8.6 Adaptation of the transmit power

Change the second and third paragraphs of 10.8.6 as follows:

A STA may use a TPC Request frame to request another STA to respond with a TPC Report frame containing link margin and transmit power information. A STA receiving a TPC Request frame shall respond with a TPC Report frame containing the power used to transmit the response in the Transmit Power field and the estimated link margin in a Link Margin field.<u> A DMG STA may also use the Link Measurement procedure and the DMG Link Margin element to perform TPC.</u>

An AP in a BSS<u>, PCP in a PBSS,</u> or a STA in an IBSS shall autonomously include a TPC Report element with the Link Margin field set to 0 and containing transmit power information in the Transmit Power field in any Beacon frame<u>, DMG Beacon frame, Announce frame,</u> or Probe Response frame it transmits.

10.9 DFS procedures

10.9.1 General

Change the second paragraph of 10.9.1 as follows:

This subclause describes DFS procedures that can be used to satisfy these and similar future regulatory requirements. The procedures might also satisfy comparable needs in other frequency bands and may be useful for other purposes. <u>For example, some of the procedures described in this subclause may be used for channel selection in a DMG BSS.</u>

Insert the following paragraph after the third paragraph ("STAs shall use ….") of 10.9.1:

In a DMG BSS, the following DFS procedures apply:

- Associating a STA with an AP or a PCP based on the STA's supported channels (see 10.9.2).
- Quieting the current channel so it can be tested for interference with less interference from associated STAs (see 10.9.3).
- Requesting and reporting measurements in the current and other channels (see 10.9.7).
- Selecting and advertising a new channel to assist the migration of an infrastructure BSS, IBSS, or PBSS (see 10.9.8).

Change the first sentence in the now fifth paragraph of 10.9.1 as follows:

For the purposes of DFS<u> in a non-DMG BSS</u>, the following statements apply:

10.9.2 Association based on supported channels

Insert the following subclause title immediately after the title of 10.9.2:

10.9.2.1 Association based on supported channels in a non-DMG BSS

The text formerly in 10.9.2 ("A STA shall provide … scope of this standard.") is unchanged.

Insert the following subclause, 10.9.2.2, after 10.9.2.1:

10.9.2.2 Providing supported channels upon association in a DMG BSS

A PCP/AP may advertise the regulatory domain in which it is located via a Country element in the DMG Beacon, Announce, or Information Response frame if dot11MultiDomainCapabilityEnabled is true.

A STA shall provide a PCP/AP with a list of the channels in which it can operate when associating or reassociating using a Supported Channels element in Information Request, Association Request, or Reassociation Request frames. A PCP/AP can use the supported channels list for associated STAs as an input into an algorithm used to select a new channel for the BSS. The specification of the algorithm is beyond the scope of this standard.

The PCP/AP may advertise the supported channels of associated STAs via an Information Response frame with Subject Address field set to the broadcast address and a Supported Channels element that lists the intersection of channels supported by STAs associated with the BSS, as indicated by their Supported Channels elements.

10.9.3 Quieting channels for testing

Insert the following paragraph at the beginning of 10.9.3:

A PCP/AP in a DMG BSS may measure one or more channels itself, or the PCP/AP may request associated non-PCP/non-AP STAs in the same BSS to measure one or more channels, either in a dedicated measurement interval or during normal operation. The PCP/AP in a DMG BSS may schedule a service period allocated to itself to quiet the associated STAs and use the self-allocated SP for measurement.

10.9.7 Requesting and reporting of measurements

Change the first paragraph of 10.9.7 as follows:

The response to a basic request is a basic report. It is mandatory for a STA in a PBSS or in an infrastructure BSS to generate a basic report in response to a basic request if the request is received from the PCP/AP with which it is associated, except as specified in this subclause.

Change Table 10-4 as follows:

Table 10-4—Allowed Measurement Requests

Service set	Source of request	Destination of request	Type of measurement request allowed
BSS	AP	STA	Individual or group
	STA	AP	Individual only
	STA	STA	None
IBSS, MBSS	STA	STA	Individual or group
PBSS	PCP	Non-PCP STA	Individual or group
	Non-PCP STA	PCP	Individual
	Non-PCP STA	Non-PCP STA	None

Change the 13th paragraph of 10.9.7 as follows:

A STA may enable or disable measurement requests or autonomous measurement reports from another STA by transmitting Measurement Request elements with the Enable bit set to 1 and the Request bit and Report bit set to 0 or 1, as appropriate. These elements do not require a corresponding Measurement Report element in a Measurement Report frame. All measurement requests and reports are enabled by default. A~~n~~ PCP/AP may ignore a request to disable a mandatory measurement request. All others requests shall be honored.

Insert the following paragraph at the end of 10.9.7:

The measurement request and report procedures are defined in 10.11.

10.9.8 Selecting and advertising a new channel

Insert the following subclause, 10.9.8.6, after 10.9.8.5:

10.9.8.6 Selecting and advertising a new channel in a DMG BSS

The decision to switch to a new operating channel in a BSS shall be made only by a PCP/AP. A PCP/AP may make use of the information in Supported Channel elements and the results of measurements undertaken by the PCP/AP and other STAs in the BSS to assist the selection of the new channel. The algorithm to choose a new channel is beyond the scope of this standard, but shall satisfy applicable regulatory requirements.

A PCP/AP shall inform associated STAs that the PCP/AP is changing to a new channel and maintain the association by advertising the switch using the Extended Channel Switch Announcement element in DMG Beacon frames, Announce frames, and Information Response frames until the intended channel switch time. The channel switch should be scheduled so that all non-PCP/non-AP STAs in the BSS, including STAs in power save mode, have the opportunity to receive at least one Extended Channel Switch Announcement element before the switch. A STA may ignore the Channel Switch Mode field and either cease transmissions or attempt new transmissions in the operating channel until the channel change takes effect.

A STA that receives an Extended Channel Switch Announcement element may choose not to perform the specified switch, but to take alternative action. For example, it may choose to move to a different BSS. A non-PCP/non-AP STA in an infrastructure BSS or PBSS shall not transmit the Extended Channel Switch Announcement element.

10.11 Radio measurement procedures

10.11.6 Requesting and reporting of measurements

Change Table 10-6 as follows:

Table 10-6—Allowed Measurement Requests

Service set	Source of request	Destination of request	Receiver address of radio measurement request frame
Infrastructure BSS	AP	Non-AP STA	Individual or group
	Non-AP STA	AP	Individual only
	Non-AP STA	Non-AP STA	Individual only for Direct Link within a BSS served by Qos PA; otherwise, no allowed
IBSS	Non-AP STA	Non-AP STA	Individual or group
PBSS	PCP	STA	Individual or group
	STA	PCP	Individual only
	STA	STA	None

Change the fourth paragraph of 10.11.6 as follows:

The source and destination of a measurement request shall both be a member of the same infrastructure BSS, a member of the same PBSS, or a member of the same IBSS. Measurement requests with an individual Receiver Address shall be sent only to STAs that have indicated Radio Measurement capability.

10.11.8 Triggered autonomous reporting

Change the ninth paragraph of 10.11.8 as follows:

A STA in an infrastructure BSS or PBSS shall cease all triggered autonomous reporting if it disassociates or reassociates to a different BSS (reassociation to the same BSS shall not affect triggered reporting). A STA in an independent BSS shall cease all triggered autonomous reporting if it leaves the BSS.

10.11.11 Link Measurement

Change the second paragraph of 10.11.11 as follows:

If dot11RMLinkMeasurementActivated is false in a~~n~~ PCP/AP receiving a Link Measurement Request, it shall ignore the request.

10.11.14 Multiple BSSID Set

Change the third paragraph of 10.11.14 as follows:

A Multiple BSSID element, with or without optional subelements, indicates that all PCPs/APs within the indicated range of BSSIDs transmit using a common class, channel, and antenna connector.

10.11.16 Access Delay Measurement

Change 10.11.6 as follows:

Access delay is measured by the PCP/AP's MAC layer being the average medium access delay for transmitted frames measured from the time the MPDU is ready for transmission (i.e., begins CSMA/CA access or SP access, as appropriate) until the actual frame transmission start time. Access delay measurement results are included in the BSS Average Delay element and in the BSS AC Access Delay element.

For the BSS Average Delay measurement, the PCP/AP shall measure and average the medium access delay for all transmit frames using the DCF or EDCAF over a continuous 30 s measurement window. For the infrastructure BSS AC Access Delay measurement, the PCP or QoS AP shall measure and average the medium access delay for all transmit frames of the indicated AC (see Figure 8-227) using EDCA mechanism over a continuous 30 s measurement window. The accuracy for the average medium access delay shall be ± 100 µs or better when averaged over at least 200 frames. Accuracy is not defined for measurements averaged over less than 200 frames.

10.22 Tunneled direct-link setup

10.22.1 General

Insert the following paragraph after the third paragraph ("To set up and maintain ….") of 10.22.1:

Since the channel access in a DMG BSS allows DMG STAs to send frames directly to each other, DMG STAs shall not use the TDLS protocol.

10.23 Wireless network management procedures

10.23.14 Channel usage procedures

Change the second paragraph of 10.23.14 as follows:

Implementation of Channel Usage is optional for a WNM STA. A STA that implements Channel Usage has dot11MgmtOptionChannelUsageImplemented set to true. When dot11MgmtOptionChannel-UsageImplemented is true, dot11WirelessManagementImplemented shall be true, or the STA shall be capable of acting as an S-AP within a CCSS. A STA that has a value of true for dot11MgmtOptionChannelUsageActivated is defined as a STA that supports Channel Usage. A STA for which dot11MgmtOptionChannelUsageActivated is true shall set the Channel Usage field of the Extended Capabilities element to 1.

10.23.15 Group addressed transmission service

10.23.15.1 General

Change 10.23.15.1 as follows:

The group addressed transmission service provides delivery of group addressed frames and comprises the two services, DMS and GCR. DMG STAs do not use GCR.

10.23.15.2 DMS procedures

Change the beginning of 10.23.15.2 as follows:

The directed multicast service (DMS) is a service that may be provided by an AP or DMG STA to its associated non-AP STAs or DMG STAs that support DMS, where the AP or DMG STA transmits group addressed MSDUs as individually addressed A-MSDUs.

In a PBSS, DMS is a service that may be provided by any STA to other STAs associated in the same PBSS that support DMS, where the STA transmits group addressed MSDUs as individually addressed A-MSDUs. If the PCP of the PBSS has the PCP forwarding field within the PCP's DMG Capabilities element set to 0, a non-PCP STA in the PBSS cannot employ the PCP to forward frames using DMS to another STA in the PBSS.

Implementation of DMS is optional for a WNM STA and mandatory for a robust AV streaming STA (as defined in 10.26.1). A STA that implements DMS has dot11MgmtOptionDMSImplemented set to true. When dot11MgmtOptionDMSImplemented is true, at least one of dot11WirelessManagementImplemented and dot11RobustAVStreamingImplemented shall be true, ~~and~~ dot11HighThroughputOptionImplemented shall be true for a non-DMG STA, and dot11DMGOptionImplemented shall be true for a DMG STA. A STA that has a value of true for dot11MgmtOptionDMSActivated is defined as a STA that supports Directed Multicast. A STA for which dot11MgmtOptionDMSActivated is true shall set the DMS field of the Extended Capabilities element to 1.

In the remaining text in 10.23.15.2, change "AP" to "AP or DMG STA" (in 25 places) and "non-AP STA" to "non-AP or DMG STA" (in 14 places).

10.23.15.3 GCR procedures

10.23.15.3.1 Overview

Change the second paragraph of 10.23.15.3.1 as follows:

A non-DMG STA with dot11RobustAVStreamingImplemented true shall implement the GCR procedures defined in 10.23.15.3.2 to 10.23.15.3.6. When dot11RobustAVStreamingImplemented is true, dot11MgmtOptionDMSImplemented and dot11HighThroughputOptionImplemented shall be true. A non-DMG STA that implements advanced GCR supports GCR Block Ack (10.23.15.3.7) and GCR-SP (10.23.15.3.8) and has dot11AdvancedGCRImplemented set to true. When dot11AdvancedGCRImplemented is true, dot11RobustAVStreamingImplemented shall be true. In a mesh BSS, a non-DMG STA that implements GCR has dot11MeshGCRImplemented set to true. When dot11MeshGCRImplemented is true, dot11HighThroughputOptionImplemented shall be true.

10.24 WLAN interworking with external networks procedures

10.24.3 Interworking procedures: generic advertisement service (GAS)

10.24.3.1 GAS Protocol

10.24.3.1.2 STA procedures to transmit a GAS Query

Change item a) of the first paragraph of 10.24.3.1.2 as follows:

a) The requesting STA sends a GAS Query by transmitting a GAS Initial Request frame containing a Dialog Token, an Advertisement Protocol element containing an Advertisement Protocol ID, and the GAS Query in the Query Request field. <u>If the GAS Initial Request frame requests information relative to a frequency band different from the frequency band in which the frame is transmitted, the STA shall include a Multi-band element in the GAS Initial Request frame with the Band ID, Operating Class, and Channel Number fields set to indicate to which frequency band the GAS Initial Request frame applies, with other fields within the Multi-band element being reserved. If the frame requests information relative to the frequency band in which the frame is transmitted, a Multi-band element shall not be included in the frame.</u>

10.24.3.1.4 STA procedures for transmitting the GAS Query Response

Insert the following paragraph after the second paragraph ("The GAS protocol supports ….") of 10.24.3.1.4:

If the GAS Initial Request frame that initiated the GAS transaction contains a Multi-band element, but the GAS Initial Response frame transmitted as a response does not contain a copy of the same Multi-band element, the Status Code in the GAS Initial Response frame shall be set to "The request has been declined." Otherwise, the requesting and responding STAs shall include a copy of the same Multi-band element in all subsequent GAS Initial Response, GAS Comeback Request, and GAS Comeback Response frames transmitted as part of the GAS transaction. Inclusion of the Multi-band element indicates to which frequency band the GAS transaction applies. If the GAS Initial Request frame that initiated the GAS transaction does not contain a Multi-band element, then none of the subsequent GAS Initial Response, GAS Comeback Request, and GAS Comeback Response frames transmitted as part of the GAS transaction shall include a Multi-band element.

10.27 Procedures to manage OBSS

Insert the following subclauses, 10.28 to 10.38 (including Figure 10-28 to Figure 10-38 and Table 10-15 to Table 10-18), after 10.27.4.3:

10.28 DMG beamformed link and BSS maintenance

10.28.1 Beamformed link maintenance

A pair of DMG STAs that have established a beamformed link can maintain this link. This subclause describes procedures that allow a pair of DMG STAs to maintain a beamformed link that was established between them.

A beamformed link is established as a result of the most recent success of the procedures specified in 9.35.2 if the STAs completed the SLS phase or as a result of the most recent success of the procedures specified in 9.35.6.4 if the STAs completed the BRP phase.

The DMG STAs shall negotiate the value of dot11BeamLinkMaintenanceTime or may leave it undefined as specified in 8.4a.6.

If the dot11BeamLinkMaintenanceTime has been defined as described in 8.4a.6, the DMG STAs shall implement a beam link maintenance timer to control each beamformed link. The DMG STA shall keep one beam link maintenance timer per beamformed link. After it is set, the beam link maintenance timer shall count down. The timer shall be stopped when it reaches the value zero. The beam link maintenance timer of a beamformed link shall be halted during the following periods of time:

- BTI and A-BFT of a beacon interval
- SPs and CBAPs in which the DMG STA does not participate
- When any of the DMG STAs involved in the beamformed link is in Doze state

The beam link maintenance timer shall be set to the value of dot11BeamLinkMaintenanceTime when the source DMG STA and destination DMG STA successfully complete the BRP if the beam refinement phase is performed (9.33.3) or the source DMG STA and destination DMG STA successfully complete the SLS (9.35.2) if the beam refinement phase is skipped as defined in 9.33.3.

A PCP/AP DMG STA shall set the beam link maintenance timer to the value of dot11BeamLinkMaintenanceTime when it receives a response from the non-PCP/non-AP DMG STA during the ATI or when it receives an SPR frame as a response to a Poll frame, if these frames are received using the beamformed link established with the non-PCP/non-AP DMG STA.

The non-PCP/non-AP DMG STA shall set the beam link maintenance timer to the dot11BeamLinkMaintenanceTime when it receives a request from the PCP/AP DMG STA during the ATI or when it receives a Poll or a Grant frame, if these frames are received using the beamformed link established with the PCP/AP DMG STA.

The initiator DMG STA shall set the beam link maintenance timer to the dot11BeamLinkMaintenanceTime when an immediate response or acknowledgment (ACK, BA, DMG CTS, DMG DTS) has been received from the recipient DMG STA of the beamformed link.

The recipient DMG STA shall set the beam link maintenance timer to the dot11BeamLinkMaintenanceTime after the transmission of the immediate response or acknowledgment (ACK, BA, DMG CTS, DMG DTS) has been completed to the initiator DMG STA of the beamformed link.

To prevent expiration of the beam link maintenance timer when a DMG STA does not have MSDUs to send, the DMG STA shall transmit QoS Null frames to maintain a beamformed link.

Following the expiration of the beamlink maintenance time (specified by the current value of the dot11BeamLinkMaintenanceTime variable), the destination DMG STA of the SP shall configure its receive antenna to a quasi-omni antenna pattern for the remainder of the SP and during any SP following the expiration of the beamlink maintenance time.

Any time after dot11BeamLinkMaintenanceTime has elapsed, the source DMG STA of the SP may initiate an ISS to restore the beamformed link with the destination DMG STA of the SP following the rules defined in 9.35.2. If restoration is desired sooner, the source DMG STA can also initiate the ISS before expiration of dot11BeamLinkMaintenanceTime.

The responder DMG STA of the beamformed link in the CBAP shall configure its receive antenna to a quasi-omni antenna pattern following the expiration of dot11BeamLinkMaintenanceTime except when it is involved in a frame exchange with another STA.

Any time after dot11BeamLinkMaintenanceTime has elapsed, the initiator DMG STA of the beamformed link in the CBAP may initiate an ISS to restore the beamformed link with the responder STA following the rules defined in 9.35.2. If restoration is desired sooner, the initiator STA can also initiate the ISS before expiration of dot11BeamLinkMaintenanceTime.

If a DMG STA detects degradation in the link quality between itself and another DMG STA, the DMG STA can use beam tracking or beam refinement to improve the link quality. The DMG STA can request the PCP/AP DMG STA to schedule an SP to perform BF with the other DMG STA or use a CBAP to perform BF. The DMG STA can use the A-BFT to perform BF if the other DMG STA is its PCP/AP. A PCP/AP DMG STA can perform BF with a non-PCP/non-AP DMG STA during a CBAP or by scheduling an SP between the PCP/AP DMG STA and the non-PCP/non-AP DMG STA through an Extended Schedule element transmitted in a DMG Beacon or Announce frame.

If the link quality between a PCP/AP DMG STA and a non-PCP/non-AP DMG STA degrades, but the DMG STA can still receive DMG Beacon frames with the Next A-BFT field equal to 0, the DMG STA should improve the link quality by performing RSS during the A-BFT period as described in 9.35.5.

A DMG STA may use the value of the parameter LAST_RSSI within the RXVECTOR of a received frame to decide to initiate beamforming with a peer DMG STA if the value of the LAST_RSSI parameter is different from zero (9.3.2.3.3).

Figure 10-28 illustrates the operation of the beam link maintenance timer for an example involving STA-A and STA-B. In beacon interval *n*, STA-A and STA-B successfully perform beamforming and set up the beam link maintenance timer. In beacon interval *n*+1, the STAs have two SPs established between them. The beam link maintenance timer is halted and released according to the rules described above. Once the timer beam link maintenance timer expires, the STAs redo beamforming.

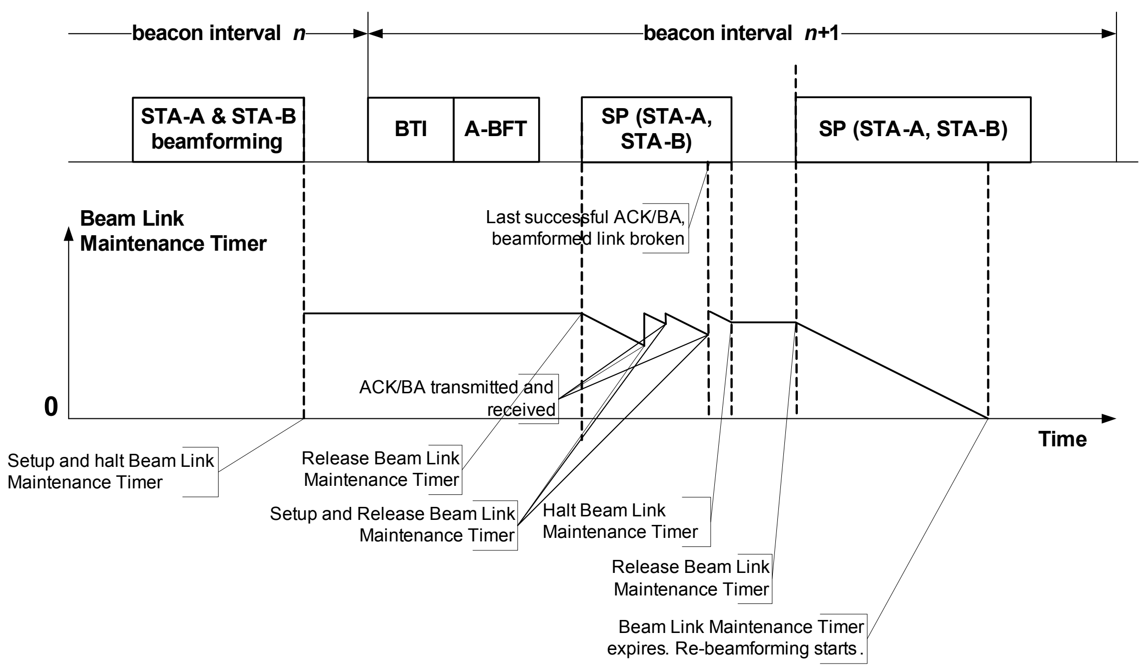


Figure 10-28—Example of beamformed link maintenance

10.28.2 PCP Handover

10.28.2.1 General

A STA is PCP handover capable if the PCP Handover field within the STA's DMG Capabilities element (8.4.2.130) is 1. The STA is PCP handover incapable otherwise.

The PCP handover process allows the information pertinent to the operation of the PBSS to be distributed to suitable PCP handover capable STA(s) and for a PCP handover capable STA to take over the PCP responsibilities from the PCP explicitly or implicitly.

The information pertinent to the operation of a PBSS includes STA information and pseudo-static scheduling information.

The STA information is comprised of the STA's AID, MAC address and DMG Capabilities element. The PCP may relay the information to all STAs in the PBSS by using the Information Response frame.

The pseudo-static scheduling information comprises pseudo-static SP and CBAP allocations carried in the Extended Schedule element (8.4.2.134).

A PCP handover capable STA supports two types of PCP Handover, explicit and implicit. In Explicit PCP Handover, the PCP explicitly selects and schedules the transfer of PCP responsibilities to another PCP handover capable STA as described in 10.28.2.2. In Implicit PCP Handover the PCP distributes the Next PCP List element (8.4.2.142) in its DMG Beacon or Announce frames and maintains the content of the NextPCP List element to facilitate the implicit handover process described in 10.28.2.3. The PCP may decide the priority of Next PCPs and update the Next PCP List based on information contained within a STA's DMG Capabilities element.

If there is at least one PCP handover capable STA in the PBSS, the NextPCP List element contains an ordered list of one or more PCP handover capable STAs that can take over the role of the PCP during implicit handover. The ordering of STAs in the NextPCP List is specified in decreasing priority order and the criteria for updating the NextPCP List are implementation specific. The PCP shall increment the Token field of the NextPCP List by 1 every time the list is changed. If there are no PCP handover capable STAs in the PBSS, the length of the NextPCP List element is 0, and Implicit PCP Handover cannot be performed.

When a PCP handover capable STA takes over the PCP responsibilities of a PBSS, the pseudo-static scheduling information shall remain unchanged. Any outstanding request for resource allocation is lost and STAs that have outstanding requests for allocation may re-request the resource allocation.

In explicit PCP handover, the PCP shall use the value of the PCP Factor when selecting the candidate PCP (see 10.1.4.3.4).

Following a PCP handover, non-PCP STAs shall attempt to transmit a frame to the new PCP within dot11MaxLostBeacons beacon intervals. If the new PCP does not receive at least one frame from an associated non-PCP STA for dot11MaxLostBeacons beacon intervals following a PCP handover, it should disassociate the STA from the PBSS.

10.28.2.2 Explicit Handover procedure

The PCP may transmit a Handover Request frame to a non-PCP STA that is handover capable. Upon receiving a Handover Request, a non-PCP STA becomes the candidate PCP. If the Handover Request is accepted, the candidate PCP shall transmit a Handover Response frame to the PCP with the Handover Result field set to 0. If the Handover Request is rejected, the candidate PCP shall transmit a Handover Response frame to the PCP with the Handover Result field set to 1, 2, or 3 and cease to be the candidate PCP.

A non-PCP STA that is handover capable may transmit a Handover Request frame to the PCP of the PBSS if the PCP is handover capable. Upon transmission of the Handover Request frame, the non-PCP STA becomes the candidate PCP. If the Handover Request is accepted, the PCP shall transmit a Handover Response frame to the candidate PCP with the Handover Result field set to 0. If the Handover Request is rejected, the PCP shall transmit a Handover Response frame to the candidate PCP with the Handover Result field set to 1, 2, or 3, and the candidate PCP shall cease to be a candidate PCP.

Following the transmission or reception of a successful Handover Response frame, a candidate PCP should request STA information and pseudo-static scheduling information from the PCP using an Information Request frame within the next dot11NbrOfChangeBeacons beacon intervals. The candidate PCP should also request SPs to perform beamforming and, if appropriate, establish a security association with other associated STAs prior to the completion of PCP handover.

Following the successful reception or transmission of a Handover Response frame, the PCP shall transmit a PCP Handover element within every DMG Beacon or Announce frame for each of the next dot11NbrOfChangeBeacons beacon intervals with the Old BSSID field set to the BSSID of the PBSS, the New PCP Address field set to the MAC address of the candidate PCP, and the Remaining BIs field set to the number of beacon intervals remaining until the candidate PCP takes over the role of PCP for the PBSS. The initial value of the Remaining BIs field shall be equal to the Remaining BI field value last transmitted by the PCP in a Handover Request frame to the candidate PCP or equal to the Remaining BI field value last received by the PCP in a Handover Request frame from the candidate PCP, whichever is later. A non-PCP STA receiving a DMG Beacon or Announce frame containing the PCP Handover element shall set the STA's local countdown counter to the value of the Remaining BIs field contained in the PCP Handover element. The STAs shall then decrease the local countdown counter by one at each TBTT, and shall use the candidate PCP's address contained in the New PCP Address field within the PCP Handover element as the new beacon filter address once the STA's local countdown reaches zero. When the countdown timer equals zero, the candidate PCP shall assume the role of PCP.

10.28.2.3 Implicit Handover procedure

Upon receiving the NextPCP List element, a PCP handover capable STA that finds its AID as the AID entry *i* in the NextPCP List element received from the PCP becomes the Implicit candidate PCP *i*. Upon detecting a Token value contained in the NextPCP List element that is different from the value of the last Token received from the PCP, each Implicit candidate PCP should request STA information and pseudo-static scheduling information from the PCP by transmitting an Information Request frame addressed to the PCP (10.29.1).

The implicit handover process is triggered at the Implicit candidate PCP *i* when the Implicit candidate PCP *i* fails to receive a DMG Beacon or Announce frames from the PCP for ($i \times$ dot11ImplicitHandoverLostBeacons) beacon intervals. When triggered, the Implicit candidate PCP *i* shall send at least one DMG Beacon frame during each of the next dot11MaxLostBeacons BTIs if the following conditions are met:

- No DMG Beacon or Announce frames are received from the PCP.
- No DMG Beacon frame carrying a PCP Handover element with the value of the Old BSSID field equal to the BSSID of the PBSS is received from an Implicit candidate PCP with a smaller index on the NextPCP List.

Each DMG Beacon sent by the Implicit candidate PCP *i* shall contain a PCP Handover element with the Old BSSID field set to the BSSID of the PBSS from which control is being taken, i.e., the previous PBSS, the New PCP Address field set to its MAC address, and the Remaining BIs field initially set to dot11MaxLostBeacons and decremented by 1 at each TBTT. A member non-PCP STA of the PBSS, after failing to receive a DMG Beacon or Announce frame for dot11MaxLostBeacons beacon intervals, should associate with the new PCP sending a DMG Beacon frame containing the PCP Handover element with Old

BSSID field equal to the BSSID of the previous PBSS and the smallest Remaining BIs field value. The Implicit candidate PCP that successfully transmits a DMG Beacon with the Remaining BIs field within the PCP Handover element equal to zero completes the implicit handover by scheduling, if appropriate, pseudo-static SPs between its member STAs following the pseudo-static scheduling information it obtained from the previous PBSS.

To avoid disruptions to pseudo-static SPs due to implicit handover, the value of dot11ImplicitHandoverLostBeacons should be lower than the value of dot11MaxLostBeacons.

10.29 DMG BSS peer and service discovery

10.29.1 Information Request and Response

A STA may request information about either a single STA in the PBSS or about all of the STAs in the PBSS by sending an Information Request frame (8.5.20.4). If the STA is requesting information about only a single STA in the PBSS, it shall set the Subject Address field in the Information Request frame to the MAC address of that STA. If the STA is requesting information about all of the STAs in the PBSS, it shall set the Subject Address field in the Information Request frame to the broadcast address and shall transmit the Information Request frame to the PCP.

A STA may transmit an Information Request frame with the length field of the Request element set to 0 to another STA in the PBSS to determine if the destination DMG STA is still present in the PBSS and is within range of the sending STA.

A STA may transmit an Information Request frame including its STA Capability element and other elements. A non-PCP STA shall not include in the Information Request frame the capability information corresponding to another STA.

The STA may transmit an Information Response frame (8.5.20.5) either unsolicited or as a response to an Information Request frame. If a STA is providing information about a single STA in the PBSS, it shall set the Subject Address field in the Information Response frame to the MAC address of that STA. If a STA is providing information about all of the STAs in the PBSS, it shall set the Subject Address field in the Information Response frame to the broadcast address.

A STA shall include in the Information Response frame the elements requested by the originator STA.

A STA shall send an Information Response frame with an empty payload in response to a received Information Request frame that solicits information about a single target STA if

- The target STA is not a member of the PBSS and the STA sending the Information Response frame is the PCP of the PBSS, or
- The target STA is not the STA sending the Information Response frame.

In all other cases, the STA shall send the Information Response frame with the information requested by the requesting STA.

10.29.2 Peer Service Discovery

A PCP/AP may provide different types of information to a non-PCP/non-AP STA upon request. To query available services in a BSS, a non-PCP/non-AP STA shall send either an Information Request frame or a Probe Request frame to the PCP/AP (10.29.1). The Information Request and Information Response frames are robust management frames, while the Probe Request and Probe Response frames are not.

Upon receiving the Information Request frame, the PCP/AP shall respond with an Information Response only if all of the following three criteria are true:

a) The SSID in the Information Request is the wildcard SSID or the specific SSID of the PCP/AP.
b) The BSSID field in the Information Request is the wildcard BSSID or the BSSID of the PCP/AP.
c) The DA field in the Information Request is the MAC address of the PCP/AP.

The PCP/AP transmits the Information Response frame to the address of the non-PCP/non-AP STA that generated the Information Request.

The Information Response frame may include vendor-specific elements.

10.30 Changing DMG BSS parameters

10.30.1 General

This subclause describes the methods used by the PCP/AP to change certain key characteristics of the BSS. It also describes a method for a non-PCP/non-AP STA to make a recommendation on those characteristics to the PCP/AP.

The PCP/AP delivers the DMG BSS Parameter Change element to STAs holding pseudo-static SPs and STAs in power save mode before a DMG BSS parameter change.

The PCP/AP shall initiate a DMG BSS parameter change by including a DMG BSS Parameter Change element (8.4.2.129) in its DMG Beacon or Announce frames. The PCP/AP places the DMG BSS Parameter Change element in every DMG Beacon or Announce frame after the DMG BSS Parameter Change element is first included in the frame, stopping in the DMG Beacon or Announce frame immediately after the DMG BSS parameter change takes effect.

10.30.2 Moving the TBTT

The PCP/AP may move the TBTT and hence move the entire beacon interval. Moving the beacon interval means that except for the beacon interval in which the change takes effect, the beacon interval duration is unchanged while the position of the TBTT is moved.

The TBTT shall not be moved by an amount that is larger than the value in the Beacon Interval field present in DMG Beacon and Announce frames in which the DMG BSS Parameter Change element is sent.

To move the TBTT to an intended new TBTT, the PCP/AP shall insert the DMG BSS Parameter Change element in DMG Beacon frames and/or Announce frames with the Move field set to 1 (8.4.2.129). The DMG Beacon frames and/or the Announce frames containing the DMG BSS Parameter Change element shall be sent at each TBTT dot11NbrOfChangeBeacons times before the TBTT is changed as indicated in the TBTT offset field.

At each transmission of the DMG BSS Parameter Change element, the TBTT Offset field shall be set to a value equal to the lower order 4 octets of the intended new TBTT.

The value of dot11NbrOfChangeBeacons shall be greater than dot11MaxLostBeacons.

NOTE—As defined in 10.1.2.1, the PCP transmits at least one DMG Beacon frame to each associated STA within a time interval that is not longer than dot11BeaconPeriod × dot11MaxLostBeacons TUs.

Announce frames shall be used to deliver the DMG BSS Parameter Change element to all STAs participating in pseudo-static SPs.

The value of the Beacon Interval field of DMG Beacon frames and the Announce frames sent at the dot11NbrOfChangeBeacons+1 TBTT shall be set to the difference of the intended new TBTT and the TBTT where the DMG Beacon or Announce frames were sent.

STAs associated with a PCP/AP that moves the TBTT shall not transmit during the beacon interval that precedes a new TBTT if the transmission time ends at the TBTT or later, even if the SP or the CBAP were scheduled in the beacon interval.

At the intended new TBTT that is dot11NbrOfChangeBeacons+2 TBTTs after the DMG BSS Parameter Change element is first transmitted, the TSF timer is reset to 0 as defined in 10.1.3.2a.

A PCP/AP member of a PCP/AP cluster that wishes to move its TBTT shall set the TBTT Offset field to an empty Beacon SP allocated by its S-PCP/S-AP as defined in 9.34.

Figure 10-29 illustrates the process in moving the TBTT position.

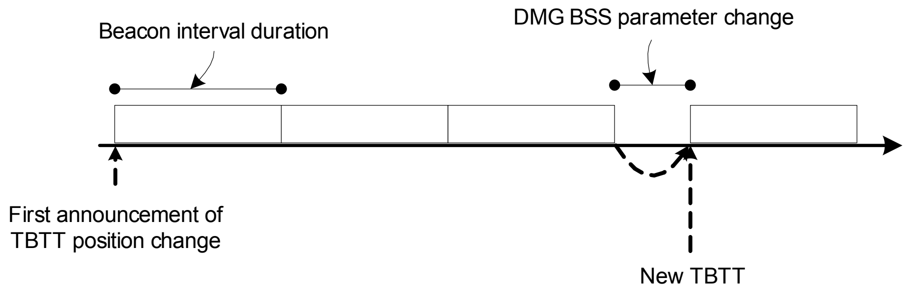


Figure 10-29—Moving the TBTT position

10.30.3 Changing beacon interval duration

The PCP/AP may change the duration of its beacon interval during the BSS operation.

To change its beacon interval, the PCP/AP shall insert the DMG BSS Parameter Change element into DMG Beacon frames and/or Announce frames with the Size field set to 1 and the BI Duration field set to the duration of the beacon interval following this DMG BSS parameter change. The TBTT Offset field shall be set to the lower order 4 octets of the TBTT at dot11NbrOfChangeBeacons+1 TBTT position when this DMG BSS parameter change takes effect.

The DMG Beacon frames and/or the Announce frames shall be sent at each TBTT dot11NbrOfChangeBeacons times before the beacon interval is changed as indicated in the BI Duration field of the DMG BSS Parameter Change element.

At each transmission of the DMG BSS Parameter Change element the TBTT Offset field shall be set to a value equal to the lower order 4 octets of the intended TBTT.

The value of dot11NbrOfChangeBeacons shall be greater than dot11MaxLostBeacons.

Announce frames shall be used to deliver the DMG BSS Parameter Change element to all STAs participating in pseudo-static SPs.

The PCP/AP that shortens the beacon interval shall not schedule SP and CBAP allocations that use more time than allowed in the beacon interval indicated in the BI Duration field of the DMG BSS Parameter Change element.

The value of the beacon interval shall be set to the BI Duration field of the DMG BSS Parameter Change element at the dot11NbrOfChangeBeacons+1 TBTT. At this TBTT, the TSF timer is reset to 0 as defined in 10.1.3.2a.

If the PCP/AP sets the Move and the Size fields to 1 in the same DMG BSS Parameter Change element, it shall set the TBTT Offset field and proceed as defined in 10.30.2. The value of the beacon interval shall be set to the BI Duration field of the DMG BSS Parameter Change element at the new TBTT as defined in 10.30.2.

Figure 10-30 illustrates the process in changing the beacon interval duration.

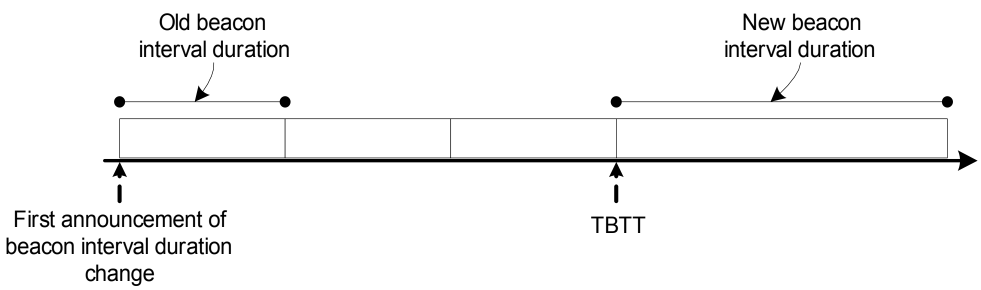


Figure 10-30—Changing beacon interval duration

10.30.4 Maintaining synchronization in a PCP/AP cluster

A S-PCP/S-AP shall update the Clustering Control field transmitted in the DMG Beacon if the DMG BSS parameter change modifies the allocation of the Beacon SPs (9.34). If the Clustering Control field is modified as a result of a DMG BSS parameter change, the S-PCP/S-AP shall transmit the updated Clustering Control field in every DMG Beacon in which the DMG BSS Parameter Change element is transmitted.

A PCP/AP member of a PCP/AP cluster receiving a S-PCP/S-AP DMG Beacon with a DMG BSS Parameter Change element indicating a change in the beacon interval duration or TBTT time shall immediately insert the appropriate DMG BSS Parameter Change element into its DMG Beacons if the S-PCP/S-AP's DMG BSS parameter change causes a modification in the allocation of the Beacon SPs.

If a PCP/AP is required to change the beacon interval or/and TBTT to participate in a PCP/AP cluster or to change the beacon interval or/and TBTT as a result of its S-PCP/S-AP's parameters change (see 9.34), it shall follow the procedures in 10.30.2 and 10.30.3.

10.30.5 Recommending DMG BSS parameters to the PCP/AP

A non-PCP/non-AP STA may make a recommendation for DMG BSS parameters to the PCP/AP by including a DMG BSS Parameter Change element in an Information Request or Information Response frame sent to the PCP/AP.

A non-PCP/non-AP STA may recommend a shift in TBTT by setting the Move subfield in the Change Type Bitmap field of the DMG BSS Parameter Change element to 1 and setting the TBTT Offset field to the lower order 4 octets of the non-PCP/non-AP STA's TSF timer at the recommended first changed TBTT. The non-PCP/non-AP should select a value for the TBTT Offset field that gives the PCP/AP enough time to exercise the change. Similarly, a non-PCP/non-AP STA may recommend a beacon interval duration to the PCP/AP by setting the Size subfield in the Change Type Bitmap field of the DMG BSS Parameter Change element to 1 and setting the BI Duration field to the recommended beacon interval duration in TUs.

A PCP/AP that receives an Information Request or an unsolicited Information Response frame from a non-PCP/non-AP STA containing a DMG BSS Parameter Change element may use the information within the element to change the DMG BSS parameters. When receiving an Information Request frame that includes the DMG BSS Parameter Change element, PCP/AP responds with an Information Response frame as specified in 10.29.1. If the PCP/AP changes the BSS parameters in the transmitted Information Response frame, the PCP/AP shall include a DMG BSS Parameter Change element reflecting the BSS parameter changes and shall use the procedure defined in 10.30.2 and 10.30.3, as appropriate, to change the BSS parameters. If the PCP/AP decides not to change the BSS parameters, it shall not include a DMG BSS Parameter Change element in the transmitted Information Response frame.

10.31 Spatial sharing and interference mitigation for DMG STAs

10.31.1 General

This subclause describes mechanisms to enable spatial sharing and interference mitigation within a PBSS/infrastructure BSS and in a uncoordinated OBSS environment.

Spatial sharing mechanisms allow SPs belonging to different STAs in the same spatial vicinity to be scheduled concurrently over the same channel, and for interference mitigation. Alternatively, the PCP/AP can use CBAPs to mitigate interference.

The SPSH and Interference Mitigation field in the DMG Capabilities element indicates whether a STA supports spatial sharing.

A STA that supports spatial sharing, as indicated in the SPSH and Interference Mitigation field equal to 1 in the STA's DMG Capabilities element, shall support the directional channel quality measurements described in 8.4.2.23.16 and 8.4.2.24.15.

10.31.2 Spatial sharing and interference assessment

The PCP/AP should request STAs to perform and report spectrum and radio resource measurements described in 10.11 to assess the possibility to perform spatial sharing and for interference mitigation.

The PCP/AP should use the directional channel quality described in 8.4.2.23.16 and 8.4.2.24.15 to assess the possibility for spatial sharing of SPs.

An SP to be assessed for spatial sharing with other scheduled (existing) SPs or considered to be reallocated in the beacon interval is hereby termed as a candidate SP. There might be multiple candidate and existing SPs at one time, and an SP may simultaneously assume the role of candidate and existing SP depending upon the context it is used for spatial sharing and interference assessment.

STAs that participate in an SP and that support spatial sharing should perform beamforming training with each other before engaging in any other communication or performing any measurements described in this subclause.

The PCP/AP should request source DMG STA and destination DMG STA involved in a candidate SP to perform measurements for the purpose of spatial sharing with an existing SP only after the STAs have beamforming trained with each other. The PCP/AP can infer that the STAs in a candidate SP have a beamformed link with each other if the Beamforming Training field within the DMG TSPEC used to set up the candidate SP was set to 1 and at least one beacon interval has elapsed since the candidate SP was first scheduled.

If the PCP/AP transmits a Directional Channel Quality Request to a STA involved in a candidate SP to assess the possibility for spatial sharing with another existing SP, it shall set the Target STA to the corresponding peer STA's MAC address involved in the candidate SP and shall set the Measurement Method field to indicate ANIPI.

If the candidate SP has already been allocated channel time, the PCP/AP should additionally transmit a Directional Channel Quality Request to the STAs involved in the existing SP to assess the possibility for spatial sharing with the candidate SP. In the Directional Channel Quality Request, the PCP/AP shall set the Target STA to the corresponding peer STA involved in the existing SP and shall set the Measurement Method field to indicate ANIPI.

NOTE—When the PCP/AP transmits a directional channel quality request to a STA of an existing SP, it intends to assess the channel quality during transmission by STAs belonging to the candidate SP. Similarly, when the PCP/AP transmits a directional channel quality request to a STA of a candidate SP, it intends to assess the channel quality during transmission by STAs belonging to the existing SP.

If a recipient STA that receives a Directional Channel Quality Request frame is already beamformed trained with the target STA specified by the AID field within the frame, then the recipient STA shall carry out the measurement employing the same receive antenna configuration as is used by the recipient STA when receiving frames from the target STA. If the AID field is set to the broadcast AID or an unknown AID, then the recipient STA shall perform the measurements using a quasi-omni antenna pattern.

Figure 10-31 illustrates an example of spatial sharing assessment between two SPs. In this example, SP1 is the existing SP and SP2 is the candidate SP. The PCP/AP transmits a Directional Channel Quality Request to STAs C and D to measure over SP1's channel allocation, and transmits a Directional Channel Quality Request to STAs A and B to measure over SP2's channel allocation. The relation of the Measurement Start Time and Measurement Duration fields in the Directional Channel Quality Request message is shown in Figure 10-31, while the field Number of Time Blocks is the ratio (Measurement Duration/Measurement Unit).

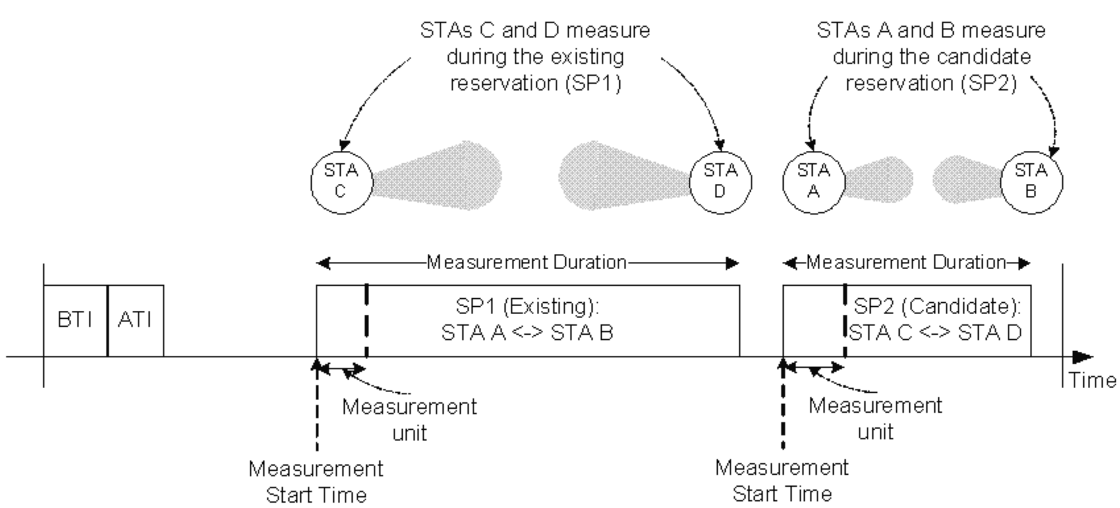


Figure 10-31—Example of spatial sharing assessment

If a non-PCP/non-AP STA receives a Directional Channel Quality Request from its PCP/AP, it should perform the measurements as indicated in the request and shall report back to the PCP/AP using the Directional Channel Quality Report. The report shall be formatted and transmitted as per specified in the Directional Channel Quality Request. The non-PCP/non-AP STA shall set the Report Mode field (8.4.2.24) in the report frame to indicate whether it performed the measurement as requested by the PCP/AP.

10.31.3 Achieving spatial sharing and interference mitigation

A PCP/AP can estimate the channel quality across STAs participating in the BSS and implement spatial sharing and interference mitigation based on the results of the measurements performed by the STAs associated with the PCP/AP.

A PCP/AP should schedule a candidate SP that overlaps with an existing SP in its beacon interval only after it receives a Directional Channel Quality Report from the STAs involved in the candidate SP.

If a candidate SP is already scheduled in the beacon interval, the PCP/AP should schedule this candidate SP time-overlapping with an existing SP in its beacon interval only after it receives a Directional Channel Quality Report from the STAs involved in the existing SP.

The PCP/AP should schedule a candidate SP during a period of time in the beacon interval where the PBSS/infrastructure BSS performance is expected to be maximized. The determination of performance maximization should be based on measurement reports received by the PCP/AP, but is implementation dependent and beyond the scope of this standard.

The decision process at the PCP/AP to perform spatial sharing of a candidate and an existing SP is implementation dependent and beyond the scope of this standard.

The candidate SP is referred to as a Time-Overlapped SP following the allocation by the PCP/AP of a candidate SP overlapping in time with an existing SP.

Figure 10-32 illustrates an example of the resulting SP schedule in the beacon interval for the spatial sharing between the two SPs shown in Figure 10-31.

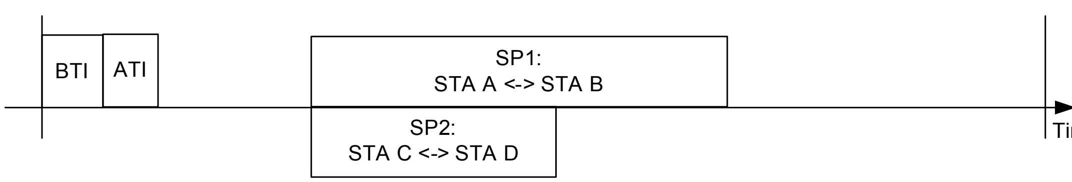


Figure 10-32—Example of spatial sharing between SP1 and SP2

The PCP/AP should periodically transmit a Directional Channel Quality Request to each spatial sharing capable STA involved in a Time-Overlapped and existing SP scheduled under spatial sharing. In the Directional Channel Quality Request that the PCP/AP transmits to each STA, the PCP/AP shall set the Target STA to the peer STA involved in the same SP and shall set the Measurement Method field to indicate RSNI.

If a spatial sharing capable non-PCP/non-AP STA receives a Directional Channel Quality Request from its PCP/AP, it should perform the measurements as indicated in the request and shall report the results back to the PCP/AP using the Directional Channel Quality Report. The report shall be formatted and transmitted as per specified in the corresponding Directional Channel Quality Request.

The PCP/AP should stop the spatial sharing of two or more SPs if it determines that the link quality of any of the links involved in the spatial sharing has dropped below acceptable levels. This determination should be based on Directional Channel Quality Reports received by the PCP/AP, but is implementation dependent and beyond the scope of this standard.

The STA may include the TSCONST field with the ADDTS Request sent to the PCP/AP for the purpose of interference mitigation. The PCP/AP should consider the information in the TSCONST field specified by a STA in its SP schedule.

Specific algorithms to realize spatial sharing and interference mitigation among SPs between different STAs is implementation dependent and beyond the scope of this standard.

10.31.4 PBSS and infrastructure BSS stability in OBSS scenarios

Except when performing FST (10.32), the PCP/AP limits the frequency with which it changes the operating PBSS/infrastructure BSS channel to alleviate the instability and ripple effect that might result from frequent channel changes in OBSS scenarios. Upon a channel switch, the PCP/AP of a PBSS/infrastructure BSS shall select a random number, N, uniformly distributed between [0, SwitchInterval-1] and shall not attempt a new channel switch until N beacon intervals have elapsed since the preceding channel switch. The initial value of SwitchInterval is aMinSwitchInterval and it is doubled upon every new channel switch up to a maximum value of aMaxSwitchInterval. The PCP/AP resets SwitchInterval to aMinSwitchInterval if it remains on the same operating channel for a minimum of aMaxSwitchInterval consecutive beacon intervals.

NOTE—The PCP/AP can keep the SP schedule stable across beacon intervals and minimize schedule changes. This is to allow for STAs to associate with the PBSS/infrastructure BSS or add or modify their SP reservations. Stability in the allocation schedule in a beacon interval allows a PBSS/infrastructure BSS to assess the interference pattern produced by OBSSs and adapt to the environment by scheduling SPs over periods of time in the beacon interval when less interference is expected.

10.32 Multi-band operation

10.32.1 General

A device is multi-band capable if the value of its local MIB variable dot11MultibandImplemented is true. A multi-band capable device is said to be a member of a BSS when one or more of the STAs in the device is a member of the BSS. A STA that is part of a multi-band capable device advertises the capability by including the Multi-band element in Beacon, DMG Beacon, (Re)Association Request, (Re)Association Response, Information Request, Information Response, Probe Request, Probe Response, Announce, FST Setup Request, FST Setup Response, TDLS Discovery Request, TDLS Discovery Response, TDLS Setup Request, and TDLS Setup Response frames.

Except for the FST Setup Request and FST Setup Response frames, which shall not include more than one Multi-band element, a STA may include more than one Multi-band element in any one of these frames if it is part of a device that supports more than two bands or channels. If a PCP/AP includes one or more Multi-band elements within a (Re)Association Response frame with Status Code equal to DENIED_WITH_SUGGESTED_BAND_AND_CHANNEL or a Probe Response frame, the order in which these elements appear in the frame indicate the order, in terms of frequency band and channel number, that the device that includes the STA addressed by the frame should attempt join the BSS following the rules applicable to the respective frequency band and channel (see 10.1). For each Multi-band element contained in the frame starting from the first one and proceeding in increasing order, the STA should attempt to join the BSS using the BSSID indicated by the BSSID field, frequency band indicated by the Band ID field and channel number indicated by the Channel Number field provided the Beacon Interval and the Channel Number fields in the Multi-band element are both nonzero.

NOTE—The first Multi-band element in the frame can refer to the current operating frequency band and channel.

A multi-band capable device shall set the Band ID and Operating Class fields within a Multi-band element to specify a frequency band it supports. If the multi-band capable device is or intends to operate in the band indicated within the Multi-band element, it shall set the Channel Number field to indicate the channel of operation within that band. If the multi-band capable device is a member of a BSS both on the channel indicated in the Channel Number field within the Multi-band element and also in the channel on which this element is transmitted, then the multi-band capable device shall set the TSF Offset field within a Multi-band element to the difference between the TSF of the BSS of which the STA is member on the channel indicated in the Channel Number field of this element and the TSF of the BSS corresponding to the BSSID indicated in the Address 3 field of the MPDU in which this element is transmitted. In all other cases, the TSF Offset field shall be set to 0.

The FST session transition is managed by FST session setup protocol. A multi-band capable device participates as an initiator or as a responder in the FST session setup. Depending on the STA's behavior during the FST session setup, the FST session can be operational in one band, or may be transferred to another band or channel in the same band, or can be operational in multiple bands and/or channels simultaneously and in this case MSDUs can be transmitted in different bands and/or channels any time an MSDU arrives at the MAC SAP. If a multi-band capable device is operational in more than one band/channel simultaneously, the STA may use the FST session setup protocol to change the operation to a single channel.

An FST session between an initiator and a responder is identified by an FSTS ID. The value of the FSTS ID is allocated by the initiator of an FST session and shall remain unchanged whether the FST session is operational in one band or more than one band simultaneously. The value of the FSTS ID shall be unique for an initiator and responder pair, and there shall be no more than one FST session between an initiator and responder pair. If an initiator or responder desires to change the FSTS ID of its existing FST session, it shall tear down the existing FST session (10.32.3) and set up a new one with a different FSTS ID value.

In each band/channel, a multi-band capable device may use the same or different MAC addresses. When the STA MAC Address Present field is 1 in a Multi-band element, the STA MAC Address field in the Multi-band element specifies the MAC address that the STA uses in the band and channel that are indicated in the Multi-band element. If the STA MAC Address Present field is 0, the MAC address that the STA uses in the frequency band and channel that are indicated in the Multi-band element is the same as the address the STA uses in the current operating band and channel.

The FST session addressing mode is Transparent if both initiator and responder of the FST session use the same MAC address in the frequency bands/channels involved in the FST session transfer. The FST session addressing mode is Nontransparent if either the initiator or responder use different MAC addresses in the different frequency bands/channels involved in the FST session. When transparent FST is used, the STA shall present a single MAC-SAP to higher layers for all frequency bands/channels in which it uses that MAC address.

An FST is allowed if the FST Setup Request and FST Setup Response frames are permitted to be transmitted as indicated in 10.3.3.

A multi-band capable device should deliver all fragments, if any, of an MSDU of an FST session before it transfers the FST session.

A multi-band capable device shall include, in any transmitted FST Setup Request and in any transmitted FST Setup Response, the capabilities element, the operation element, the EDCA Parameter Set element, Supported Rates element, Extended Supported Rates element, and Supported Channels element that are applicable to the band and channel number indicated within its most recently transmitted Multi-band element that was transmitted on the same band and channel number on which it is transmitting the FST Setup Request or FST Setup Response frames. If a Multi-band element is present in the transmitted FST

Setup Request or FST Setup Response frames, the Multi-band element is considered as the most recently transmitted Multi-band element.

If a Session Transition element and a Multi-band element are present in the same frame and the values of the Operating Class and Channel Number fields within the Multi-band element are both nonzero, the value of the Band ID field related to the new band within the Session Transition element shall be the same as the Band ID field within the Multi-band element.

10.32.2 FST setup protocol

10.32.2.1 General

The FST setup protocol comprises four states and rules for how to move from one state to the next. The states are Initial, Setup Completion, Transition Done, and Transition Confirmed. In the Initial state, the FST session is operational in one or both bands/channels. In the Setup Completion state, both initiator and responder are ready to change their currently operating band(s)/channel(s). An FST session can be fully or partially transferred to another band/channel or transferred back to one band/channel. The Transition Done state enables both initiator and responder to operate in the other band/channel if the value of the LLT was zero. Both initiator and responder have to successfully communicate in the new band/channel to reach the Transition Confirmed state. The state transition diagram of the FST setup protocol is shown in Figure 10-34.

Figure 10-33 depicts the procedure of the FST setup protocol that drives the state machine shown in Figure 10-34. The figure is only an example of the basic procedure and is not meant to be exhaustive of all possible uses of the protocol. In the figure, MLME 1 and MLME 2 represent any two MLMEs of a multi-band capable device according to the reference model described in 4.9.4. In addition, the parameter *n* corresponds to the number of FST Setup Request and FST Setup Response frame exchanges until both the FST initiator and FST responder successfully move to the Setup Completion state, as described below.

To establish an FST session in the Initial state and transfer it to the Setup Completion state of the FST setup protocol (Figure 10-34), an initiator and responder shall exchange FST Setup Request and FST Setup Response frames. An FST session exists in Setup Completion state, Transition Done state, or Transition Confirmed state. In the Initial and in the Setup Completion states, the old band/channel represents the frequency band/channel from which the FST session is to be transferred, and the new band/channel represents the frequency band/channel to which the FST session is to be transferred. In the Transition Done state, the new band/channel represents the frequency band/channel from which the FST Ack Request and FST Ack Response frames, if any, are transmitted, and the old band/channel represents the frequency band/channel from which the FST session is being transferred.

The responder shall set the Status Code field to SUCCESS if it accepts the FST Setup Request, shall set the Status Code to REJECTED_WITH_SUGGESTED_CHANGES (see 8.4.1.9) to indicate that one or more parameters of the FST Setup Request are invalid and shall suggest alternative parameters, shall set the Status Code to PENDING_ADMITTING_FST_SESSION or PENDING_GAP_IN_BA_WINDOW to indicate that an FST Setup Request is pending, and shall set the Status Code field to 37 (“The request has been declined”) to reject an FST Setup Request.

A responder that is also an enabling STA (see 10.12) may set the Status Code to REJECT_DSE_BAND to indicate that the FST Setup Request is rejected because it was initiated by a dependent STA (see 10.12) that is requesting transition to a frequency band subject to DSE procedures. In this case, if the responder is the enabling STA for the dependent STA, the responder may include a Timeout Interval element in the FST Setup Response frame to indicate the period in TUs before which it initiates an FST Setup with the dependent STA. The Timeout Interval Type field within the Timeout Interval element shall be set to 4. The responder can use the parameters in the FST Setup Request frame received from the dependent STA to initiate an FST Setup with the initiator.

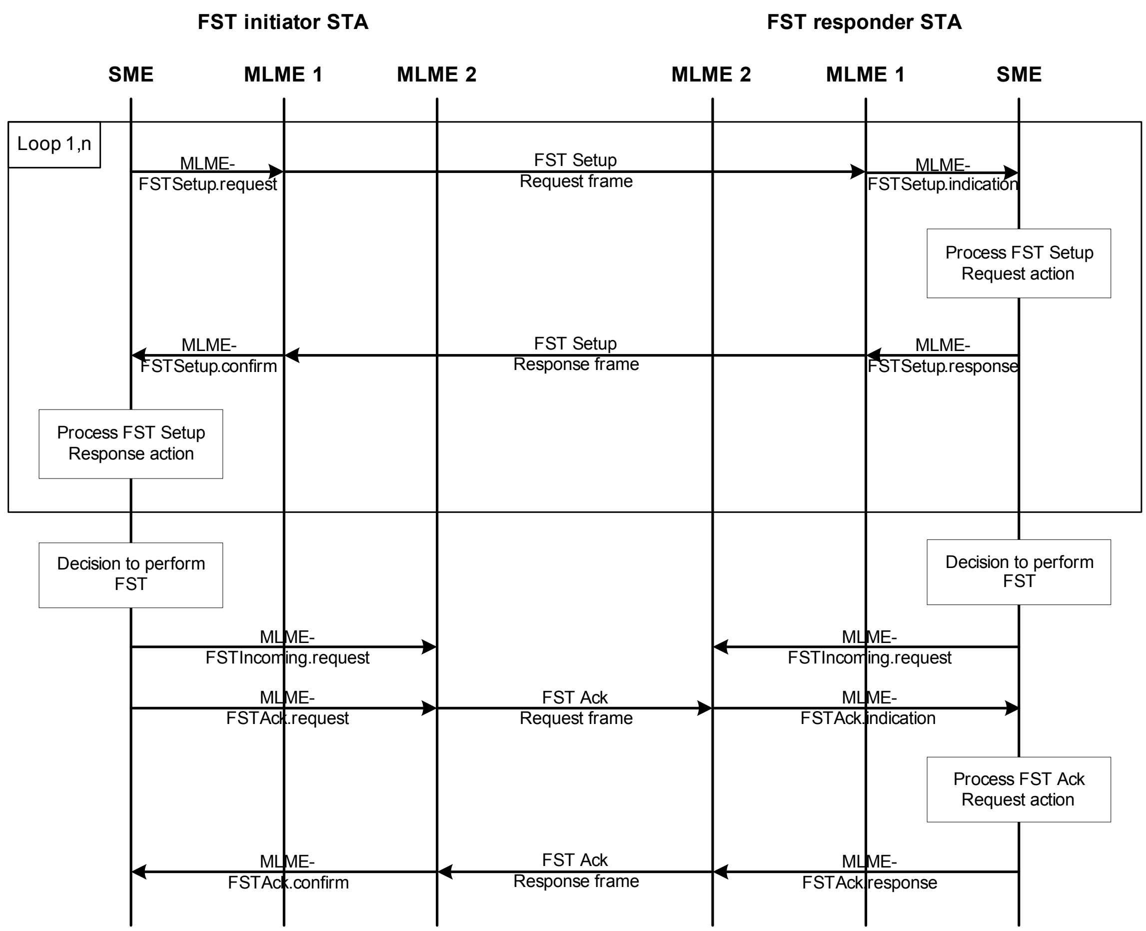


Figure 10-33—Procedure of the FST setup protocol

A responder that is also a dependent STA and not enabled shall reject all received FST Setup Request frames for transitioning to a frequency band subject to DSE procedures, except if the transmitter of the FST Setup Request frame is the enabling STA of the dependent STA.

10.32.2.2 Transitioning between states

A state transition within the FST setup protocol is controlled by the State Transition Timer (STT). Each STA maintains a STT for each FST session. The STAs shall move to the Initial state when the STT moves from 1 to 0 (other than set to 0) or upon reception or transmission of an FST Tear Down frame.

The initiator shall set the STT to the value of the FSTSessionTimeOut field at successful transmission of an FST Setup Request frame and at each ACK frame sent in response to a received FST Setup Response with the Status Code field equal to PENDING_ADMITTING_FST_SESSION or PENDING_GAP_IN_BA_WINDOW. The initiator shall set the STT to 0 at the transmission of an ACK frame sent in response to a received FST Setup Response frame with the value of the Status Code field equal to SUCCESS.

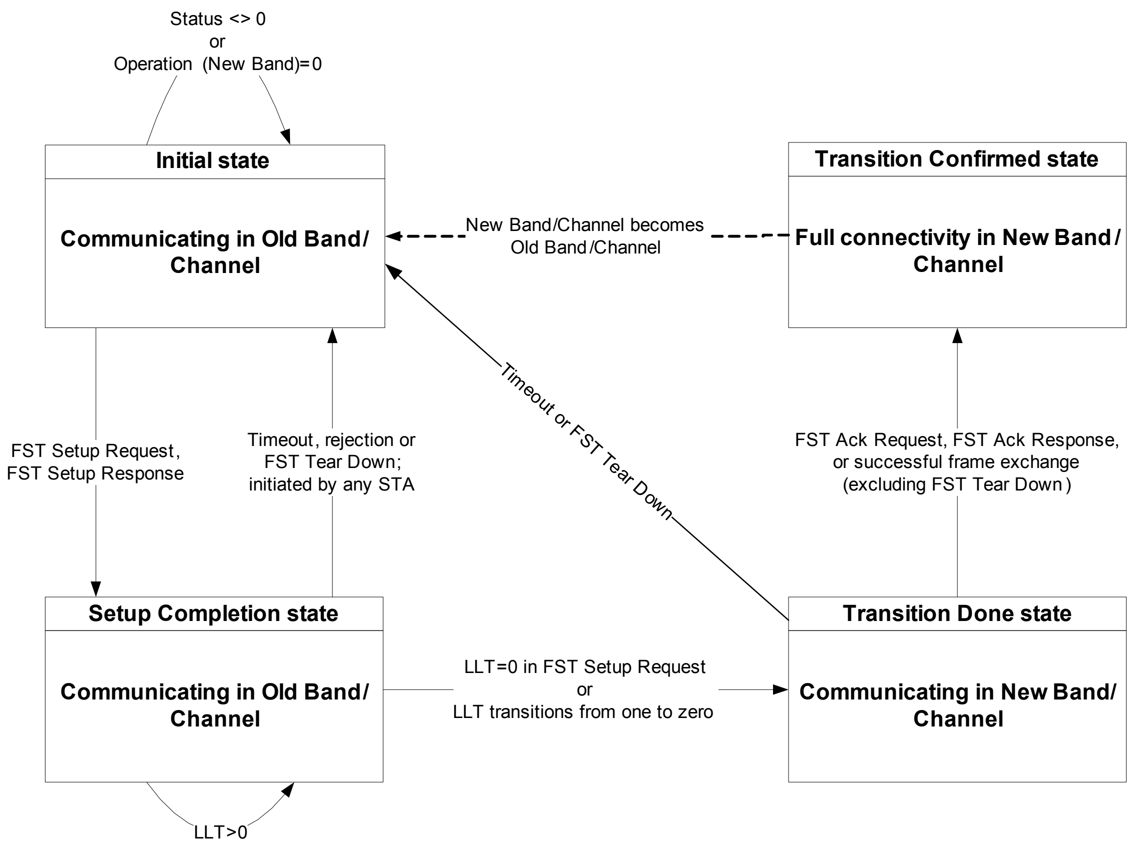


Figure 10-34—States of the FST setup protocol

The responder shall set the STT to the value of the FSTSessionTimeOut field at successful transmission of an FST Setup Response frame. The responder shall set the STT to 0 at each transmission of an ACK frame sent in response to the reception of an FST Setup Request. The responder should send an FST Setup Response frame no later than FSTSessionTimeOut after the transmission of an ACK frame sent in response to a received FST Setup Request frame or successful transmission of an FST Setup Response frame with the status code field equal to PENDING_ADMITTING_FST_SESSION or PENDING_GAP_IN_BA_WINDOW. In the latter case, the responder shall transmit the unsolicited FST Setup Response frame to the initiator.

There might be multiple FST Setup Request and FST Setup Response frame transmissions by the initiator and the responder, respectively, until the FST session between these STAs becomes established. At each transition, or attempt to transition, from the Initial state to the Setup Completion state, the initiator and responder shall perform the following procedure:

1) The initiator sends an FST Setup Request frame to the responder.
2) Upon receipt of an FST Setup Request frame, the responder shall respond with an FST Setup Response frame unless it has a pending FST Setup Request frame addressed to the initiator and the responder has a numerically larger MAC address than the initiator's MAC address, in which case, the responder shall delete the received FST Setup Request.
3) If, after the reception of the acknowledgment to the initiator's FST Setup Request frame, the initiator receives an FST Setup Request frame from the responder, the initiator shall not respond with an FST Setup Response frame if its MAC address is numerically larger (see

10.1.4.3.4) than the responder's MAC address. Otherwise, if its MAC address is numerically smaller than the responder's MAC address, it becomes the responder and responds with the FST Setup Response frame and shall not send the FST Setup Request frame during the current FST session transition.

4) The initiator shall not move to the Setup Completion state if at least one of the following conditions is met:
   a) The initiator does not successfully receive an FST Setup Response frame from the responder within the STT.
   b) The value of the Status Code field in the received FST Setup Response frame from the responder is different from SUCCESS.
   c) A state-specific exception in Table 10-15 takes place.
5) The initiator shall move to the Setup Completion state if none of conditions 4(a), 4(b), and 4(c) is met.
6) The responder shall not move to the Setup Completion state if at least one of the following conditions is met:
   a) The responder does not receive the acknowledgment to its transmitted FST Setup Response frame
   b) The value of the Status Code field in the FST Setup Response frame it transmitted to the initiator was different from SUCCESS
   c) The value of the Setup and Operation subfields within the Session Transition element in the transmitted FST Setup Response frame results in a status different from any of the rows shown in Figure 10-16, in which case the responder shall set the Status Code field with the transmitted FST Setup Response to 37 ("The request has been declined")
   d) The resulting status of the Operation subfield in the New Band field is 0.
7) The responder shall move to the Setup Completion state if none of conditions 6(a), 6(b), 6(c) and 6(d) is met.

Table 10-15—Exceptions for the initiator

State	Condition	Meaning	Next state
Initial	FST Setup Response with Status Code = 86	Pending, responder in process of admitting FST session.	Initial
Initial	FST Setup Response with Status Code = 88	Pending, Block Ack window at the responder has gaps.	Initial
Initial	FST Setup Response with Status Code = 39	One or more parameters of the FST Setup Request is invalid and the responder suggests alternative parameters.	Initial
Initial	FST Setup Response with Status Code = 37	Responder rejects the request. One particular case is that values of the operating class and channel number fields within the Multi-band element, if any, received in the FST Setup Request frame is different from the value of the corresponding fields within the Multi-band element, if any, transmitted in the following FST Setup Response.	Initial

Table 10-15—Exceptions for the initiator *(continued)*

State	Condition	Meaning	Next state
Initial	FST Setup Response with Status Code = 96	Responder rejects the request since the initiator is a dependent STA and the request is for transitioning to a frequency band subject to DSE procedures. In the rejection, the responder can include a Timeout Interval element.	Initial
Initial	Resulting status is different from shown in Table 10-16	The responder is not able to complete the setup.	Initial
Initial	Resulting status of the Operation field in the New Band field is 0 in Table 10-16	The operation in the new band is disabled.	Initial
Setup Completion	FST Setup Response with Status Code = 0 and value of the LLT field within the FST Setup Request frame is greater than zero	The STA is ready to switch to the new band if the link is lost in the old band.	Setup Completion
Setup Completion	Transmission or reception of FST Tear Down frame	Termination of FST session.	Initial

If, upon transition to the Setup Completion state, the value of the LLT field within the last successful FST Setup Request frame received by the responder or transmitted by the initiator was equal to 0, the initiator and responder shall immediately move to the Transition Done state.

If, upon transition to the Setup Completion state, the value of the LLT field within the last successful FST Setup Request frame received by the responder or transmitted by the initiator was greater than 0, the initiator and responder shall proceed as follows:

— If the last FST Setup Request or FST Setup Response frames exchanged between the initiator and responder included a Switching Stream element, then all the streams within the Switching Stream element that have the LLT Type field set to 1 shall be switched using the Stream-based Link Loss Countdown, and all the streams within the Switching Stream element that have the LLT Type field set to 0 shall be switched using the STA-based Link Loss Countdown.
— If the neither the FST Setup Request nor the FST Setup Response frames exchanged between the initiator and responder included a Switching Stream element, then the streams shall be switched using the STA-based Link Loss Countdown.

The FST transition for the STA, if STA-based, or the stream, if stream-based, from the Setup Completion state to the Transition Done state shall occur immediately after the corresponding Link Loss countdown timer transitions from 1 to 0 within any of the initiator or responder of the FST session.

An initiator and responder shall perform the STA-based and stream-based Link Loss Countdown as follows:

— STA-based Link Loss Countdown: Both initiator and responder shall remain in the Setup Completion state and start a Link Loss countdown timer with an initial value of LLT×32 µs. The Link Loss countdown is reloaded with the value of LLT×32 µs every time that an individually addressed frame is received from the peer STA of the FST session.
— Stream-based Link Loss Countdown: Both the initiator and responder shall start a Link Loss countdown timer with an initial value of LLT×32 µs for each stream identified within the Switching Stream element. The Link Loss countdown for a stream is reloaded with the value of LLT×32 µs

every time that an individually addressed frame for that stream is received from the peer STA of the FST session.

Before leaving the Setup Completion state, the initiator and responder that is performing a full FST session transfer may transmit an FST Setup Response frame in the old band with a Status Code field set to PERFORMING_FST_NOW and with the RA field set to the broadcast address as to notify other STAs in the BSS of this STA’s forthcoming full FST session transfer.

Table 10-16 shows the FST session status at each state transition. The Setup and Operation subfields shown in Table 10-16 are present within the Session Transition element. When the value of a subfield in the FST Setup Request is different from the value of that same subfield in the following FST Setup Response, the resulting status shall be the logical AND of the value of the corresponding subfields in both the FST Setup Request and the FST Setup Response.

Table 10-16—FST status at state transition

From State	Old band resulting status		New band resulting status		To State	Definition
	Setup	Operation	Setup	Operation		
Initial	1	1	0	0	Initial	New band setup and operation are disabled.
Initial	1	1	1	0	Initial	New band operation is disabled, the setup is kept alive.
Initial	0	0	1[a]	1	Setup Completion	FST session is operational in new band.
Initial	1[2]	1	1[2]	1	Setup Completion	FST session is operational in both bands.
Initial	1	0	1[2]	1	Setup Completion	FST session is operational in new band; FST session in old band is kept alive.
Setup Completion	Unchanged	Unchanged	Unchanged	Unchanged	Transition Done	No status changes.
Transition Done	Unchanged	Unchanged	Unchanged	Unchanged	Transition Confirmed	No status changes.

[a] The value of this field remains unchanged during the FST session transition.

Upon transition to the Transition Done state and if transparent FST is used, the association state (see 10.3.1) of the STA corresponding to the old band/channel is transferred to the STA corresponding to the new band/ channel.

To transition from the Transition Done state to the Transition Confirmed state, the initiator and responder shall perform the following procedure within the channel number of the operating class and band ID specified in the Multi-band element negotiated during the FST session setup:

a) The State transition is controlled by the State Transition Timer (STT). Each STA of the FST session has its own STT. The initiator and responder shall move to the Initial state when the STT moves from 1 to 0 (other than set to 0).

The initiator shall set the STT to the value of the FSTSessionTimeOut field at successful transmission of an FST Ack Request frame or at transmission of any individually addressed MPDU to responder. The initiator shall set the STT to zero at the transmission of an ACK sent in response to a received FST Ack Response from the responder or at reception of an ACK frame received in response to a frame sent to the responder.

The responder shall set the STT to FSTSessionTimeOut at transmission of an FST Ack Response frame or at transmission of any other individually addressed MPDU to the initiator. The responder shall set the STT to zero at reception of an ACK frame received in response to a transmitted FST Ack Response frame or at the reception of any individually addressed frame sent by the initiator. The responder shall transmit an FST Ack Response frame to the initiator no later than FSTSessionTimeOut after the transmission of an ACK frame sent in response to a received FST Ack Request from the initiator.

b) The SME of both the initiator and responder generates an MLME-FSTIncoming.request primitive that includes the parameters of the FST session transfer. This primitive shall be generated to the MLME associated with the channel number, operating class, and band ID specified in the Multi-band element negotiated during the FST session setup. This primitive notifies the MLME of an impending FST session transfer.

c) The initiator shall send an FST Ack Request frame or may send any other individually addressed A-MPDU, MPDU, or MMPDU to the responder.

NOTE—Depending on the BSS configuration in the new band/channel, the initiator might have to associate and/or authenticate with the BSS before it is allowed to transmit a frame to the responder.

d) Upon receipt of an FST Ack Request frame, the responder shall respond to the initiator with an FST Ack Response frame.

NOTE—Depending on the BSS configuration in the new band/channel, the responder might have to associate and/or authenticate with the BSS before it is allowed to transmit a frame to the initiator.

e) The initiator shall move to the Transition Confirmed state
   1) Upon transmission of an ACK frame sent in response to any individually addressed frame, including an FST Ack Response frame, received from the responder; or
   2) When the initiator receives an ACK frame from the responder to any non-FST Ack Request frame the initiator transmitted to the responder.

f) The responder shall move to the Transition Confirmed state
   1) When the responder receives an ACK frame in response to any individually addressed frame, including an FST Ack Response frame, sent to the initiator; or
   2) Upon transmission of an ACK frame sent in response to any individually addressed non-FST Ack Request frame.

Following the transition to the Transition Confirmed state, a STA shall adopt the role indicated in the STA Role field corresponding to the channel number, operating class and band ID that was last transmitted to the peer STA within the Multi-band element. If the STA operated within a PBSS was the initiator of the FST session and the new role of the STA is as an IBSS STA, then the STA shall be a DFS Owner of the IBSS.

In case the transition to the Transition Confirmed state was the result of a Stream-based Link Loss Countdown, the stream shall remain in the Transition Confirmed state until all the streams included within the corresponding Switching Stream element reach the Transition Confirmed state. Once all streams within the corresponding Switching Stream element reach the Transition Confirmed state or the FST session ceases to exist, the STA moves to the Initial state.

If neither the initiator nor the responder perform in the role of PCP or AP as indicated through the STA Role field within the Multi-band element corresponding to the new band for that STA, one of the STAs can initialize a new BSS (10.1, Annex R) on the new band for communication between the STAs.

If the value of the Switch intent field in the last Session Transition element transmitted to a responder is 1, an initiator may switch to the new band and channel indicated in the last transmitted FST Setup Request frame and Multi-band element, respectively, if at least one of the following conditions is satisfied:

- The value of the Status Code field within the FST Setup Response frame received in response to the transmitted FST Setup Request frame is equal to 37 ("The request has been declined").
- The initiator moves to the Initial state due to the STT at the initiator moving from 1 to 0.
- The initiator moves to the Initial state due to the reception of an FST Tear Down frame from the responder.

Immediately before a initiator switches to a new band and/or channel, the initiator shall disassociate and delete all TS and BA agreement(s) it has with a responder for which at least one of the above conditions is met.

Following the successful FST transition to a new band, the STA of the FST session shall follow the medium access rules applicable on the new band.

10.32.2.3 FST TS switching

If a STA transmitting an FST Setup Request or an FST Setup Response does not intend to switch all its streams, then the STA shall include the Switching Stream element in the transmitted frame to indicate which streams are requested to be transferred to the other band/channel. If the FST Setup Request frame includes a Switching Stream element, the FST Setup Response frame should include a Switching Stream element. If the FST Setup Request frame does not include a Switching Stream element, the FST Setup Response frame may include a Switching Stream element. If the STA transmitting the Switching Stream element has not set up a stream in the band indicated in the New Band ID field within this element, it shall set the Stream ID in New Band Valid field to 0. A STA may set up a stream in any band/channel by transmitting ADDBA Request or ADDTS Request frames that include the Multi-band element.

If a STA transmits an ADDTS Request frame to another STA with which it has established an FST session and the ADDTS Request frame is transmitted in a band or channel different from the band or channel to which the ADDTS Request is intended to apply, the ADDTS Request frame shall include the Multi-band element with the Band ID, Operating Class, and Channel Number fields set to indicate to which channel the ADDTS Request frame applies. In addition, if these STAs use the nontransparent mode for FST session transfer, the STA transmitting the ADDTS Request frame sets the STA MAC Address Present field to 1 and the STA MAC Address field to the MAC address that the STA uses in the band and channel number that are indicated in the Multi-band element contained in the ADDTS Request frame. Similar to the ADDTS Request frame, the Multi-band element shall be included in the ADDBA Request, ADDTS Response, ADDBA Response, DELTS, and DELBA frames when these frames are transmitted in a band or channel different from the band or channel to which they are intended to apply.

When using transparent mode to transfer an FST session corresponding to a TID/TSID, the Direction subfield within the TSPEC element, if any, used to set up the TID/TSID should not be set to indicate a bidirectional link. This enables the SME to use the TID/TSID in conjunction with the source and destination MAC addresses in both the old and new frequency band/channel to uniquely identify the FST session.

If any of the ADDTS variants is used to switch the TS, the PTP TSPEC or the DMG TSPEC shall be used when the TS is being established to operate in a DMG BSS, and the Basic TSPEC shall be used when the TS is being established to operate in a non-DMG BSS irrespective of the band and channel used to communicate the ADDTS frames and the DMG ADDTS frames.

The rules defined below apply when the ADDTS frames or the DMG ADDTS frames are used to switch TS. When the ADDTS frames and the DMG ADDTS frames are used, then the ADDTS requester and the ADDTS responder provide the functions defined for the ADDBA Originator and the ADDBA Recipient, respectively.

If the ADDBA Recipient includes the Switching Stream element in any of the FST Setup Request or FST Setup Response frames and if the Stream ID in New Band Valid field within the Switching Stream element is 0, the ADDBA Originator should issue the DELBA frame to reject the BA agreements indicated in the Stream ID in Old Band field. If the Originator intends to establish new BA agreements in the band indicated in the Multi-band element sent by the Recipient and with the Recipient MAC address indicated in the Multi-band element sent by the Recipient, the Originator shall transmit an ADDBA Request frame addressed to the Recipient.

The Originator may include the Multi-band element and the Ethernet type TCLAS element in the ADDBA request frame. If the MAC Addresses of the Originator and Recipient to be used in the new band are different from the MAC addresses used in the old band, then the ADDBA frame sent in the old band to establish a Block Ack in the new band shall include the Multi-band and the TCLAS elements. The resulting BA agreement, if established, applies to the band and channel identified in the Multi-band element included in the ADBBA frame. The BA is identified by the TID/TSID and MAC addresses of the Originator and the Recipient used in the band and channel indicated in the Multi-band element included in the ADDBA frames.

The ADDBA Request frame may be issued in the old band and channel, and the corresponding ADDBA Response frame may be transmitted in the band and channel indicated in the Multi-band element within the ADDBA Request frame.

The following rules for the multi-band BA establishment shall apply:

1) If the TA and/or the RA fields of the ADDBA Request frame are different from the Originator MAC address and/or the Recipient MAC address, respectively, used in the channel and band where the BA agreement should operate, then the Originator shall set the Source Address field and the Destination Address field of the classifier to the Originator MAC Address and the Recipient MAC address, respectively, to be used in the band and channel indicated in the Multi-band element included in the ADDBA Request frame.
2) If the TA and RA are equal to the Originator MAC address and the Recipient MAC address, respectively, then the Multi-band element, if any, included in the ADDBA Request frame shall indicate the band and channel over which the established BA is operating. The TCLAS element shall not be included in this ADDBA Request frame.
3) The Multi-band element should not be included in the ADDBA Request frame if in the case (2) the ADDBA Request frame is issued in the same band and channel over which the BA shall operate.
4) If the TA and/or the RA fields of the ADDBA Response frame are different from the Recipient MAC address and/or the Originator MAC address, respectively, to be used in the channel and band where the BA agreement should operate, then the Recipient shall set the Source Address field and the Destination Address field of the classifier to the Recipient MAC Address and the Originator MAC address, respectively, to be used in the band and channel indicated in the Multi-band element included in the ADDBA Response frame. The indicated band and channel shall be equal to the band and channel indicated in the Multi-band element of the ADDBA Request frame.
5) If the TA and RA fields are equal to the Recipient MAC address and the Originator MAC address, respectively, then the Multi-band element, if any, included in the ADDBA Response frame shall indicate the band and channel over which the established BA is operating. The indicated band and channel shall be equal to the band and channel indicated in the Multi-band element of the ADDBA Request frame. The TCLAS element shall not be included in the ADDBA Response frame.

6) The Multi-band element should not be included in the ADDBA Response frame if in case 5) the ADDBA Response frame is issued in the same band and channel over which the BA, if established, shall operate.

10.32.3 FST teardown

At the Setup Completion state or Transition Done state, a STA may transmit an FST Tear Down frame to its peer STA of the FST session in order to tear down an FST session that was previously set up using the FST Setup Request/Response frame exchange. Upon transmission or reception of an FST Tear Down frame, the initiator and responder move to the Initial state (10.32.2). When moving to the Initial state and if the value of the Switch intent field in the last Session Transition element transmitted to a responder is 1, the initiator behaves as described in 10.32.2.2.

10.32.4 On-channel Tunneling (OCT) operation

OCT allows a STA of a multi-band capable device to transmit an MMPDU that was constructed by a different STA of the same device. An MMPDU transmitted this way is referred to as an OCT MMPDU. The MLME of the nontransmitting STA that constructs or is the destination of an OCT MMPDU is referred to as an NT-MLME. The MLME of the STA that transmits or receives an OCT MMPDU over the air is referred to as a TR-MLME.

NOTE—OCT can be used in conjunction with or independent from the FST setup protocol.

Figure 10-35 depicts the overall OCT procedure. In this figure, <primitive> refers to the name of any of the MLME primitives defined in 6.3 that meets all of the following conditions:

— Defines request, indication, response, and confirm primitives, or just request and indication primitives.
— Includes a peer Multi-band element. The peer Multi-band element is used to identify the peer NT-MLME.
— Includes a local Multi-band element. The local Multi-band element is used to identify the local NT-MLME.

An MLME primitive meeting all of the above conditions is referred to as an OCT MLME primitive.

NOTE—MLME-AUTHENTICATE, MLME-ASSOCIATE, and MLME-REASSOCIATE are examples of primitives that are OCT MLME primitives.

To transmit a tunneled MMPDU, the SME of a multi-band capable device generates an OCT MLME request primitive that includes the peer Multi-band element and the local Multi-band element.

A NT-MLME receiving an OCT MLME request primitive shall

— As defined in this standard, process the request and construct an OCT MMPDU corresponding to the primitive in question. The NT-MLME shall not transmit any frame as a result of this primitive.
— Generate an MLME-OCTunnel.request primitive with parameters including the OCT MMPDU and the peer Multi-band element. The MLME-OCTunnel.request primitive shall be generated to the TR-MLME identified by the local Multi-band element which is contained within the OCT MMPDU.

A TR-MLME receiving an MLME-OCTunnel.request primitive shall transmit an On-channel Tunnel Request frame addressed to the peer TR-MLME and which includes the tunneled MMPDU.

A TR-MLME receiving an On-channel Tunnel Request frame shall generate an MLME-OCTunnel.indication primitive. The MLME-OCTunnel.indication primitive shall be generated to the NT-MLME identified by the peer Multi-band element contained within the received On-channel Tunnel Request frame.

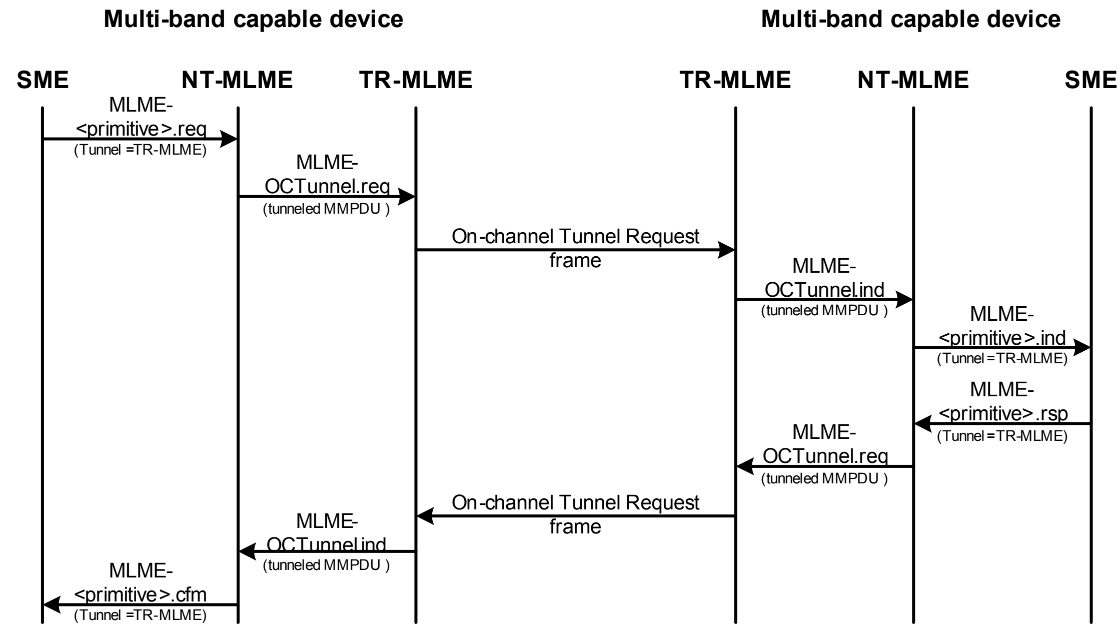


Figure 10-35—On-channel tunneling procedure

A NT-MLME receiving an MLME-OCTunnel.indication primitive shall

— As defined in this standard, process the OCT MMPDU parameter of the primitive as if the MMPDU had been received over the air.
— Generate an OCT MLME indication primitive corresponding to the frame type of tunneled MMPDU. This primitive is generated to the SME of the STA, which processes the MMPDU as defined in this standard.

In the case of a .request/.indication primitive, the process stops here. Otherwise, the process continues as described below.

The peer SME responds to the reception of an OCT MLME indication primitive by generating the corresponding OCT MLME response primitive. This response includes the peer Multi-band element and the local Multi-band element.

A NT-MLME receiving an OCT MLME response primitive shall

— As defined in this standard, process the response and construct an OCT MMPDU corresponding to the primitive in question. The NT-MLME shall not transmit any frame as a result of this primitive.
— Generate an MLME-OCTunnel.request primitive with parameters including the OCT MMPDU and the peer Multi-band element. The MLME-OCTunnel.request primitive shall be generated to the TR-MLME identified by the local Multi-band element which is contained within the OCT MMPDU.

A TR-MLME receiving an MLME-OCTunnel.request primitive transmits an On-channel Tunnel Request frame addressed to the peer TR-MLME that includes the tunneled MMPDU.

A TR-MLME receiving an On-channel Tunnel Request frame generates an MLME-OCTunnel.indication primitive. The MLME-OCTunnel.indication primitive is generated to the NT-MLME identified by the peer Multi-band element contained within the received On-channel Tunnel Request frame.

A NT-MLME receiving an MLME-OCTunnel.indication primitive

— Processes the OCT MMPDU parameter of the primitive as if the MMPDU had been received over the air.
— Generates an OCT MLME confirm primitive corresponding to the frame type of the OCT MMPDU. This primitive is directed at the SME.

10.32.5 FST payload

When FST action frames are forwarded by an AP, FST uses Ethertype 89-0d frames as defined in Annex H. In this case, the FST payload contains an FST Action frame body as is specified in 8.5.21.

10.33 MMSL cluster operation

10.33.1 Introduction

A STA is MMSL cluster capable if it includes an MMS element in its most recent transmission of (Re)Association Request, (Re)Association Response, ADDTS Request, ADDTS Response, Probe Request, Probe Response, Information Request, or Information Response frames.

An MM-SME coordinated STA shall be MMSL cluster capable, except for an MM-SME that coordinates two STAs where one STA is a member PCP/AP in a centralized PCP/AP cluster and the other STA is associated to the S-AP of the centralized PCP/AP cluster.

NOTE—In the centralized clustering case, the two STAs in the MM-SME are communicating with different MAC entities with different SMEs, so there is no individual link for MMSL.

A non-MM-SME coordinated STA may be MMSL cluster capable.

An MMSL cluster capable STA shall include an MMS element in transmitted (Re)Association Request and (Re)Association Response frames.

As described in 4.9.3, an MM-SME may coordinate multiple MACs (and their respective STAs).

Each STA coordinated by the same MM-SME may be used for the MMSL cluster setup and maintenance.

The PCP may deliver an MMS element that includes a MAC address that is equal to the BSSID and other MAC addresses that are not equal to the BSSID. The MAC addresses that are not the BSSID shall not be used to request and respond to association, reassociation, probing, and scheduling services provided by the PCP.

If a non-PCP/non-AP STA has delivered an MMS element to the PCP/AP, the non-PCP/non-AP STA shall not send an ADDTS Request frame to the PCP/AP with the TA field equal to a MAC address that was not included in the delivered MMS element.

If an MM-SME coordinated STA is associated with a PCP/AP that allocates one single AID to all STAs advertised in the MMS element sent by the MM-SME coordinated STA, the AID can be also used to identify the MMSL cluster. If the AID is provided for one of the advertised STAs of the MM-SME coordinated STA, then the same AID applies to all STAs whose addresses are referenced in the delivered MMS element and the Single AID field is set as per Table 8-183t.

Table 10-17 covers the possible cases of the AID use for MMSL cluster identification.

Table 10-17—Setting of Single AID field

MMSL cluster configuration	Is the Single AID allocated to the MM-SME coordinated STA A?	Is the Single AID allocated to the MM-SME coordinated STA B?	AID identification of MMSL cluster
Non-PCP/non-AP MM-SME coordinated STA A is associated to PCP MM-SME coordinated STA B.	Yes	Yes	Yes
Non-PCP/non-AP MM-SME coordinated STA A and non-PCP/non-AP MM-SME coordinated STA B are both associated to the same BSS.	Yes	Yes	Yes
Non-PCP/non-AP MM-SME coordinated STA A is associated to a BSS and non-PCP/non-AP MM-SME coordinated STA B is not associated to the BSS.	Yes	No	No
Non-PCP/non-AP MM-SME coordinated STA A and non-PCP/non-AP STA B are both associated to the same BSS.	Yes	NA	Yes
Non-PCP/non-AP MM-SME coordinated STA A is associated to a BSS and one MAC entity of non-PCP/non-AP MM-SME coordinated STA B is associated to the same BSS.	Yes	NA	Yes

10.33.2 MMSL cluster setup

10.33.2.1 General

To establish an MMSL cluster, an MMS element of an MM-SME coordinated STA that lists its advertised STAs shall be delivered to the peer STA. The peer STA may be an MM-SME coordinated STA or a non-MM-SME coordinated STA. An MMSL cluster is identified by one of the following:

a) Advertised MAC addresses of the MAC entities of two MM-SME coordinated STAs
b) Advertised MAC addresses of the MAC entities of an MM-SME coordinated STA and of a non-MM-SME coordinated STA

In both cases, the MMS element shall be exchanged between the STAs to set up the MMSL cluster agreement.

If an MMSL cluster capable non-MM-SME coordinated STA receives an ADDTS Request frame that includes an MMS element, the SME of the non-MM-SME coordinated STA shall include the received MMS element in the MLME-ADDTS.response primitive used to send the ADDTS Response frame if the SME accepts the MMSL cluster setup. The SME of the non-MM-SME coordinated STA may set the MMS Element Owner field to “no Owner” in the MMS element included in an MLME-ASSOCIATE.request primitive and MLME-ADDTS.request primitive to establish the MMSL cluster with an MM-SME coordinated STA.

The MMS element shall be exchanged between the STAs of the MMSL cluster only once per MMSL cluster setup.

10.33.2.2 MMSL cluster setup of non-PCP/non-AP MM-SME coordinated STA with PCP/AP

The Association Request and Response frames are used to establish an MMSL cluster between a non-PCP/non-AP MM-SME coordinated STA and a PCP/AP. The MMS Control field within the MMS element included in the Association Request and Response frame should be asserted as per 8.4.2.155. If the PCP/AP is not an MM-SME coordinated STA, the PCP/AP shall include the MMS element received from the non-PCP/non-AP MM-SME coordinated STA in the Association Response frame sent as response. If the PCP/AP is an MM-SME coordinated STA, the PCP/AP should include its own MMS element that contains its advertised MAC entities in the Association Response frame and shall not include the MMS element received from the non-PCP/non-AP MM-SME coordinated STA in the Association Response frame. The PCP/AP shall not respond with any MMS element if it is not MMSL cluster capable.

The setup of the MMSL cluster fails if the Association Response frame does not contain the MMS element.

10.33.2.3 MMSL cluster setup of non-PCP/non-AP STA with another non-PCP/non-AP STA

If a non-PCP/non-AP MM-SME coordinated STA associated with a PCP/AP has established an AID identified MMSL cluster with the PCP/AP, the non-PCP/non-AP MM-SME coordinated STA shall not use a MAC address that was not included in the MMS element delivered to the PCP/AP to establish an MMSL cluster with another non-PCP/non-AP MM-SME coordinated STA associated with the same PCP/AP.

An ADDTS Request/Response frame exchange with a PTP TSPEC shall be used to establish the MMSL cluster between non-PCP/non-AP MM-SME coordinated STAs and between a non-PCP/non-AP MM-SME coordinated STA and a non-PCP/non-AP non-MM-SME coordinated STA.

A non-PCP/non-AP MM-SME coordinated STA shall include an MMS element that contains its advertised MAC entities in transmitted ADDTS Request frames. The MMS Control field within the transmitted MMS element should be asserted as per 8.4.2.155. If the non-PCP/non-AP STA is not an MM-SME coordinated STA, the non-PCP/non-AP STA should include the MMS element with the MMS Element Owner field set to “no Owner” in the ADDTS Request frame.

The non-PCP/non-AP MM-SME coordinated STA shall include its own MMS element that contains its advertised MAC entities in transmitted ADDTS Response frames. The MMS Control field within the transmitted MMS element should be asserted as per 8.4.2.155. The non-MM-SME coordinated STA may include the MMS element of the MM-SME coordinated STA from which it received an ADDTS Request frame in the ADDTS Response sent as response. The non-MM-SME coordinated STA shall not respond with any MMS element if it is not MMSL cluster capable.

The setup of the MMSL cluster fails if the ADDTS Response does not contain the MMS element.

10.34 DMG coexistence with non-IEEE-802.11 systems

This subclause describes the features available in this standard to improve coexistence with other DMG systems, including IEEE Std 802.15.3c™.

The same common channelization that is defined in other DMG standards and specifications is adopted (21.3.1). In regulatory domains where 2 or more channels are defined, a DMG STA should support at least 2 channels.

An AP should not start an infrastructure BSS on a channel where the signal level is at or above aDMGDetectionThres or upon detecting a valid IEEE 802.15.3c CMS preamble at a receive level equal to or greater than –60 dBm.

If a DMG STA is capable of performing directional channel measurements (10.31) to detect non-IEEE-802.11 transmissions on a channel, it can report the results of the measurements to the DMG STA's PCP/AP.

If a DMG STA detects a non-IEEE-802.11 transmission on its channel or if the PCP/AP receives a report (10.11) from a DMG STA on a non-IEEE-802.11 transmission, the following mechanisms might be used to mitigate interference:

- Change operating channel (10.9)
- Beamforming (9.35)
- Reduce transmit power (10.8)
- Perform FST (10.32)
- Move the TBTT (10.30.2), and thus the beacon interval, in the case of an AP or PCP
- Change the schedule of SPs and CBAPs in the beacon interval (8.4.2.134) in the case of an AP or PCP
- Defer transmission for a later time
- For periods of time in the beacon interval where the DMG STA experiences poor channel quality, the DMG STA can use the TSCONST field within the DMG TSPEC element (8.4.2.136) to request its PCP/AP to avoid scheduling an SP for that DMG STA during those periods of time in the beacon interval.

10.35 DMG relay procedures

10.35.1 General

Relaying allows a source relay endpoint DMG STA (REDS) to transmit frames to a destination REDS with the assistance of another DMG STA called the relay DMG STA (RDS). Relaying can improve the reliability of communication in a DMG BSS in case the direct link between the source REDS and the destination REDS is disrupted.

A STA is a REDS if both dot11REDSActivated and dot11RelayActivated are true. A REDS shall set the Relay Usability field within its Relay Capabilities element to 1. A STA is an RDS if both dot11RDSActivated and dot11RelayActivated are true. An RDS shall set the Relay Supportability field within its Relay Capabilities element to 1. A STA is relay capable if dot11RelayActivated is true and it is either a REDS or an RDS or both, and it is relay incapable otherwise.

A relay capable STA shall advertise its capability by including the Relay Capabilities element in (Re)Association Request, (Re)Association Response, Probe Request, Probe Response, Information Request, and Information Response frames. An AP or relay capable PCP may include the Relay Capabilities element in DMG Beacon frames.

For a STA to operate as a REDS or an RDS in an Infrastructure BSS or PBSS, the following conditions shall be met:

- The STA is a member of the Infrastructure BSS or PBSS.
- The TDDTI field within the DMG STA Capabilities element of the PCP/AP of the BSS is 1.
- The Relay permission field within the Relay Capabilities element of the PCP/AP of the BSS is 1.

After an RDS selection through the common relay setup procedures defined in 10.35.2 and prior to data frame transmission, a source REDS, a destination REDS and an RDS shall establish pair-wise authentication among these STAs if the dot11RSNAEnabled variable for any of these STAs is true.

A source REDS, a destination REDS and an RDS can establish the types of relay operation as specified in 9.39.

As needed, in the following subclauses, source REDS, RDS, and destination REDS are expressed as ‘S’, ‘R’, and ‘D’, respectively. Also, a direct link between STA S and STA D can be simply referred to as ‘S-D’ link.

10.35.2 Common relay setup procedures

10.35.2.1 Introduction

This subclause describes the procedures that a source REDS, a destination REDS, and an RDS employ to set up a relay operation among these STAs. These procedures are used for both link switching and link cooperating relays, and shall be performed in the order shown in this subclause.

10.35.2.2 Relay capabilities and RDS discovery procedures

A source REDS can obtain the capabilities of other STAs in the BSS following the STA’s association with the BSS or with the transmission of an Information Request frame as described in 10.29.1.

A source DMG STA that intends to set up relay operation with a destination DMG STA shall obtain the capabilities of the destination DMG STA prior to initiating the relay setup procedure with the destination DMG STA. The source DMG STA may attempt to set up relay operation with the destination DMG STA only if both the source DMG STA and destination DMG STA are REDS, and there exists at least one RDS in the BSS.

Upon receiving an MLME-RELAYSearch.request primitive, the source DMG STA can discover a list of RDSs in the BSS by transmitting a Relay Search Request frame to the PCP/AP with the destination REDS AID field set to the AID of the destination DMG STA. The MLME of the PCP/AP receiving a Relay Search Request frame shall generate an MLME-RELAYSearch.indication primitive. Upon receiving an MLME-RELAYSearch.response primitive, the PCP/AP shall transmit a Relay Search Response frame addressed to the requesting STA and shall include in the transmitted frame a list of RDSs in the BSS. The MLME of the source DMG STA receiving a Relay Search Response frame shall generate an MLME-RELAYSearch.confirm primitive. After the transmission of the Relay Search Response frame to the source DMG STA, the PCP/AP shall transmit an unsolicited Relay Search Response frame to the destination DMG STA with the Relay Capable STA Info field of the source DMG STA and the list of RDSs that the PCP/AP included in the last Relay Search Response frame transmitted to the source DMG STA.

10.35.2.3 RDS selection procedure

Following the transmission of a Relay Search Response frame, the PCP/AP should schedule within its Extended Schedule element two SPs for each RDS included in the transmitted Relay Search Response frame:

- An SP having as source DMG STA the source REDS and as destination DMG STA the RDS, and with the Beamforming Training field set to 1. The duration of the SP should be such that the source REDS and RDS can complete BF as described in 9.35.
- An SP having as source DMG STA the RDS and as destination DMG STA the destination REDS, and with the Beamforming Training field set to 1. The duration of the SP should be such that the RDS and the destination REDS can complete BF as described in 9.35.

After the RDS completes BF with both the source REDS and destination REDS, the source REDS shall send a Multi-Relay Channel Measurement Request frame to the RDS, which shall respond with the transmission of a Multi-Relay Channel Measurement Report frame back to the source REDS. Following the reception of this frame, the source REDS should perform BF with the destination REDS as described in 9.35, and once BF is completed the source REDS shall transmit a Multi-Relay Channel Measurement Request frame to the destination REDS. In response, the destination REDS shall transmit a Multi-Relay Channel Measurement Report frame to the source REDS including the channel measurement information between the destination REDS and all RDSs known to the destination REDS. To shorten the time it takes to complete this procedure, STAs can limit BF to the SLS phase only.

Once this procedure is completed, the source REDS becomes aware of all the channel measurement information between the source REDS and zero or more RDSs and between the destination REDS and zero or more RDSs. The source REDS shall then select a single STA to operate as the RDS between the source REDS and the destination REDS. The selection of the RDS is implementation-dependent, and it can be based on information contained within an RDS's Relay capability element and channel measurements.

10.35.2.4 RLS procedure

Following the selection of the RDS to be used between the source REDS and the destination REDS, the source REDS receiving an MLME-RLS.request primitive initiates the RLS procedure by sending an RLS Request frame to the selected RDS. The RLS Request frame includes the capabilities and the AIDs of the source REDS, the destination REDS, and the RDS, and the relay transfer parameter set. Upon receiving the RLS Request frame, the RDS shall transmit an RLS Request frame to the destination REDS containing the same information as received within the frame body of the source REDS's RLS Request frame.

The MLME of the destination REDS receiving a Relay Search Request frame shall generate an MLME-RLS.indication primitive. Upon receiving an MLME-RLS.response primitive, the destination REDS shall transmit an RLS Response frame to the RDS with the destination status code field set to SUCCESS if the destination REDS is willing to participate in the RLS, and set to 37 ("The request has been declined") if the destination REDS is not willing to participate in the RLS. Upon receiving the RLS Response frame, the RDS shall transmit an RLS Response frame to the source REDS containing the same information as received within the destination REDS's RLS Response frame, with the exception that the RDS shall set the relay status code field to SUCCESS if the RDS is willing to participate in the RLS, and shall set it to 37 ("The request has been declined") if the RDS is not willing to participate in the RLS.

The MLME of the source DMG STA receiving an RLS Response frame from the RDS shall generate an MLME-RLS.confirm primitive. Upon receiving an RLS Response frame with the destination status code and relay status code fields set to SUCCESS, the source DMG STA may transmit an RLS Announcement frame to the PCP/AP to indicate that the RLS procedure was successfully completed. If either or both of the destination status code and relay status code fields are nonzero, the RLS procedure is unsuccessful.

Upon the completion of RLS procedure, the source REDS, the destination REDS, and the RDS can redo BF among them.

10.35.3 Relay operation-type change procedure

The source REDS may change the relay operation type from link switching to link cooperating, and vice-versa, if either one of S-D, or S-R, or R-D links becomes unavailable or for other reasons. Link unavailability can be determined by the source DMG STA not receiving expected frames from the destination REDS. To assist in this decision, the source REDS can use the link adaptation procedure (9.39.4) to obtain the quality of a link.

To change the relay operation type within an SP from link cooperating to link switching in a case that the S-D link becomes unavailable, the source REDS shall transmit a ROC Request frame to the RDS with the link cooperating subfield set to 0 and the relay-link subfield set to 1. Upon receiving a ROC Request frame, the RDS shall transmit a ROC Request frame to the destination REDS containing the same information as received within the frame body of the source REDS's ROC Request frame. Following the reception of a

ROC Request frame, the destination REDS shall respond with a ROC Response frame to the RDS with the status code field set to SUCCESS if the destination REDS accepts to change the operation into link switching, and set to 37 (“The request has been declined”) if the destination REDS rejects the request. Upon receiving the ROC Response frame, the RDS shall transmit a ROC Response to the source REDS with the status code field set to SUCCESS only if the RDS accepts to change the operation into link switching and the status code field set to SUCCESS in the ROC Response frame received from destination REDS. Otherwise, the RDS shall set the status code field to 37 (“The request has been declined”). Upon reception of a ROC Response from the RDS with the status code field set to SUCCESS, the source REDS immediately starts to transmit frames to the destination REDS via the RDS relay link.

To change the relay operation type from link cooperating to link switching in other case that the S-R link becomes unavailable, the source REDS shall a ROC Request frame to the destination REDS with the link cooperating subfield set to 0 and the relay-link subfield set to 0. Following the reception of a ROC Request frame, the destination REDS shall respond with a ROC Response frame to the source REDS with the status code field indicating the acceptance or rejection of the request. Upon reception of a ROC Response from the destination REDS with the status code field set to SUCCESS, the source REDS starts to transmit frames to the destination REDS via the direct link in link switching mode.

To change the relay operation type within an SP from link switching to link cooperating, the source REDS shall transmit a ROC Request frame to the destination REDS via the RDS with the link cooperating subfield set to 1. Following the reception of a ROC Request frame from the RDS, the destination REDS shall respond with a ROC Response frame to the source REDS via the RDS with the status code field indicating the acceptance or rejection of the request. Upon reception of a ROC Response frame from the RDS with the status code field set to SUCCESS, the source REDS immediately starts to transmit frames to the destination REDS using the RDS in link cooperating mode. If a TPA procedure was not performed beforehand since the link switching operation has been continued from the start of relay operation, the STA shall perform the TPA procedure before transmitting using link cooperating mode.

NOTE—As described in 9.39.3.2.3, during the SP in link cooperating operation the destination REDS has its receive antenna pattern such that it simultaneously covers the links towards both the source REDS and the RDS.

10.35.4 Relay teardown

A source REDS that has successfully completed the RLS procedure with a destination REDS may teardown the relay operation between the source REDS, destination REDS and RDS. To do that, the source REDS shall transmit an RLS Teardown frame to the RDS, destination REDS and PCP/AP of the BSS. Within the RLS Teardown frame, the source REDS shall set the source AID field to the AID of the source REDS, the destination AID field to the AID of the destination REDS and the relay AID field to the AID of the RDS.

A RDS may teardown the relay operation between the source REDS, destination REDS and RDS. To do that, the RDS shall transmit an RLS Teardown frame to the source REDS, destination REDS and PCP/AP of the BSS. Within the RLS Teardown frame, the RDS shall set the source AID field to the AID of the source REDS, the destination AID field to the AID of the destination REDS and the relay AID field to the AID of the RDS.

10.36 Quieting adjacent DMG BSSs

10.36.1 General

An AP that supports QAB shall set the QAB Capability field within the AP’s Extended Capabilities element to 1 and shall set the QAB Capability field to 0 otherwise. In addition, if an AP supports QAB, the AP shall also support scheduling SPs as defined in 9.33.6.

10.36.2 Procedure at the requester AP

Upon receipt of an MLME-QAB.request primitive, an AP shall perform the following procedure to start the Quiet Adjacent BSS operation (Figure 10-36):

a) If both the requester and responder APs are QAB capable as indicated by the QAB Capability field within the Extended Capabilities element, the requester AP sends a QAB Request frame indicating the duration, period, offset, and number of the quiet intervals. The requester AP may include multiple Quiet Period Request elements in one frame targeting multiple responder APs.

b) If a QAB Response frame is received with the matching dialog token and request token with a status code set to a value of SUCCESS, the AP has confirmed the responder AP has scheduled the requested quiet periods, and the MLME shall issue an MLME-QAB.confirm primitive indicating the success of the procedure.

c) If a QAB Response frame is received with the matching dialog and request token with a status code set to a value other than SUCCESS, the procedure is considered to have failed, and the MLME shall issue an MLME-QAB.confirm primitive indicating the failure of the procedure.

d) If there is no response from the recipient within dot11QABTimeout, the MLME shall issue an MLME-QAB.confirm primitive indicating the failure of the procedure with a result code of TIMEOUT.

NOTE—The GAS protocol can be used by an AP to verify the capabilities of another AP.

10.36.3 Procedure at the responder AP

A responder AP shall operate as follows (Figure 10-36):

a) When a QAB.Request frame matching the BSSID is received from another AP, the MLME shall issue an MLME-QAB.indication primitive.

b) Upon receipt of the MLME-QAB.response primitive, the AP shall respond by transmitting a QAB Response frame.

    1) If the result code is SUCCESS, the request is accepted. The AP shall use SPs to schedule the quiet period(s) according to the accepted request. The SPs shall have the AP as both source and destination and the AP shall not transmit during the SP. The QAB procedure shall be terminated if the number of quiet intervals exceeds the value of the Repetition Count field specified. Contained in the transmitted QAB Response frame is the copy of the request token and the BSSID of the AP.

    2) If the result code is REJECTED, the request has not been fulfilled.

10.37 DMG beamforming

Upon receipt of an MLME-BF-TRAINING.request primitive, a STA shall undertake beamforming training with the STA indicated by the PeerSTAAddress parameter according to the procedures defined in 9.35. This training shall start with the SLS and shall include the BRP if and only if the RequestBRP parameter of the MLME-BF-TRAINING.request primitive is true.

A STA receiving MLME-BF-TRAINING.request primitive may act as either initiator or responder in the beamforming training.

If the STA indicated by the PeerSTAAddress parameter of a received MLME-BF-TRAINING.request primitive is a PCP or AP of a BSS in which a STA is a member, the STA receiving the MLME-BF-TRAINING.request primitive may perform beamforming training during the A-BFT as described in 9.35.5. Alternatively, the STA receiving the MLME-BF-TRAINING.request primitive may use an SP or a TXOP to perform ISS as described in 9.35.2.2.

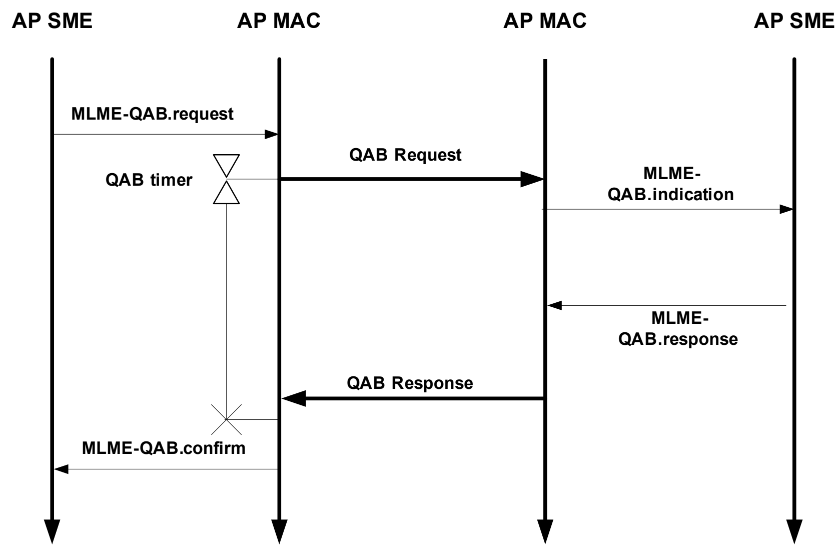


Figure 10-36—Quieting adjacent BSS operation

A STA receiving the MLME-BF-TRAINING.request primitive shall issue an MLME-BF-TRAINING.confirm primitive on completion of the requested beamforming training or on timeout as specified in 9.35.

A STA that performs beamforming training with a peer STA at the request of the peer STA shall issue a MLME-BF-TRAINING.indication primitive on completion of that beamforming training, or on timeout as specified in 9.35.

Figure 10-37 illustrates an example of the beamforming training procedure in the DTI for a case where the STA receiving the MLME-BF-TRAINING.request primitive acts as initiator.

Figure 10-38 illustrates an example of the beamforming training procedure in the context of a non-PCP/non-AP STA joining an infrastructure BSS or PBSS. In this scenario, the MLME-BF-TRAINING.request primitive is issued by the STA attempting to associate in order that the link be trained to a degree that allows the over-the-air exchanges necessary for association to succeed.

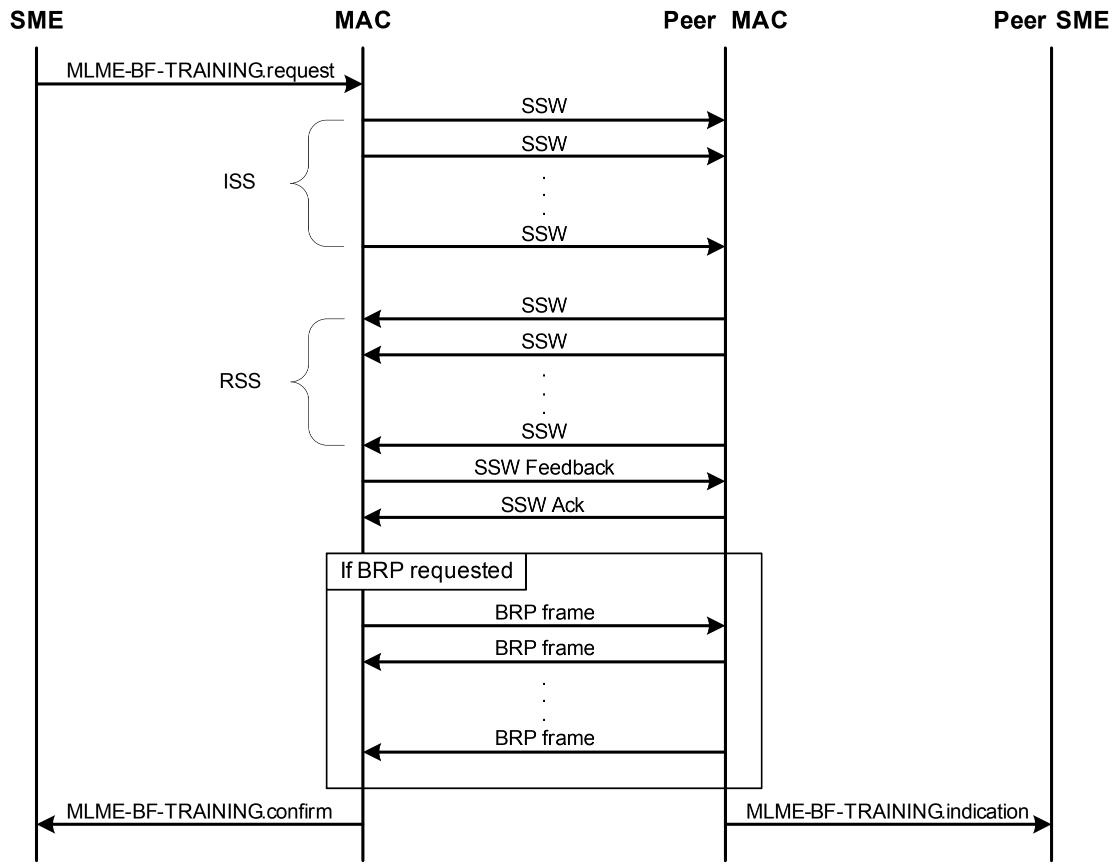


Figure 10-37—Beamforming training procedure in the DTI

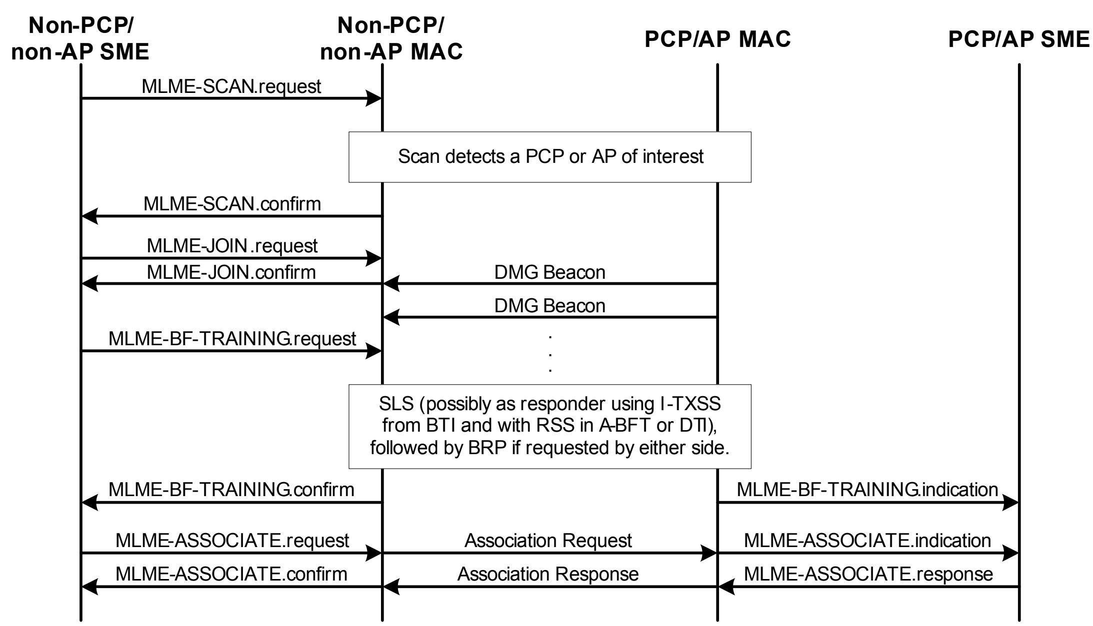


Figure 10-38—Beamforming training when joining an infrastructure BSS or PBSS

10.38 DMG MAC sublayer parameters

The parameters that define some of the MAC characteristics are given in Table 10-18.

Table 10-18—DMG MAC sublayer parameter values

Parameter	Value
aMaxBIDuration	1000 TUs
aMinChannelTime	aMaxBIDuration
aMinBTIPeriod	4
aMinSwitchInterval	2×aMinBTIPeriod
aMaxSwitchInterval	16×aMinSwitchInterval
aTSFResolution	1 µs
aDMGPPMinListeningTime	150 µs
aSSFramesPerSlot	4
aSSDuration	(FSS – 1) × SBIFS + FSS × TXTIME(SSW)
aSSFBDuration	TXTIME(SSW-Feedback)
aMinSSSlotsPerABFT	1
aRTSTimeoutTime	TXTIME(RTS) + aAirPropagationTime + aRxRFDelay + aMACProcessingDelay
aClockAccuracy	± 20 ppm
aMinNAVTimersNumber	2
aCWminDMGIBSS	3
aMinAllocationDeliveryTime	300 µs
aMaxABFTAccessPeriod	2
aDtime	aSBIFSTime+TXTIME(TPA Request frame)
aRelayTPATime	aSBIFSTime+2×aAirPropagationTime+2×aDtime+ TXTIME(TPA Request frame)+2×TXTIME(TPA Response frame)

11. Security

11.1 Framework

11.1.2 Security methods

Change the second paragraph of 11.1.2 as follows:

RSNA security comprises the following algorithms:

- TKIP, described in 11.4.2
- CCMP, described in 11.4.3
- BIP, described in 11.4.4
- GCMP, described in 11.4.5
- RSNA establishment and termination procedures, including use of IEEE 802.1X authentication, described in 11.5 and SAE authentication described in 11.3
- Key management procedures, described in 11.6

11.1.3 RSNA equipment and RSNA capabilities

Change the first paragraph of 11.1.3 as follows:

RSNA-capable equipment can create RSNAs. When dot11RSNAEnabled is true, RSNA-capable equipment shall include the RSNE in Beacon, Probe Response, Information Response, and (Re)Association Request frames and in Message 2 and Message 3 of the 4-Way Handshake; shall set the DMG Privacy subfield to 1 within transmitted DMG Beacons; and may include the RSNE in DMG Beacon and Announce frames. Pre-RSNA equipment is not capable of creating RSNAs.

11.1.4 RSNA establishment

Change the first paragraph of 11.1.4 as follows:

An SME establishes an RSNA in one of ~~four~~ six ways:

a) If an RSNA is based on IEEE 802.1X AKM in an ESS, an RSNA-capable STA's SME establishes an RSNA as follows:
   1) It identifies the AP as RSNA-capable from the AP's Beacon, DMG Beacon, Announce, Information Response, or Probe Response frames.
   2) It shall invoke Open System authentication if the STA is a non-DMG STA.

Items a) 3) to 7) remain unchanged.

b) If an RSNA is based on a PSK or password in an ESS, the SME establishes an RSNA as follows:
   1) It identifies the AP as RSNA-capable from the AP's Beacon, DMG Beacon, Announce, Information Response, or Probe Response frames.
   2) If the RSNA-capable AP advertises support for SAE authentication in its Beacon or Probe Response frames, and the STA has a group defined in the dot11RSNAConfigDLCGroupTable and a password for the AP in the dot11RSNAConfigPasswordValueTable, the STA shall invoke SAE authentication to establish a PMK. If the RSNA-capable AP does not advertise support for SAE authentication in its Beacon and Probe Response frames but advertises support for the alternate form of PSK authentication (see 4.10.3.4), and the STA also supports the alternate form of PSK authentication, the non-DMG STA may invoke Open System

authentication and use the PSK as the PMK with the key management algorithm in step 4) below.

Items b) 3) to 6) remain unchanged.

c) If an RSNA is based on a PSK or password in an IBSS, the SME executes the following sequence of procedures:
   1) It identifies the peer as RSNA-capable from the peer's Beacon, DMG Beacon, Announce, Information Response, or Probe Response frames.

      NOTE—STAs might respond to a data MPDU from an unrecognized STA by sending a Probe Request frame to find out whether the unrecognized STA is RSNA-capable.

   2) If the RSNA-capable peer advertises support for SAE authentication in its Beacon and Probe Response frames and the STA has a group defined in the dot11RSNAConfigDLCGroupTable and a password for the peer in the dot11RSNAConfigPasswordValueTable, the STA shall invoke SAE authentication and establish a PMK. If the RSNA-capable peer does not advertise support for SAE authentication but advertises support for the alternate form of PSK authentication (see 4.10.3.4) and the STA also supports the alternate form of PSK authentication, the STA may optionally invoke Open System authentication if the STA is a non-DMG STA and use a PSK as the PMK with the alternate form of PSK authentication.

Items c) 3) and 4) remain unchanged.

d) If an RSNA is based on IEEE 802.1X AKM in an IBSS, an RSNA-capable STA's SME establishes an RSNA as follows:
   1) It identifies the peer as RSNA-capable from the peer's Beacon, DMG Beacon, Announce, Information Response, or Probe Response frames.

      NOTE—STAs might respond to a data MPDU from an unrecognized STA by sending a Probe Request frame to find out whether the unrecognized STA is RSNA-capable.

   2) It may optionally invoke Open System authentication if the STA is a non-DMG STA.

Items d) 3) to 5) remain unchanged.

e) In order to associate with a PCP in a PBSS, an RSNA-capable STA's SME establishes an RSNA with the PCP following the RSNA establishment steps in an ESS in accordance with method a) and b) above, as appropriate, with the PCP taking the role of the AP.
f) When an RSNA-capable STA chooses not to associate with a peer in a PBSS, its SME establishes an RSNA with the peer following the RSNA establishment steps in an IBSS in accordance with method c) or d) above, as appropriate, with the caveat that the RSNA authentication and key management algorithm is executed only once between the peers.

Insert the following paragraph after the first paragraph of 11.1.4:

In a DMG BSS, IEEE 802.11 Authentication and Deauthentication shall not be used. Instead, STAs proceed immediately with Association.

11.4 RSNA confidentiality and integrity protocols

11.4.1 Overview

Change the first paragraph of 11.4.1 as follows:

This standard defines ~~two~~ three RSNA data confidentiality and integrity protocols: TKIP, ~~and~~ CCMP, and GCMP. DMG STAs claiming RSNA compliance shall support GCMP. This standard defines one integrity protocol for management frames: BIP.

11.4.3 CTR with CBC-MAC Protocol (CCMP)

11.4.3.1 General

Change the first paragraph of 11.4.3.1 as follows:

Subclause 11.4.3 specifies the CCMP, which provides data confidentiality, authentication, integrity, and replay protection. In a non-DMG network, CCMP is mandatory for RSN compliance.

11.4.3.3 CCMP cryptographic encapsulation

11.4.3.3.3 Construct AAD

Change item g) in the lettered list of the third paragraph of 11.4.3.3.3 as follows:

g) QC – QoS Control field, if present, a 2-octet field that includes the MSDU priority. The QC TID is used in the construction of the AAD. When in a non-DMG BSS and both the STA and its peer have their SPP A-MSDU Capable fields equal to 1, bit 7 (the A-MSDU Present field) is used in the construction of the AAD. The remaining QC fields are masked to 0 for the AAD calculation (bits 4 to 6, bits 8 to 15, and bit 7 when either the STA or its peer has the SPP A-MSDU Capable field equal to 0). When in a DMG BSS, the A-MSDU Present bit 7 and A-MSDU Type bit 8 are used in the construction of the AAD, and the remaining QC fields are masked to 0 for the AAD calculation (bits 4 to 6, bits 9 to 15).

11.4.4 Broadcast/Multicast Integrity Protocol (BIP)

Insert the following subclauses, 11.4.5 to 11.4.5.4.4 (including Figure 11-23a to Figure 11-23d), after 11.4.4.6:

11.4.5 GCM with Galois Message Authentication Code (GMAC) Protocol (GCMP)

11.4.5.1 GCMP overview

Subclause 11.4.5 specifies the GCMP, which provides data confidentiality, authentication, integrity, and replay protection.

GCMP is based on the GCM of the AES encryption algorithm. GCM combines Galois/Counter Mode for data confidentiality and GMAC for authentication and integrity. GCM protects the integrity of both the MPDU Data field and selected portions of the MPDU header.

The AES algorithm is defined in FIPS PUB 197-2001. All AES processing used within GCMP uses AES with a 128-bit key and a 128-bit block size.

GCM is defined in NIST Special Publication 800-38D. GCM is a generic mode that can be used with any block-oriented encryption algorithm.

GCM requires a fresh temporal key for every session. GCM also requires a unique nonce value for each frame protected by a given temporal key, and GCMP uses a 96-bit nonce that includes a 48-bit packet number (PN) for this purpose. Reuse of a PN with the same temporal key voids all security guarantees. GCMP uses a 128-bit MIC.

Annex M provides test vectors for GCM.

When GCMP is selected as the RSN pairwise cipher and management frame protection is negotiated, individually addressed robust management frames shall be protected with GCMP.

11.4.5.2 GCMP MPDU format

Figure 11-23a shows the MPDU format when using GCMP.

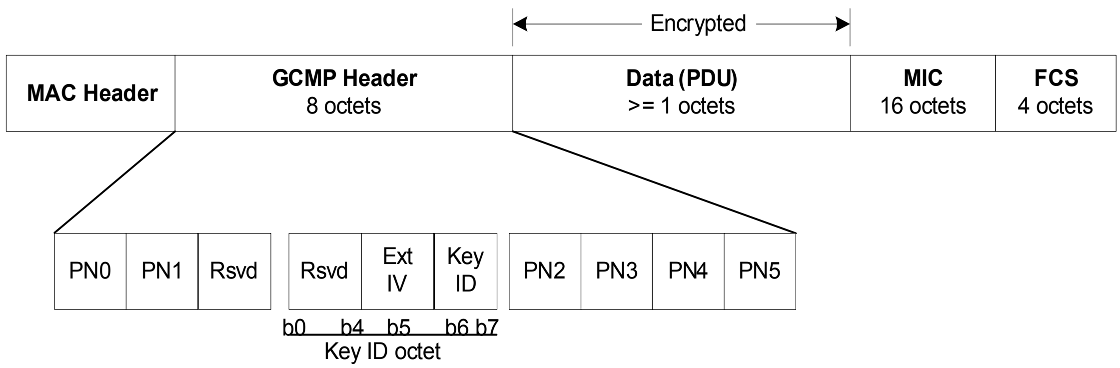


Figure 11-23a—Expanded GCMP MPDU

GCMP processing expands the original MPDU size by 24 octets, 8 octets for the GCMP Header field and 16 octets for the MIC field. The GCMP Header field is constructed from the PN and Key ID subfields. The 48-bit PN is represented as an array of 6 octets. PN5 is the most significant octet of the PN, and PN0 is the least significant.

The ExtIV subfield (bit 5) of the Key ID octet is always set to 1 for GCMP.

Bits 6–7 of the Key ID octet are for the Key ID subfield. The remaining bits of the Key ID octet are reserved.

11.4.5.3 GCMP cryptographic encapsulation

11.4.5.3.1 General

The GCMP cryptographic encapsulation process is depicted in Figure 11-23b.

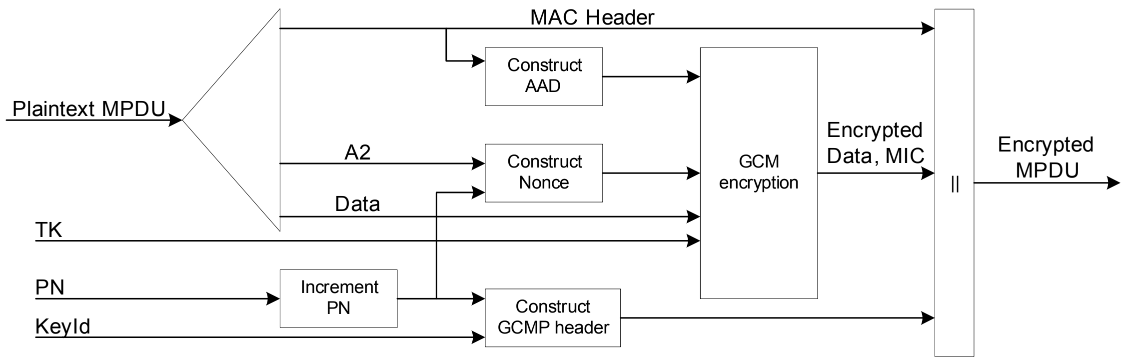


Figure 11-23b—GCMP encapsulation block diagram

GCMP encrypts the payload of a plaintext MPDU and encapsulates the resulting cipher text using the following steps:

a) Increment the PN, to obtain a fresh PN for each MPDU, so that the PN never repeats for the same temporal key.

   NOTE—Retransmitted MPDUs are not modified on retransmission.

b) Use the fields in the MPDU header to construct the additional authentication data (AAD) for GCM. The GCM algorithm provides integrity protection for the fields included in the AAD. MPDU header fields that may change when retransmitted are masked to 0 when calculating the AAD.
c) Construct the GCM Nonce block from the PN and A2, where A2 is MPDU Address 2.
d) Place the new PN and the key identifier into the 8-octet GCMP Header.
e) Use the temporal key, AAD, nonce, and MPDU data to form the cipher text and MIC. This step is known as GCM originator processing.
f) Form the encrypted MPDU by combining the original MPDU header, the GCMP header, the encrypted data and MIC, as described in 11.4.5.2.

The GCM reference describes the processing of the key, nonce, AAD, and data to produce the encrypted output. See 11.4.5.3.2 to 11.4.5.3.6 for details of the creation of the AAD and nonce from the MPDU and the associated MPDU-specific processing.

11.4.5.3.2 PN processing

Each transmitter shall maintain a single PN (48-bit counter) for each PTKSA, GTKSA, and STKSA.

The PN shall be implemented as a 48-bit monotonically incrementing non-negative integer, initialized to 1 when the corresponding temporal key is initialized or refreshed.

The PN is incremented by a positive number for each MPDU. The PN shall never repeat for a series of encrypted MPDUs using the same temporal key.

If the PN is larger than the value of dot11PNExhaustionThreshold, an MLME-PN-Exhaustion.indication primitive shall be generated.

11.4.5.3.3 Construct AAD

The AAD construction is as defined in 11.4.3.3.3.

11.4.5.3.4 Construct GCM nonce

The Nonce field occupies 12 octets, and its structure is shown in Figure 11-23c.

	A2	PN
Octets:	6	6

Figure 11-23c—Nonce construction

The Nonce field has an internal structure of A2 || PN (“||” is concatenation), where

— MPDU address A2 field occupies octets 0 to 5. This shall be encoded with the octets ordered with A2 octet 0 at octet index 0 and A2 octet 5 at octet index 5.

— The PN field occupies octets 6 to 11. The octets of PN shall be ordered so that PN0 is at octet index 11 and PN5 is at octet index 6.

11.4.5.3.5 Construct GCMP header

The format of the 8-octet GCMP Header is given in 11.4.5.2. The header encodes the PN and Key ID field values used to encrypt the MPDU.

11.4.5.3.6 GCM originator processing

GCM is a generic authenticate-and-encrypt block cipher mode, and in this standard, GCM is used with the AES block cipher.

There are four inputs to GCM originator processing:

a) *Key:* the temporal key (16 octets).

b) *Nonce:* the nonce (12 octets) constructed as described in 11.4.5.3.4.

c) *Frame body:* the frame body of the MPDU.

d) *AAD:* the AAD (22-30 octets) constructed from the MPDU header as described in 11.4.5.3.3.

The GCM originator processing provides authentication and integrity of the frame body and the AAD as well as data confidentiality of the frame body. The output from the GCM originator processing consists of the encrypted data and 16 additional octets of encrypted MIC.

A GCMP protected individually addressed robust management frame shall be protected with the TK.

11.4.5.4 GCMP decapsulation

11.4.5.4.1 General

Figure 11-23d shows the GCMP decapsulation process.

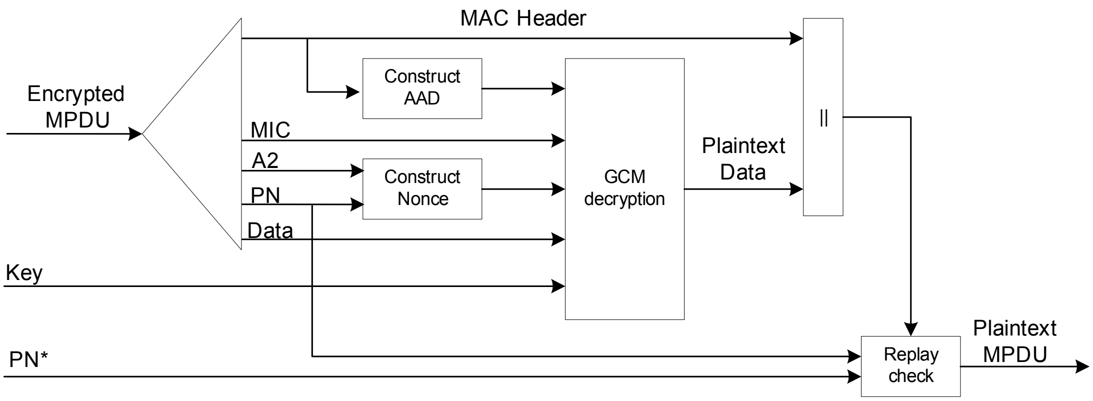


Figure 11-23d—GCMP decapsulation block diagram

GCMP decrypts the payload of a cipher text MPDU and decapsulates a plaintext MPDU using the following steps:

a) The encrypted MPDU is parsed to construct the AAD and nonce values.
b) The AAD is formed from the MPDU header of the encrypted MPDU.
c) The Nonce value is constructed from the A2 and PN fields.
d) The MIC is extracted for use in the GCM integrity checking.
e) The GCM recipient processing uses the temporal key, AAD, nonce, MIC, and MPDU cipher text data to recover the MPDU plaintext data as well as to check the integrity of the AAD and MPDU plaintext data.
f) The received MPDU header and the MPDU plaintext data from the GCM recipient processing may be concatenated to form a plaintext MPDU.
g) The decryption processing prevents replay of MPDUs by validating that the PN in the MPDU is greater than the replay counter maintained for the session.

See 11.4.5.4.2 through 11.4.5.4.4 for details of this processing.

When the received frame is a GCMP protected individually addressed robust management frame, the contents of the MMPDU body after protection is removed and shall be delivered to the MLME rather than through the MA-UNITDATA.indication primitive.

11.4.5.4.2 GCM recipient processing

GCM recipient processing shall use the same parameters as GCM originator processing. A GCMP protected individually addressed robust management frame shall use the same TK as a Data MPDU.

There are four inputs to GCM recipient processing:

— *Key:* the temporal key (16 octets).
— *Nonce:* the nonce (12 octets) constructed as described in 11.4.5.3.4.
— *Encrypted frame body:* the encrypted frame body from the received MPDU. The encrypted frame body includes a 16-octet MIC.
— *AAD*: the AAD (22-30 octets) that is the canonical MPDU header as described in 11.4.5.3.3.

The GCM recipient processing checks the authentication and integrity of the frame body and the AAD as well as decrypting the frame body. The plaintext is returned only if the MIC check is successful.

There is one output from error-free GCM recipient processing:

— *Frame body:* the plaintext frame body, which is 16 octets smaller than the encrypted frame body.

11.4.5.4.3 Decrypted GCMP MPDU

The decapsulation process succeeds when the calculated MIC matches the MIC value obtained from decrypting the received encrypted MPDU. The original MPDU header is concatenated with the plaintext data resulting from the successful GCM recipient processing to create the plaintext MPDU.

11.4.5.4.4 PN and replay detection

To effect replay detection, the receiver extracts the PN from the GCMP header. See 11.4.5.2 for a description of how the PN is encoded in the GCMP header. The following processing rules are used to detect replay:

a) The PN values sequentially number each MPDU.

b) A receiver shall maintain a separate set of PN replay counters for each PTKSA, GTKSA, and STKSA. The receiver initializes these replay counters to 0 when it resets the temporal key for a peer. The replay counter is set to the PN value of accepted GCMP MPDUs.

c) For each PTKSA, GTKSA, and STKSA, the recipient shall maintain a separate replay counter for each possible IEEE 802.11 MSDU or A-MSDU priority (including, for example, each possible TID) and shall use the PN recovered from a received frame to detect replayed frames. A replayed frame occurs when the PN extracted from a received frame is less than or equal to the current replay counter value for the frame's MSDU or A-MSDU priority (including, for example, each possible TID) and frame type.

   For each IGTKSA the recipient shall maintain a single replay counter for protected group addressed robust management frames, and shall compare the IPN recovered from a received, protected group addressed robust management frame to the replay counter to detect replayed frames as described above for data frames.

   If dot11RSNAProtectedManagementFramesActivated is true, the recipient shall maintain a single replay counter for received individually addressed robust management frames within the context of each Protected Management frame pairing and shall use the PN from the received frame to detect replays. A replayed frame occurs when the PN from the frame is less than or equal to the current management frame replay counter value corresponding to the TA of the received management frame. The transmitter shall preserve the order of protected robust management frames sent to the same DA.

d) A receiver shall discard any data MPDU that is received with its PN less than or equal to the value of the replay counter that is associated with the TA and priority of the received MPDU. If dot11RSNAProtectedManagementFramesActivated is true, a receiver shall discard any group addressed MMPDU that is received with its PN less than or equal to the value of the replay counter associated with group addressed MMPDUs. If dot11RSNAProtectedManagementFramesActivated is true, the receiver shall discard any individually addressed robust MMPDU that is received with its PN less than or equal to the value of the replay counter associated with the TA of that individually addressed MMPDU. When discarding a frame, the receiver shall increment by 1 the value of dot11RSNAStatsGCMPReplays for data frames or dot11RSNAStatsRobustMgmtGCMPReplays for robust management frames.

e) For MSDUs or A-MSDUs sent using the Block Ack feature, reordering of received MSDUs or A-MSDUs according to the Block Ack receiver operation (described in 9.21.4) is performed prior to replay detection.

11.5 RSNA security association management

11.5.1 Security associations

11.5.1.1 Security association definitions

11.5.1.1.2 PMKSA

Change the second list item in the dashed list of the first paragraph of 11.5.1.1.2 as indicated:

— Authenticator’s or peer’s MAC address. For multi-band RSNA, the MAC address is associated with the operating band in use when the PMKSA is established.

11.5.1.1.6 PTKSA

Change the first paragraph in 11.5.1.1.6 as follows:

The PTKSA is a result of the 4-Way Handshake, FT 4-Way Handshake, FT Protocol, or FT Resource Request Protocol. This security association is also bidirectional. PTKSAs are cached for the life of the PMKSA or PMK-R1 security association. Because the PTKSA is tied to the PMKSA or to a PMK-R1 security association, it only has the additional information from the 4-Way Handshake. For the PTKSA derived as a result of the 4-Way Handshake, there shall be only one PTKSA per band (see 11.5.19) with the same Supplicant and Authenticator MAC addresses. For the PTKSA derived as a result of an initial mobility domain association or fast BSS transition, there shall be only one PTKSA with the same STA’s MAC address and BSSID.

11.5.1.3 Security association life cycle

11.5.1.3.1 General

Change 11.5.1.3.1 as indicated:

A STA can operate in ~~either~~ an ESS, a PBSS, or in an IBSS, and a security association has a distinct life cycle for each.

Insert the following subclause, 11.5.1.3.5, after 11.5.1.3.4:

11.5.1.3.5 Security association in a PBSS

A STA and a peer establish an initial security association via the following steps:

a) The STA selects an authorized PBSS by identifying a peer from a DMG Beacon, Announce, Probe Response, or Information Response frames.
b) A STA may associate with a peer if the peer is a PCP.
c) If authentication is required, the STA or the peer initiates IEEE 802.1X authentication. The EAP method used by IEEE Std 802.1X-2004 shall support mutual authentication.
d) The last step is key management. The authentication process creates cryptographic keys shared between the IEEE 802.1X AS and the STA. The AS transfers these keys to the peer and the peer and the STA use one of the key confirmation handshakes, e.g., the 4-Way Handshake or FT 4-Way Handshake, to complete security association establishment. The key confirmation handshake indicates when the link has been secured by the keys and is ready to allow data traffic and protected robust management frames.

11.5.2 RSNA selection

Change the first three paragraphs of 11.5.2 as follows:

A STA prepared to establish RSNAs shall advertise its capabilities by including the RSNE in Beacon, Information Response, and Probe Response messages and may also include the RSNE in DMG Beacon and Announce frames. The included RSNE shall specify all the authentication and cipher suites enabled by the STA's policy. A STA shall not advertise any authentication or cipher suite that is not enabled.

The SME shall utilize the MLME-SCAN.request primitive to identify neighboring STAs that assert robust security and advertise an SSID identifying an authorized ESS, PBSS, or IBSS. A STA may decline to communicate with STAs that fail to advertise an RSNE in their Beacon, Information Response, and Probe Response frames or that do not advertise an authorized SSID. A STA may also decline to communicate with other STAs that do not advertise authorized authentication and cipher suites within their RSNEs.

A STA shall advertise the same RSNE in ~~both~~ its Beacon, DMG Beacon, Announce, Information Response, and Probe Response frames.

Insert the following subclause, 11.5.7a, after 11.5.7:

11.5.7a RSNA policy selection in a PBSS

RSNA policy selection in a PBSS utilizes the association procedure (10.3.1) if the initiating STA chooses to associate with a PCP. RSNA policy selection is performed by the associating STA. The STA does this by including an RSNE in its (Re)Association Requests.

The STA follows the procedures in 11.4.3 to select RSNA policy with the PCP, with the PCP taking the role of the AP. If the initiating STA chooses not to associate with a peer in a PBSS, it follows the procedures in 11.4.5 to select RSNA policy with the peer.

11.5.8 RSNA management of the IEEE 802.1X Controlled Port

Change the second and third paragraphs of 11.5.8, and insert a new fifth paragraph as indicated below:

In an ESS/PBSS, if the STA associates with the PCP/AP, the STA indicates the IEEE 802.11 link is available by invoking the MLME-ASSOCIATE.confirm or MLME-REASSOCIATE.confirm primitive. This signals the Supplicant that the MAC has transitioned from the disabled to enabled state. At this point, the Supplicant's Controlled Port is blocked, and communication of all non-IEEE-802.1X MSDUs sent or received via the port is not authorized.

In an ESS/PBSS, if the PCP/AP associates with a STA, the PCP/AP indicates that the IEEE 802.11 link is available by invoking the MLME-ASSOCIATE.indication or MLME-REASSOCIATE.indication primitive. At this point the Authenticator's Controlled Port corresponding to the STA's association is blocked, and communication of all non-IEEE-802.1X MSDUs sent or received via the Controlled Port is not authorized.

In an IBSS, the STA shall block all IEEE 802.1X ports at initialization. Communication of all non-IEEE-802.1X MSDUs sent or received via the Controlled Port is not authorized.

In a PBSS, if a STA chooses not to associate with the PCP, the STA shall block all IEEE 802.1X ports at initialization. Communication of all non-IEEE-802.1X MSDUs sent or received via the Controlled Port is not authorized.

Insert the following subclause, 11.5.11a, after 11.5.11:

11.5.11a RSNA authentication in a PBSS

IEEE 802.11 Open System authentication is not used in a PBSS.

When establishing an RSNA with a PCP, a STA may associate to the PCP and initiate RSNA authentication with the PCP following the procedures of 11.4.8, with the PCP taking the role of the AP. When a STA chooses not to associate to a peer, it initiates RSNA authentication with the peer following the procedures of 11.4.9 with the following caveat: if both peers simultaneously initiate RSNA authentication, the peer with the lower MAC address shall abandon the authentication it initiated in favor of the authentication initiated by the peer with the higher MAC address.

Insert the following subclause, 11.5.14a, after 11.5.14:

11.5.14a RSNA key management in a PBSS

Upon successful association and authentication in a PBSS, a STA performs a key confirmation handshake with the PCP, following the procedures in 11.4.10 with the PCP taking the role of the AP. If a STA chooses not to associate to a peer, after successful authentication, it performs a key confirmation handshake with the peer following the procedures in 11.4.11 with the following caveat: if both peers simultaneously initiate the key confirmation handshake, the peer with the lower MAC address shall abandon the handshake it initiated in favor of the handshake initiated by the peer with the higher MAC address.

11.5.15 RSNA security association termination

Insert the following paragraphs at the end of 11.5.15:

When an STA's SME receives an MLME-PN-Exhaustion.indication primitive and the PN is associated with a PTKSA, the STA's SME shall invoke an MLME-DISASSOCIATE.request primitive and delete the PTKSA.

When a STA's SME receives an MLME-PN-Exhaustion.indication primitive and the PN is associated with a GTKSA, the STA's SME shall delete the GTKSA.

When a STA's SME receives an MLME-PN-Exhaustion.indication primitive and the PN is associated with a STKSA, the STA's SME shall invoke a STSL application teardown procedure for the STKSA and delete the STKSA.

Once the security associations have been deleted, the SME then invokes MLME-DELETEKEYS.request primitive to delete all temporal keys associated with the deleted security associations.

Insert the following subclauses, 11.5.18 to 11.5.19.4, after 11.5.17:

11.5.18 RSNA rekeying

When a PTKSA is deleted, a non-PCP/non-AP STA may reassociate with the same PCP/AP and/or establish a new RSNA with the PCP/AP. If the non-PCP/non-AP STA has cached one or more PMKSAs, it may skip the PMKSA establishment and proceed with the creation of a new PTKSA by using 4-Way Handshake.

When a GTKSA is deleted, an originating STA may create a new GTKSA by using 4-Way Handshake or Group Key Handshake.

When a STKSA is deleted, the STA_I may establish a new STSL with the STA_P. If the SMK between the STA pair has not expired, the STA_I may initiate a 4-Way Handshake and create a new STKSA with STA_P. If the SMK has expired, the STA_I shall create both a new SMKSA and a new STKSA with the STA_P.

An Authenticator/STA_I may initiate a 4-Way Handshake for the purpose of renewing the key associated with a PTKSA or STKSA. A supplicant/STA_P may send an EAPOL request message to the authenticator/STA_I to request rekeying. In addition, if both the Authenticator and the Supplicant support multiple keys for individually addressed traffic, a smooth switchover to the new key is possible using the following procedure.

The 802.11 MAC shall issue an MLME-PN-Warning.indication primitive when the Packet Number assignment for a particular PTKSA, GTKSA, or STKSA reaches or exceeds dot11PNWarningThreshold for the first time. The indication shall be issued only once for a given PTKSA, GTKSA, or STKSA. The SME may use the indication as a trigger to establish a new PTKSA, GTKSA, or STKSA before the Packet Number space is exhausted.

A PTKSA or STKSA has a limited lifetime, either in absolute time or due to exhausting the PN space. To maintain an uninterrupted security association, a STA should establish a new PTKSA or STKSA prior to the expiry of the old PTKSA or STKSA.

When both ends of the link support the expanded Key ID space for individually addressed traffic, it is possible to install the new PTKSA or STKSA without data loss, provided the new PTKSA or STKSA uses a different Key ID from the old PTKSA or STKSA. Data loss might occur if the same Key ID is used because it is not possible to precisely coordinate (due to software processing delays) when the new key is used for transmit at one end and when it is applied to receive at the other end. If a different Key ID is used for the new PTKSA or STKSA, then provided the new key is installed at the receive side prior to its first use at the transmit side there is no need for precise coordination. During the transition, received packets are unambiguously identified using the Key ID as belonging to either the old or new PTKSA or STKSA.

11.5.19 Multi-band RSNA

11.5.19.1 General

A STA is multi-band capable and RSNA-capable if the values of both its local MIB variables dot11MultibandImplemented and dot11RSNAEnabled are true.

A STA that is multi-band capable and RSNA-capable shall set the Pairwise Cipher Suite Present field of the Multi-band element to 1 and shall include the Pairwise Cipher Suite Count field and the Pairwise Cipher Suite List field in the Multi-band element. The STA may include the RSNE and the Multi-band element in the DMG Beacon and Announce frames and shall include the RSNE and the Multi-band element in Beacon, Probe Response, and Information Response frames. The included RSNE shall specify all the authentication and cipher suites enabled by the STA's policy for the band where this element is transmitted, and the included Multi-band element shall specify all the pairwise cipher suites enabled by the STA's policy for the band specified within the Multi-band element. A STA shall not advertise any cipher suite that is not enabled.

A multi-band capable and RSNA-capable STA shall include the Multi-band element in the (Re)Association Request frame and in Message 2 and Message 3 of the 4-Way Handshake.

In order to set up an RSNA with a peer STA for a supported band/channel, a STA that does not know the peer's policy for the band/channel shall first obtain the peer STA's policy for the supported band/channel by using a Probe Request frame or Information Request frame. The STA initiating RSNA establishment for a supported band/channel is called *RSNA initiator*, and the targeted STA of the RSNA establishment is called *RSNA responder*.

A multi-band capable device can create its own group key(s) for one or more supported bands/channels. If the STA uses different MAC addresses in different bands/channels, different GTKSAs shall be created for different bands. If the STA uses a same MAC address in all supported bands/channels, a single GTKSA shall be created for all supported bands/channels.

If the pairwise and group cipher suites used by a pair of multi-band capable devices to communicate with each other in the current operating band/channel is also supported after the transfer to another band/channel that was performed using transparent FST, the devices shall continue using the same cipher suites to communicate with each other after the transfer. In all other cases, a separate RSNA has to be established for the other band/channel (see 11.5.19).

11.5.19.2 Nontransparent multi-band RSNA

An RSNA initiator can establish a nontransparent (10.32) multi-band RSNA with an RSNA responder for a supported band/channel other than the current operating band/channel. The two STAs use the same PMKSA for both the supported band/channel and the current operating band/channel and create different PTKSAs for different bands/channels.

If the RSNA initiator does not have an existing PMKSA with the RSNA responder, the RSNA initiator shall first establish a PMKSA with the RSNA responder in the current operating band/channel and then use the PMKSA to create a PTKSA with the RSNA responder for the supported band/channel. If the RSNA initiator has already established a PMKSA with the RSNA responder, the PMKSA shall be used to create a PTKSA between the two STAs for the supported band/channel.

With the PMK in place, the RSNA initiator and RSNA responder can proceed in two ways depending on the setting of the Joint Multi-band RSNA subfield within the RSN Capabilities field in the RSNE of both STAs.

If the Joint Multi-band RSNA subfield within the RSN Capabilities field of either the RSNA initiator or RSNA responder is 0, the STA pair uses a 4-Way Handshake to establish a PTKSA for the current band/channel and may start a separate 4-Way Handshake in the current operating band/channel to negotiate a pairwise cipher suite for the supported band/channel and establish a PTKSA for the supported band/channel. As specified in 11.6.6, Message 2 and Message 3 of the 4-Way Handshake convey the Multi-band element associated with the supported band/channel. The Multi-band element in Message 2 includes the selected pairwise cipher suite for the supported band/channel. Message 3 includes the Multi-band element that the STA would send in a Beacon, DMG Beacon, Announce, Probe Response, or Information Response frame. Message 3 may optionally include a second Multi-band element that indicates the STA's pairwise cipher suite assignment for the supported band/channel.

If the Joint Multi-band RSNA subfield within the RSN Capabilities field is 1 for both the RSNA initiator and the RSNA responder and at least one of the STAs uses different MAC addresses for different bands/channels, the STAs shall use a single 4-Way Handshake to negotiate pairwise cipher suites and establish PTKSAs for both the current operating band/channel and the other supported band(s)/channel(s). As specified in 11.6.6, Message 2 and Message 3 of the 4-Way Handshake convey the RSNE and the Multi-band element(s). The RSNE in Message 2 includes the selected pairwise cipher suite for the current operating band/channel, and the Multi-band element(s) in Message 2 includes the selected pairwise cipher suite(s) for the other supported band(s)/channel(s). Message 3 includes the RSNE and the Multi-band element(s) that the STA would send in a Beacon, DMG Beacon, Announce, Probe Response, or Information Response frame. Message 3 may optionally include a second RSNE and Multi-band element(s) that indicate the STA's pairwise cipher suite assignments for the current operating band/channel and the other supported band(s)/channel(s). KCK and KEK associated with the current operating band/channel shall be used in the 4-Way Handshake.

11.5.19.3 Transparent multi-band RSNA

An RSNA initiator can establish a transparent (10.32) multi-band RSNA with an RSNA responder for both the current operating band/channel and the other supported band(s)/channel(s) if

a) Both STAs use the same MAC address in the current operating band/channel and the other supported band(s)/channel(s); and
b) At least one common pairwise cipher suite is supported by both STAs in the current operating band/channel and the other supported band(s)/channel(s).

Two STAs that establish a transparent multi-band RSNA create one PMKSA and one PTKSA for both the current operating band/channel and other supported band(s)/channel.

A STA shall use a single PN counter (11.4.3.3 and 11.4.5.3) for transmission in both the current operating band and the other supported band(s) when transparent multi-band RSNA is used.

If the RSNA initiator does not have an existing PMKSA with the RSNA responder, the RSNA initiator shall first establish a PMKSA with the RSNA responder in the current operating band/channel and then use the PMKSA to create a PTKSA with the RSNA responder for all involved bands/channels. If the RSNA initiator has already established a PMKSA with the RSNA responder, the PMKSA shall be used to create a PTKSA between the two STAs for all involved bands/channels.

With the PMK in place, the STA pair shall use a single 4-Way Handshake in the current operating band/channel to negotiate a pairwise cipher suite for all involved bands/channels and also establish a single PTKSA for all involved bands/channels. As specified in 11.6.6, Message 2 and Message 3 of the 4-Way Handshake convey the RSNE and the Multi-band element(s). The RSNE and the Multi-band element(s) in Message 2 include one selected pairwise cipher suite for all involved bands/channels. Message 3 includes the RSNE and the Multi-band element(s) that the STA would send in a Beacon, DMG Beacon, Announce, Probe Response, or Information Response frame. Message 3 may optionally include a second RSNE and Multi-band element(s) that indicate the STA's pairwise cipher suite assignment for all involved bands/channels.

11.5.19.4 Multi-band RSNA with TDLS in a non-DMG BSS

When two multi-band capable devices operate in a non-DMG BSS and set up a TDLS direct link in the non-DMG BSS, the TDLS Peer Key Handshake protocol can be used to create a PTKSA for use in another supported band/channel that is supported by both STAs and that was indicated within both of the STA's Multi-band element. Only TK in PTKSA is required for the supported band/channel and it shall be equal to the TPK-TK of the TPK.

If at least one of the peer STAs has a different MAC address in the supported band/channel from that of the current operating band/channel, the TDLS Peer Key Handshake protocol may be used to establish a PTKSA for the supported band/channel. In this case, the TPK key creation method shall be used to calculate a different PTKSA in the supported band/channel: the TDLS peer MAC addresses and cipher suite shall be replaced by the MAC addresses and cipher suite indicated within the corresponding Multi-band elements contained in the TDLS Setup Request and Response frames used to establish the PTKSA for the supported band/channel.

If two TDLS peer STAs use the same MAC addresses and pairwise cipher suites in the operating band/channel and in the supported band/channel, the TPKSA that is acquired by the successful completion of the TDLS Peer Key Handshake protocol may be used as the PTKSA for the supported band/channel.

11.6 Keys and key distribution

11.6.2 EAPOL-Key frames

Insert the following row at the end of Table 11-4:

Table 11-4—Cipher suite key lengths

Cipher suite	Key length (octets)	TK_bits (bits)
GCMP	16	128

Insert the following rows in Table 11-6 in numeric order, and change the indicated Reserved row as follows:

Table 11-6—KDE

OUI	Data type	Meaning
00-0F-AC	11	Multi-band GTK KDE
00-0F-AC	12	Multi-band Key ID KDE
00-0F-AC	13~~1~~–255	Reserved

Insert the following paragraphs (including Figure 11-39a and Figure 11-39b) at the end of 11.6.2:

The format of the Multi-band GTK KDE is shown in Figure 11-39a.

Key ID (0, 1, 2, or 3)	Tx	Reserved (0)	Band ID	GTK
bits 0-1	bit 2	bits 3-7	1 octet	6 octets

Figure 11-39a—Multi-band GTK KDE

The definitions of the Key ID, Tx, and GTK fields are the same as in the GTK KDE described above.

The Band ID field contains the identification of the frequency band (see 8.4.1.45).

The format of the Multi-band Key ID KDE is shown in Figure 11-39b.

Key ID	Reserved	Band ID
bits 0-1	bits 2-7	bits 8-15

Figure 11-39b—Multi-band Key ID KDE

The definitions of the Key ID and Band ID fields are the same as in the Multi-band GTK KDE described above.

11.6.6 4-Way Handshake

11.6.6.3 4-Way Handshake Message 2

Change the description of the Key Data field in 11.6.6.3 as follows:

Key Data =

- Included RSNE – the sending STA's RSNE for PTK generation or peer RSNE for the current operating band, or;
- The sending STA's Multi-band element for PTK generation for a supported band other than the current operating band if dot11MultibandImplemented is true, or;
- The sending STA's RSNE and Multi-band element(s) for generating a single PTK for all involved bands, if dot11MultibandImplemented is true and both the Authenticator and the Supplicant use the same MAC address in the current operating band and the other supported band(s); or;
- The sending STA's RSNE and Multi-band element(s) for generating a different PTK for each involved band, if dot11MultibandImplemented is true and the Joint Multi-band RSNA subfield of the RSN capabilities field is 1 for both the Authenticator and the Supplicant, and either the Authenticator or the Supplicant uses different MAC addresses for different bands.
- Lifetime of SMK and SMKID for STK generation.

11.6.6.4 4-Way Handshake Message 3

Change the description of the Key Data field in 11.6.6.4 as follows:

Key Data =

- For PTK generation for the current operating band, the AP's Beacon/Probe Response frame's RSNE for the current operating band, and, optionally, a second RSNE that is the Authenticator's pairwise cipher suite assignment for the current operating band, and, if a group cipher has been negotiated, the encapsulated GTK and the GTK's key identifier (see 11.6.2) for the current operating band, and if management frame protection is negotiated, the IGTK KDE; or;
- For PTK generation for a supported band other than the current operating band, the Authenticator's Beacon/DMG Beacon/Announce/Probe Response/Information Response frame's Multi-band element associated with the supported band, and optionally a second Multi-band element that indicates the Authenticator's pairwise cipher suite assignment for the supported band, and, if group cipher for the supported band is negotiated, the Multi-band GTK KDE for the supported band if dot11MultibandImplemented is true, or;
- For generating a single PTK for all involved bands, the Authenticator's Beacon/DMG Beacon/Announce/Probe Response/Information Response frame's RSNE and Multi-band element(s), and optionally, additional RSNE and Multi-band element(s) that indicate the Authenticator's assignment of one pairwise cipher suite for all involved bands; if a group cipher for all involved bands is negotiated, the encapsulated GTK and the GTK's key identifier for all involved bands, if dot11MultibandImplemented is true and both the Authenticator and the Supplicant use the same MAC address in the current operating band and the other supported band(s), or;
- For generating different PTKs for the current operating band and other supported band(s), the Authenticator's Beacon/DMG Beacon/Announce/Probe Response/Information Response frame's RSNE and Multi-band element(s), and optionally, additional RSNE and Multi-band elements that are the Authenticator's pairwise cipher suite assignments for one or more involved bands; if group ciphers for the involved bands are negotiated, the Multi-band GTK KDEs for the involved bands, if dot11MultibandImplemented is true and the Joint Multi-band RSNA subfield is 1 for both the Authenticator and Supplicant, and either the Authenticator or the Supplicant uses different MAC addresses for different bands.

- For STK generation Initiator RSNE, Lifetime of SMK is used.
- If the Extended Key ID for Individually Addressed Frames subfield of the RSN Capabilities field is 1 for both the Authenticator/STA_I and Supplicant/STA_P, then the Authenticator/STA_I includes the Key ID KDE with the assigned key identifier for the current operating band; or the Authenticator includes the Multi-band Key ID KDE(s) with the assigned key identifier(s) for one or more supported bands if dot11MultibandImplemented is true.

11.7 Mapping EAPOL keys to IEEE 802.11 keys

Insert the following subclause, 11.7.8, after 11.7.7:

11.7.8 Mapping PTK to GCMP keys

See 11.6.1.3 for the definition of the EAPOL temporal key derived from PTK.

A STA shall use the temporal key as the GCMP key for MPDUs between the two communicating STAs.

13. MLME mesh procedures

13.1 Mesh STA dependencies

Insert the following paragraph at the end of 13.1:

When dot11DMGOptionImplemented is true, dot11MeshActivated shall be set to false.

Insert the following text, Clause 21, after Clause 20:

21. Directional multi-gigabit (DMG) PHY specification

21.1 DMG PHY introduction

21.1.1 Scope

The DMG PHY supports three modulation methods:

- A control modulation using MCS 0 (the control PHY; see 21.4)
- A single carrier (SC) modulation using MCS 1 to MCS 12 (the SC PHY; see 21.6) and MCS 25 to MCS 31 (the low-power SC PHY; see 21.7)
- An OFDM modulation using MCS 13 to MCS 24 (the OFDM PHY; see 21.5)

All these modulation methods share a common preamble (see 21.3.6).

The services provided to the MAC by the DMG PHY consist of two protocol functions, defined as follows:

a) A PHY convergence function, which adapts the capabilities of the physical medium dependent (PMD) system to the PHY service. This function is supported by the physical layer convergence procedure (PLCP), which defines a method of mapping the PLCP service data units (PSDU) into a framing format (PPDU) suitable for sending and receiving PSDUs between two or more STAs using the associated PMD systems.
b) A PMD system whose function defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the DMG MCSs, these STAs support a mixture of DMG SC PHY, DMG OFDM PHY, DMG low-power SC PHY, and DMG control PHY.

21.1.2 DMG PHY functions

The DMG PHY contains three functional entities: the PHY convergence function (PLCP), the layer management function (PLME) and the PMD function. Each of these functions is described in detail in 21.3 to 21.11. The DMG PHY service is provided to the MAC through the PHY service primitives defined in Clause 12.

21.1.2.1 DMG PLCP sublayer

In order to allow the MAC to operate with minimum dependence on the PMD sublayer, a PHY convergence sublayer is defined (PLCP). The PLCP sublayer simplifies the PHY service interface to the MAC services.

21.1.2.2 DMG PMD sublayer

The DMG PMD sublayer provides a means to send and receive data between two or more STAs. This subclause is concerned with SC and OFDM modulations.

21.1.2.3 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

21.1.2.4 Service specification method

The models represented by figures and state diagrams are intended to be illustrations of the functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation; the actual method of implementation is left to the discretion of the DMG PHY compliant developer. The service of a layer or sublayer is the set of capabilities that it offers to a user in the next higher layer (or sublayer). Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

21.2 DMG PHY service interface

21.2.1 Introduction

The PHY interfaces to the MAC through the TXVECTOR, RXVECTOR, and the PHYCONFIG_VECTOR. The TXVECTOR supplies the PHY with per packet transmit parameters. Using the RXVECTOR, the PHY informs the MAC of the received packet parameters. Using the PHYCONFIG_VECTOR, the MAC configures the PHY for operation, independent of frame transmission or reception.

This interface is an extension of the generic PHY service interface defined in 7.3.4.

21.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 21-1 are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request primitive and/or as part of the RXVECTOR parameter list in the PHY-RXSTART.indication primitive.

Table 21-1—TXVECTOR and RXVECTOR parameters

Parameter	Value	TXVECTOR	RXVECTOR
MCS	The MCS field indicates the modulation and coding scheme used in the transmission of the packet. Values are integers in the range of 0 to 31. — An MCS value of 0 indicates the use of control PHY. — MCS values of 1 to 12 indicate use of single carrier modulations. The value is an index to Table 21-18. — MCS values of 13 to 24 indicates use of OFDM modulations. The value is an index to Table 21-14. — MCS values of 25 to 31 indicate use of low-power SC PHY. The value is an index to Table 21-22.	Y	Y
LENGTH	Indicates the number of octets in the PSDU in the range of 0 to 262 143. A value of zero indicates a packet in which no data part follows the header.	Y	Y
ADD-PPDU	Enumerated Type: — ADD-PPDU indicates that this PPDU is immediately followed by another PPDU with no IFS or preamble on the subsequent PPDU. — NO-ADD-PPDU indicates no additional PPDU follows this PPDU.	Y	Y

Table 21-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Value	TXVECTOR	RXVECTOR
PACKET-TYPE	Enumerated Type: — TRN-R-PACKET indicates either a packet whose data part is followed by one or more TRN-R subfields, or a packet that is requesting TRN-R subfields to be appended to a future response packet. — TRN-T-PACKET indicates a packet whose data part is followed by one or more TRN-T subfields. This field is reserved if TRN-LEN is 0.	Y	Y
TRN-LEN	TRN-LEN indicates the length of the training field. Values are 0-64 in multiples of 4. A value of N indicates that the AGC has 4N subfields and that the TRN-R/T field has 5N subfields (21.10.2.2.3).	Y	Y
AGGREGATION	Indicates whether the PSDU contains an A-MPDU. Enumerated Type: — AGGREGATED indicates this is a packet with A-MPDU aggregation. — NOT_AGGREGATED indicates this is a packet without A-MPDU aggregation.	Y	Y
RSSI	The allowed values for the RSSI parameter are in the range from 0 through RSSI maximum. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU. RSSI shall be measured during the reception of the PLCP preamble. RSSI is intended to be used in a relative manner, and it shall be a monotonically increasing function of the received power.	N	Y
SNR	This parameter indicates the SNR measured during the reception of a control PHY packet. Values are –13 dB to 50.75 dB in 0.25 dB steps.	N	Y
RCPI	Is a measure of the received RF power measured over the preamble of a received frame. Refer to 21.3.10 for the definition of RCPI.	N	Y
ANT-CONFIG	Indicates which antenna configuration(s) is to be used throughout the transmission of the packet, and when to switch between configurations. Values are implementation dependent.	Y	N
CHAN_MEASUREMENT	Channel as measured during the reception of TRN-T subfields. Each measurement includes 63 complex numbers.	N	Y
TIME_OF_DEPARTURE_REQUESTED	Enumerated type: — TRUE indicates that the MAC entity requests that the PHY PLCP entity measures and reports time of departure parameters corresponding to the time when the first frame energy is sent by the transmitting port. — FALSE indicates that the MAC entity requests that the PHY PLCP entity neither measures nor reports time of departure parameters.	O	N
RX_START_OF_FRAME_OFFSET	0 to 2^{32}-1. An estimate of the offset (in 10 nanosecond units) from the point in time at which the start of the preamble corresponding to the incoming frame arrived at the receive antenna port to the point in time at which this primitive is issued to the MAC.	N	Y
DTP_TYPE	Enumerated: — STATIC indicating static tone paring (see 21.5.3.2.4.6.2). — DYNAMIC indicating dynamic tone pairing (see 21.5.3.2.4.6.3).	Y	Y

Table 21-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Value	TXVECTOR	RXVECTOR
DTP_INDICATOR	Takes values 0 or 1 to indicate a DTP update (see 9.38)	Y	Y
BEAM_TRACKING_REQUEST	This parameter indicates whether beam tracking is requested. Enumerated type: Beam tracking requested or Beam tracking not requested	Y	Y
LAST_RSSI	In the TXVECTOR, LAST_RSSI indicates the received power level of the last packet with a valid PHY header that was received a SIFS period before transmission of the current packet; otherwise, it is 0 (9.3.2.3.3). In the RXVECTOR, LAST_RSSI indicates the value of the LAST_RSSI field from the PCLP header of the received packet. Valid values are integers in the range of 0 to 15: — Values of 2 to 14 represent power levels (–71+value×2) dBm. — A value of 15 represents power greater than or equal to –42 dBm. — A value of 1 represents power less than or equal to –68 dBm. — A value of 0 indicates that the previous packet was not received a SIFS period before the current transmission.	Y	Y
Turnaround	Set to 1 or 0 as specified in 9.3.2.3.3.	Y	Y

21.2.3 TXSTATUS parameters

The parameters listed in Table 21-2 are defined as part of the TXSTATUS parameter list in the PHYTXSTART.confirm(TXSTATUS) primitive.

Table 21-2—TXSTATUS parameters

Parameter	Value
TIME_OF_DEPARTURE	When the first frame energy is sent by the transmitting port, in units equal to 1/TIME_OF_DEPARTURE_ClockRate. This parameter is present only if TIME_OF_DEPARTURE_REQUESTED is true in the corresponding request.
TIME_OF_DEPARTURE_ClockRate	0 to 2^{16}-1. The clock rate, in units of MHz, is used to generate the TIME_OF_DEPARTURE value. This parameter is present only if TIME_OF_DEPARTURE_REQUESTED is true in the corresponding request.
TX_START_OF_FRAME_OFFSET	0 to 2^{32}-1. An estimate of the offset (in 10 nanosecond units) from the point in time at which the start of the preamble corresponding to the frame was transmitted at the transmit antenna port to the point in time at which this primitive is issued to the MAC.

21.3 Common parameters

21.3.1 Channelization

STAs compliant with the physical layer defined in Clause 21 operate in the channels defined in Annex E and shall support at least channel number 2.

The channel center frequency is defined as:

$$\textit{Channel center frequency} = \textit{Channel starting frequency} + \textit{Channel spacing} \times \textit{Channel number}$$

where channel starting frequency, channel spacing and channel number are as defined in Annex E.

21.3.2 Transmit mask

The transmitted spectrum shall adhere to the transmit spectrum mask shown in the Figure 21-1. The transmit spectrum shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth not exceeding 1.88 GHz, -17 dBr at a 1.2 GHz offset, -22 dBr at a 2.7 GHz offset and -30dBr at a 3.06 GHz offset and above, inside the channels allowed for the regulatory domain in which the device is transmitting. The resolution bandwidth shall be set to 1 MHz.

The transmit mask shall be measured on data packets longer than 10 µs without training fields.

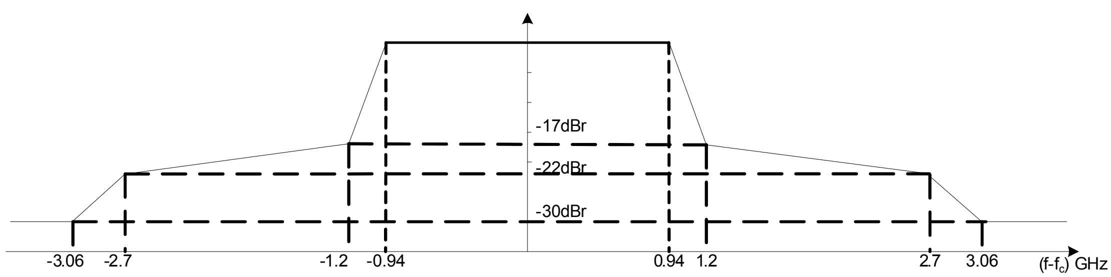


Figure 21-1—Transmit mask

21.3.3 Common requirements

21.3.3.1 Introduction

This subclause describes the common requirement from all 4 DMG PHYs: CPHY, SC, OFDM, and low-power SC.

For all the PHYs, all defined fields are transmitted bit 0 first in time.

21.3.3.2 Transmit RF delay

As defined at 17.3.8.5 and its value is implementation dependent.

21.3.3.3 Center frequency tolerance

21.3.3.3.1 General

The transmitter center frequency tolerance shall be ± 20 ppm maximum.

21.3.3.3.2 Center frequency convergence

The transmitter center frequency shall converge to within 1ppm of its final value within 0.9 µs from the start of the packet.

21.3.3.4 Symbol clock tolerance

The symbol clock frequency tolerance shall be ± 20 ppm maximum.

The transmit center frequency and the symbol clock frequency shall be derived from the same reference oscillator.

21.3.3.5 Transmit center frequency leakage

The transmitter center frequency leakage shall not exceed –23 dB relative to the overall transmitted power or, equivalently, in OFDM (MCS 13-24), +2.5 dB relative to the average power of a subcarrier, measured over a subcarrier spacing bandwidth.

21.3.3.6 Transmit rampup and rampdown

The transmit power-on ramp is defined as the time it takes for a transmitter to rise from less than 10% to greater than 90% of the average power to be transmitted in the frame.

The transmit power-on ramp shall be less than 10 ns.

The transmit power-down ramp is defined as the time it takes the transmitter to fall from greater than 90% to less than 10% of the maximum power to be transmitted in the frame.

The transmit power-down ramp shall be less than 10 ns.

21.3.3.7 Antenna setting

Antenna setting shall remain constant for the transmission of the entire packet except for the case of transmission of BRP-TX packets (see 21.10.2.2). During the transmission of BRP-TX packets, it shall remain constant for the transmission of the STF, CE field, and Data field.

21.3.3.8 Maximum input requirement

The receiver maximum input level is the maximum power level at the receive antenna(s) of the incoming signal, in dBm, present at the input of the receiver antenna for which the error rate criterion (defined in 21.3.3.9) is met. A compliant receiver shall have a receiver maximum input level at the receive antenna(s) of at least 10 microwatts/cm^2 for each of the modulation formats that the receiver supports.

21.3.3.9 Receive sensitivity

For MCS 0, the PER shall be less than 5% for a PSDU length of 256 octets with the MCS dependent input levels listed in Table 21-3 defined at the antenna port(s). For the other MCSs, the PER shall be less than 1% for a PSDU length of 4096 octets with the MCS dependent input levels listed in Table 21-3 defined at the antenna port(s).

NOTE—For RF power measurements performed over the air, the input level shall be corrected to compensate for the antenna gain in the implementation. The gain of the antenna is the maximum estimated gain by the manufacturer. In the case of the phased-array antenna, the gain of the phased-array antenna is the maximum sum of estimated element gain minus 3 dB implementation loss.

Table 21-3 assumes 5 dB implementation loss and 10 dB noise factor (Noise Figure).

Table 21-3—Receiver sensitivity

MCS index	Receive sensitivity (dBm)
0	–78
1	–68
2	–66
3	–65
4	–64
5	–62
6	–63
7	–62
8	–61
9	–59
10	–55
11	–54
12	–53
13	–66
14	–64
15	–63
16	–62
17	–60
18	–58
19	–56
20	–54
21	–53
22	–51
23	–49
24	–47
25	–64
26	–60
27	–57
28	–57
29	–57
30	–57
31	–57

21.3.4 Timing-related parameters

Table 21-4—Timing-related parameters

Parameter	Value
N_{SD}: Number of data subcarriers	336
N_{SP}: Number of pilot subcarriers	16
N_{DC}: Number of DC subcarriers	3
N_{ST}: Total Number of subcarriers	355
N_{SR}: Number of subcarriers occupying half of the overall BW	177
Δ_F: subcarrier frequency spacing	5.15625 MHz(2640 MHz/512)
F_s: OFDM sample rate	2640 MHz
F_c: SC chip rate	1760 MHz = ⅔ F_s
T_s: OFDM Sample Time	0.38 ns=1/F_s
T_c: SC Chip Time	0.57 ns=1/F_c
T_{DFT}: OFDM IDFT/DFT period	0.194 µs
T_{GI}: Guard Interval duration	48.4 ns= $T_{DFT}/4$
T_{seq}	72.7 ns=128×T_c
T_{STF}: Detection sequence duration	1236 ns=17× T_{seq}
T_{CE}: Channel Estimation sequence duration	655 ns=9×T_{seq}
T_{SYM}: Symbol Interval	0.242 µs= $T_{DFT}+T_{GI}$
T_{HEADER}: Header Duration	0.242 µs=T_{SYM} (OFDM) 0.582 µs =2×512× T_c (SC)
F_{CCP}: control PHY chip rate	1760 MHz
T_{CCP}: control PHY chip time	0.57 ns = $1/F_{CCP}$
$T_{STF\text{-}CP}$: control PHY short training field duration	3.636 µs =50× T_{seq}
$T_{CE\text{-}CP}$: control PHY channel estimation field duration	655 ns=9× T_{seq}
T_{Data}	N_{SYM}×T_{SYM} (OFDM) (N_{BLKS}×512+64)×T_c (SC) NOTE—N_{SYM} is defined in 21.5.3.2.3.3 and N_{BLKS} is defined in 21.6.3.2.3.3.

Table 21-5—Frequently used parameters

Symbol	Explanation
N_{CBPS}	Number of coded bits per symbol
N_{DBPS}	Number of data bits per symbol
N_{BPSC}	Number of coded bits per single carrier
R	Code rate

21.3.5 Mathematical conventions in the signal description

21.3.5.1 General

The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal $r(t)$ by the following relation:

$$r_{RF}(t) \quad = \quad \mathrm{Re}\left\{ r(t) \exp\left(j2\pi f_c t \right) \right\}$$

where

$\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable

f_c is the center frequency of the carrier

The transmitted RF signal is generated by modulating the complex baseband signal, which consists of several fields. The fields and the timing boundaries for the various fields are shown in Figure 21-2.

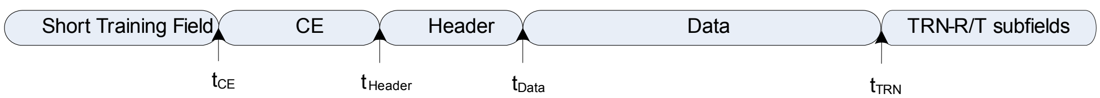


Figure 21-2—Packet structure

The time offset, t_{Field}, determines the starting time of the corresponding field.

$$\begin{aligned} r_{PPDU}(t) \quad = \quad r_{STF}(t) \quad + \quad & r_{CE}\left(t - t_{CE}\right) \\ + \; & r_{Header}\left(t - t_{Header}\right) \\ + \; & r_{Data}\left(t - t_{Data}\right) \\ + \; & r_{TRN}\left(t - t_{TRN}\right) \end{aligned}$$

where

$t_{CE} = T_{STF}$

$t_{Header} = t_{CE} + T_{CE}$

$t_{Data} = t_{Header} + T_{Header}$

$t_{TRN} = t_{Data} + T_{Data}$

Each OFDM base band waveform $r_{Field}\left(nT_S\right)$, for the fields above, is defined via the discrete inverse Fourier transform as:

$$r_{Field}\left(nT_S\right) = w_{T_{Field}}\left(nT_s\right) \sum_k X_k \exp\left(j2\pi k \Delta_F \left(nT_s - T_{\mathrm{GI}}\right)\right)$$

where

X_k is the complex constellation point to be transmitted on subcarrier k

n is the discrete time index

The window $w_{T_{Field}}\left(nT_s\right)$ is user defined and is used to smooth the transition between fields.

The base band waveform for fields defined by time domain sequences or for single carrier transmission is

$$r_{Field}\left(nT_c\right) = x\left(n\right)$$

where

$x\left(n\right)$ is the constellation point n

Conversion from the sampled digital domain to the continuous time domain is beyond the scope of this document. Filtering for pulse shaping such as in GMSK is beyond the scope of this standard.

21.3.5.2 Windowing function

The windowing function $w_{T_{Field}}\left(nT_s\right)$ is used to smooth the transition between adjacent fields in the packet where OFDM modulation is employed. No windowing is applied to preamble fields or to SC modulated fields. The windowing function is different from being equivalent to "1" only in the transition region.

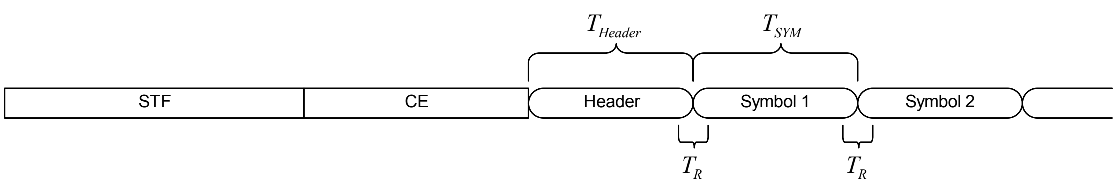


Figure 21-3—Illustration of windowing function

An example of a windowing function is given by

$$w_T\left(t\right) = \begin{cases} \sin^2\left(\dfrac{\pi}{2}\left(\dfrac{1}{2} + \dfrac{t}{T_R}\right)\right) & -T_R/2 < t \le T_R/2 \\ 1 & T_R/2 < t \le T - T_R/2 \\ \sin^2\left(\dfrac{\pi}{2}\left(\dfrac{1}{2} - \dfrac{t-T}{T_R}\right)\right) & T - T_R/2 < t \le T + T_R/2 \end{cases}$$

The transition region creates an overlap (with length T_R) between adjacent fields. The field wave form $r_{Field}\left(nT_S\right)$ is extended cyclically to fill the part of the transition region in which it is undefined. If the transition region vanishes (i.e., T_R=0), the windowing function degenerates to a rectangular window. The choice of windowing function is implementation dependent, as long as transmit EVM and transmit mask requirements are met.

21.3.6 Common preamble

21.3.6.1 General

The preamble is the part of the PPDU that is used for packet detection, AGC, frequency offset estimation, synchronization, indication of modulation (SC or OFDM) and channel estimation. The format of the preamble is common to both OFDM packets and SC packets.

The preamble is composed of two parts (Figure 21-4): the Short Training field and the Channel Estimation field.

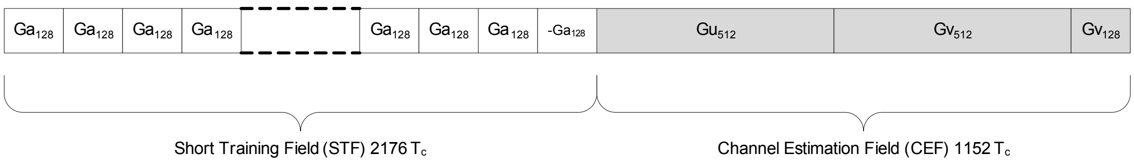


Figure 21-4—SC preamble

21.3.6.2 Short Training field

The Short Training field is composed of 16 repetitions of sequences $\mathrm{Ga}_{128}(n)$ of length 128 defined in 21.11, followed by a single repetition of $-\mathrm{Ga}_{128}(n)$.

The waveform for the Short Training field is

$$r_{STF}(nT_c) = \begin{cases} (Ga_{128}(n \bmod 128))\exp\left(j\pi\dfrac{n}{2}\right) & n = 0,1,\ldots,16\times128-1 \\ (-Ga_{128}(n \bmod 128))\exp\left(j\pi\dfrac{n}{2}\right) & n = 16\times128,\ldots,17\times128-1 \end{cases}$$

where
mod is the modulus operation

21.3.6.3 Channel Estimation field

The Channel Estimation field is used for channel estimation, as well as indication of which modulation is going to be used for the packet. The Channel Estimation field is composed of a concatenation of two sequences $\mathrm{Gu}_{512}(n)$ and Gv_{512}(n), where the last 128 samples of $\mathrm{Gu}_{512}(n)$ and $\mathrm{Gv}_{512}(n)$ are equal to the last 128 samples used in the Short Training field. They are followed by a 128 samples sequence Gv_{128}(n) equal to the first 128 samples of both Gv_{512}(n) and Gu_{512}(n).

The Gu_{512} and Gv_{512} sequences are defined as

$$\begin{aligned} Gu_{512} &= [-Gb_{128} \quad -Ga_{128} \quad Gb_{128} \quad -Ga_{128}] \\ Gv_{512} &= [-Gb_{128} \quad Ga_{128} \quad -Gb_{128} \quad -Ga_{128}] \end{aligned}$$

where
Ga_{128} and Gb_{128} are as defined in 21.11

When the data field of the packet is modulated using single carrier, the Gu_{512} and Gv_{512} fields are concatenated in the order illustrated in Figure 21-5. When the data field of the packet is modulated using OFDM, the Gu_{512} and Gv_{512} fields are concatenated in the order illustrated in Figure 21-6.

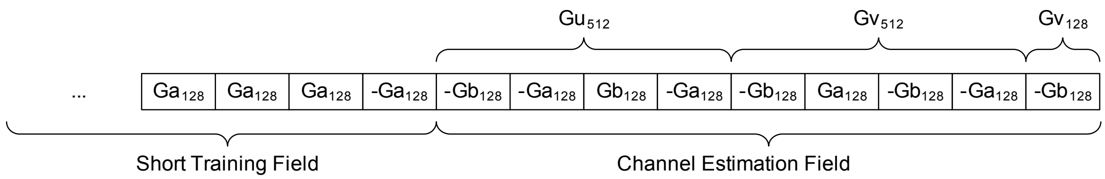


Figure 21-5—Channel Estimation field for SC packets

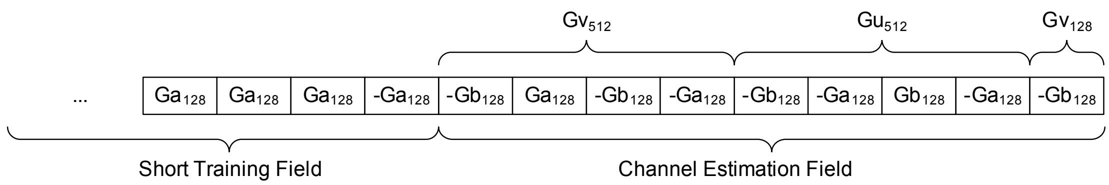


Figure 21-6—Channel Estimation field for OFDM packets

The waveform for the channel estimation sequence is

$$r_{CE_{SC}}(nT_c) = \left(Gu_{512}(n) + Gv_{512}(n-512) + Gv_{512}(n-1024)\right)\exp\left(j\pi\frac{n}{2}\right), n = 0,1,\ldots,1151$$
$$r_{CE_{OFDM}}(nT_c) = \left(Gv_{512}(n) + Gu_{512}(n-512) + Gu_{512}(n-1024)\right)\exp\left(j\pi\frac{n}{2}\right), n = 0,1,\ldots,1151$$

Note that sequences $Gu_{512}(n)$ and $Gv_{512}(n)$ are defined for $0 \le n \le 511$. For other n they are set to 0.

21.3.6.4 Transmission of the preamble and BRP fields in an OFDM packet

21.3.6.4.1 General

The preamble sequence defined in the above subclauses and the BRP fields defined in 21.10.2.2.5, 21.10.2.2.6, and 21.10.2.2.7 are specified at the SC chip rate (T_c). For transmission in the OFDM (nominal) sample rate, the signal is resampled with a 3/2 rate change. The resampling is done by upsampling by a factor of 3, filtering by the filter h_{Filt} defined in 21.3.6.3.1, and downsampling by a factor of 2 (see equation below). The resampling is performed using a specific filter h_{Filt} since the OFDM receiver needs to know this filter to correct for its response during channel estimation. To define the transmission of the preamble when the packet is an OFDM packet, the preamble waveform is defined below.

Let $r_{preamble}(nT_c) = r_{STF}(nT_c) + r_{CE}(nT_c - t_{ce})$, where r_{CE} is $r_{CE_{SC}}$ or $r_{CE_{OFDM}}$ as appropriate.

Then:

$$r_{preamble}^{OFDM(2)}\left(n\tfrac{T_s}{2}\right) = \begin{cases} r_{preamble}\left(n\tfrac{T_c}{3}\right) & n = 0,3,6,\ldots \\ 0 & otherwise \end{cases}$$
$$\tilde{r}_{preamble}^{OFDM(2)}\left(n\tfrac{T_s}{2}\right) = \sum_{k=0}^{K-1} r_{preamble}^{OFDM(2)}\left((n-k)\tfrac{T_s}{2}\right)h_{Filt}(k),\ n = 0,1,\ldots$$
$$r_{preamble}^{OFDM}(nT_s) = \tilde{r}_{preamble}^{OFDM(2)}\left(2n\tfrac{T_s}{2} - \frac{K-1}{2}\tfrac{T_s}{2}\right),\ n = 0,1,\ldots$$

where

K is the length of the filter defined in 21.3.6.4.2

$\tilde{r}^{OFDM(2)}_{preamble}(n) = 0, \text{for} \, n < 0$

21.3.6.4.2 h_{Filt} definition

The filter h_{Filt} is defined by the following coefficients (from h_0 to h_{70}):

[-1,0,1,1,-2,-3,0,5,5,-3,-9,-4,10,14,-1,-20,-16,14,33,9,-35,-42,11,64,40,-50,-96,-15,120,126,-62,-256,-148,360,985,1267,985,360,-148,-256,-62,126,120,-15,-96,-50,40,64,11,-42,-35,9,33,14,-16,-20,-1,14,10,-4,-9,-3,5,5,0,-3,-2,1,1,0,-1]. Normalized to have a norm of $\sqrt{3}$ so that $h_{Filt}(k) = \frac{\sqrt{3}h_k}{\sqrt{\sum_{l=0}^{70}|h_l|^2}}$.

21.3.7 HCS calculation for headers of control PHY, OFDM PHY, and SC PHY

The header check sequence (HCS) is a CRC of the header bits. The header is considered to be a stream of bits $b_0,\ldots,b_{M-1}$. The CRC is based on CRC 16-CCITT. The value of the CRC field is the ones complement of

$$CRC(D) = \left(M(D) \oplus I(D)\right) D^{16} \bmod G(D)$$

where

$M(D) = b_0 D^{M-1} + b_1 D^{M-2} + \cdots + b_{M-1}$ is the header bits represented as polynomial (over the binary field) where b_0 is bit 0 of the header and b_{M-1} is bit $M-1$ of the header

$I(D) = \sum_{k=M-16}^{M-1} D^k$ is an initialization polynomial added to the first 16 bits of the header (setting the shift register bits to 1)

$G(D) = D^{16} + D^{12} + D^5 + 1$ is the CRC generating polynomial

$CRC(D) = x_0 D^{15} + x_1 D^{14} + \cdots x_{14} D + x_{15}$

The CRC field is transmitted with x_{15} first.

For a block diagram and an example of how to calculate the CRC, see 16.2.3.7.

21.3.8 Common LDPC parity matrices

21.3.8.1 General

Four Low-Density Parity-Check (LDPC) codes are specified, each of a different rate but with a common codeword size of 672 bits.

Each of the parity-check matrices $\boldsymbol{H}$ is partitioned into square submatrices of size $Z \times Z$. The submatrices are either cyclic-permutations of the identity matrix, or null submatrices with all zero entries.

A location with integer i denotes the cyclic-permutation submatrix P_i obtained from the $Z \times Z$ identity matrix by cyclically shifting the columns to the right by i elements. The matrix P_0 is the $Z \times Z$ identity matrix. An empty location denotes a null submatrix of size $Z \times Z$.

Examples with $Z = 4$:

$$P_0 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, P_1 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} P_3 = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

21.3.8.2 Rate-1/2 LDPC code matrix H = 336 rows x 672 columns, Z = 42

Table 21-6—Rate 1/2 LDPC code matrix (Each nonblank element i in the table is the cyclic permutation matrix P_i of size $Z \times Z$; blank entries represent the zero matrix of size $Z \times Z$)

40		38		13		5		18							
34		35		27			30	2	1						
	36		31		7		34		10	41					
	27		18		12	20				15	6				
35		41		40		39		28			3	28			
29		0			22		4		28		27		23		
	31		23		21		20			12			0	13	
	22		34	31		14		4				13		22	24

21.3.8.3 Rate-5/8 LDPC code matrix H = 252 rows x 672 columns, Z = 42

Table 21-7—Rate 5/8 LDPC code matrix (Each nonblank element i in the table is the cyclic permutation matrix P_i of size $Z \times Z$; blank entries represent the zero matrix of size $Z \times Z$)

20	36	34	31	20	7	41	34		10	41					
30	27		18		12	20	14	2	25	15	6				
35		41		40		39		28			3	28			
29		0			22		4		28		27	24	23		
	31		23		21		20		9	12			0	13	
	22		34	31		14		4						22	24

21.3.8.4 Rate-3/4 LDPC code matrix H = 168 rows x 672 columns, Z = 42

Table 21-8—Rate 3/4 LPDC code matrix
(Each nonblank element i in the table is the cyclic permutation matrix P_i of size $Z \times Z$; blank entries represent the zero matrix of size $Z \times Z$)

35	19	41	22	40	41	39	6	28	18	17	3	28			
29	30	0	8	33	22	17	4	27	28	20	27	24	23		
37	31	18	23	11	21	6	20	32	9	12	29		0	13	
25	22	4	34	31	3	14	15	4		14	18	13	13	22	24

21.3.8.5 Rate-13/16 LDPC code matrix H = 126 rows x 672 columns, Z = 42

Table 21-9—Rate 13/16 LDPC code matrix
(Each nonblank element i in the table is the cyclic permutation matrix P_i of size $Z \times Z$; blank entries represent the zero matrix of size $Z \times Z$)

29	30	0	8	33	22	17	4	27	28	20	27	24	23		
37	31	18	23	11	21	6	20	32	9	12	29	10	0	13	
25	22	4	34	31	3	14	15	4	2	14	18	13	13	22	24

21.3.9 Scrambler

The header and data fields following the scrambler initialization field (including data padding bits) shall be scrambled by XORing each bit in turn with a length 127 periodic sequence generated by the polynomial $S(x) = x^7 + x^4 + 1$. The PLCP header bits, with the exception of the first seven bits for SC and OFDM and the first five bits for control PHY, are placed one after the other, bit 7 first (bit 5 first for control PHY). The octets of the PSDU and the pad bits shall be placed into a bit stream with bit 0 (LSB) of each octet first and bit 7 of each octet (MSB) last. The generation of the sequence and the XOR operation are defined in Figure 21-7.

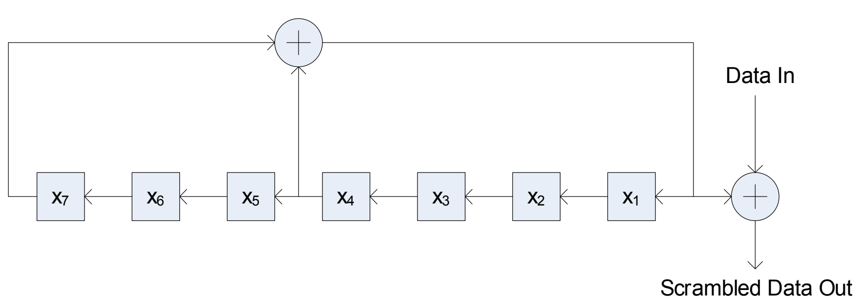


Figure 21-7—Data scrambler

For each PPDU, the transmitter shall select a nonzero seed value for the scrambler (bits x_1 through x_7). The seed value should be selected in a pseudo random fashion. The seed value is sent in the Scrambler Initialization field of the PLCP header. Each data bit in the data field of the PPDU is then XORed with the scrambler output (x_4 XOR x_7) and the scrambler content shifted once.

21.3.10 Received channel power indicator (RCPI) measurement

The RCPI is a measure of the received RF power in the selected channel as measured at the DMG Antenna output. This parameter shall be measured by the PHY of the received RF power in the channel measured over the preamble of the received frame. RCPI shall be a monotonically increasing, logarithmic function of the received power level defined in dBm. The allowed values for the Received Channel Power Indicator (RCPI) parameter shall be an 8 bit value in the range from 0 to 220, with indicated values rounded to the nearest 0.5 dB as follows:

— 0: Power < –110 dBm
— 1: Power = –109.5 dBm
— 2: Power = –109.0 dBm

And so on up to:

— 220: Power > 0 dBm
— 221–254: reserved
— 255: Measurement not available

where RCPI = int{(Power in dBm +110) × 2} for 0 dBm > Power > –110 dBm

RCPI shall equal the received RF power with an accuracy of ± 5 dB (95% confidence interval) within the specified dynamic range of the receiver. The received RF power shall be determined assuming a receiver noise equivalent bandwidth equal to the channel width multiplied by 1.1. The relative error between RF power measurements made within a 1 second interval should be less than ± 1 dB.

21.4 DMG control PHY

21.4.1 Introduction

Transmission and reception of control PHY PPDUs is mandatory. Control PHY uses the same chip rate as the SC PHY. Control PHY is transmitted when the TXVECTOR indicates MCS 0.

The modulation and coding scheme for the control PHY is shown in Table 21-10.

Table 21-10—Modulation and coding scheme for the control PHY

MCS index	Modulation	Code rate	Data rate
0	DBPSK	1/2[a]	27.5 Mbps[a]

[a]Code rate and data rate may be lower due to codeword shortening.

21.4.2 Frame format

The control PHY frame is composed of the Preamble, Header, Data field, and possibly AGC and TRN-R/T subfields. This is shown in Figure 21-8.

Figure 21-8—Control PHY frames

21.4.3 Transmission

21.4.3.1 Preamble

21.4.3.1.1 General

The preamble is the part of the control PHY PPDU that is used for packet detection, AGC, frequency offset estimation, synchronization, indication of frame type and channel estimation.

The preamble is composed of two parts as shown in Figure 21-9: the Short Training field and the Channel Estimation field.

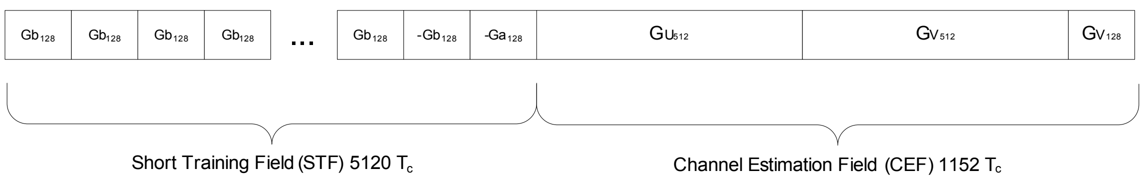


Figure 21-9—Control PHY preamble

21.4.3.1.2 Short Training field

The Short Training field is composed of 48 repetitions of the sequence $\mathrm{Gb}_{128}(n)$ of length 128,_followed by a single -Gb128(n) sequence (for synchronization) and then a single -Ga128(n) sequence. The sequences $\mathrm{Ga}_{128}(n)$ and $\mathrm{Gb}_{128}(n)$ are defined in 21.11.

The waveform for the Short Training field is

$$r_{STF}(nT_c) = \begin{cases} Gb_{128}(n \bmod 128)\exp\left(j\pi\frac{n}{2}\right) & n = 0,1,\ldots,48 \times 128 - 1 \\ -Gb_{128}(n \bmod 128)\exp\left(j\pi\frac{n}{2}\right) & n = 48 \times 128,\ldots,49 \times 128 - 1 \\ -Ga_{128}(n \bmod 128)\exp\left(j\pi\frac{n}{2}\right) & n = 49 \times 128,\ldots,50 \times 128 - 1 \end{cases}$$

where mod is the modulus operation. Note that sequences $\mathrm{Ga}_{128}(n)$ and $\mathrm{Gb}_{128}(n)$ are defined for $0 \le n \le 127$. For other n they are set to 0.

21.4.3.1.3 Channel Estimation field

The Channel Estimation field is the same as the Channel Estimation field of the SC PHY, as defined in Figure 21-5 of 21.3.6.3.

21.4.3.2 Header

21.4.3.2.1 General

In the control PHY, the preamble is followed by the header block. The header consists of several fields that define the details of the PPDU to be transmitted.

The header fields are described in Table 21-11.

Table 21-11—Control PHY header fields

Field name	Number of bits	Starting bit	Description
Reserved	1	0	Set to 0 (differential detector initialization).
Scrambler Initialization	4	1	Bits X1–X4 of the initial scrambler state.
Length	10	5	Number of data octets in the PSDU. Range 14–1023.
Packet Type	1	15	Corresponds to the TXVECTOR parameter PACKET-TYPE. — Packet Type = 0 indicates either a packet whose data part is followed by one or more TRN-R subfields, or a packet that is requesting TRN-R subfields to be appended to a future response packet. — Packet Type = 1 indicates a packet whose data part is followed by one or more TRN-T subfields. The field is reserved when the Training Length field is 0.
Training Length	5	16	Length of the training field. The use of this field is defined in 21.10.2.2.3.
Turnaround	1	21	As defined in Table 21-1.
Reserved bits	2	22	Set to 0, ignored by the receiver.
HCS	16	24	Header Check sequence. Calculation of the header check sequence is defined in 21.3.7.

All the numeric fields are encoded in unsigned binary, least significant bit first.

Reserved bits are set to 0 by the transmitter and shall be ignored by the receiver.

21.4.3.2.2 Generation of HCS bits

The header check sequence (HCS) is calculated over bits 0-23 and uses CRC 16-CCITT as described in 21.3.7.

21.4.3.2.3 Header encoding and modulation

The header bits followed by the HCS bits are prepended to the data field bits and passed into the data field encoder per 21.4.3.3. The minimal payload length is 14 octets.

21.4.3.3 Data field

21.4.3.3.1 General

The Data field consists of the payload data of the PSDU. The PSDU is scrambled, encoded, modulated and spread as described in the following subclauses.

21.4.3.3.2 Scrambler

The operation of the scrambler is defined in 21.3.9. Bits x1, x2, x3, x4 of the scrambler shift register are initialized using the bits in the scrambler initialization bits from the header, bits x5, x6, x7 are set to 1. The header is scrambled starting from bit 5. The scrambling of the data field continues the scrambling of the header with no reset.

21.4.3.3.3 Encoder

The control PHY header and data is encoded using an effective LDPC code rate less than or equal to ½, generated from the data PHY rate ¾ LDPC parity check matrix, with shortening. The following steps are used for the encoding:

1) $L_{CWD} = 168$ is the maximal number of data bits in each LDPC codeword. Define L_{HDR}=5 as the length of the header (including header CRC), and L_{FDCW} is the length of the additional data in the header LDPC codeword in octets. Define the number of header and data bits in the first LDPC codeword as $L_{DPFCW} = (L_{HDR} + L_{FDCW}) \times 8 = 88$. The number of LDPC codewords is calculated $N_{CW} = 1 + \left\lceil \frac{(Length - 6) \times 8}{L_{CWD}} \right\rceil$. The number of bits in the second and any subsequent codeword (if present), except the last, is $L_{DPCW} = \left\lceil \frac{(Length - 6) \times 8}{N_{CW} - 1} \right\rceil$
2) The number of bits in the last codeword is defined as $L_{DPLCW} = (Length - 6) \times 8 - (N_{CW} - 2) \times L_{DPCW}$.
3) The output stream of the scrambler is broken into blocks of L = L_{DPFCW}, L_{DPCW}, or L_{DPLCW} bits (depending on the codeword index) such that the mth data word is $\left(b_1^{(m)}, b_2^{(m)}, \ldots, b_L^{(m)}\right)$.
4) Each data word is padded with zeros to create 504 total bits.
5) To each data word, L_{CWD} parity bits $\left(p_1^{(m)}, p_2^{(m)}, \ldots, p_{L_{CWD}}^{(m)}\right)$ are added to create the codeword $c^{(m)} = \left(b_1^{(m)}, b_2^{(m)}, \ldots, b_L^{(m)}, 0, \ldots, 0, p_1^{(m)}, p_2^{(m)}, \ldots, p_{L_{CWD}}^{(m)}\right)$ such that $Hc^{(m)^T} = 0$.
6) The output is the stream bits generated from the codewords, with the zero padding removed from all codewords.

Example: If $Length = 120$, then $N_{CW} = 1 + \left\lceil \frac{(120 - 6) \times 8}{L_{CWD}} \right\rceil = 7$, $N_{CW} = 1 + \left\lceil \frac{(120 - 6) \times 8}{L_{CWD}} \right\rceil = 7$, and $L_{DPLCW} = (120 - 6) \times 8 - (7 - 2) \times 152 = 152$. In the first LDPC block the 40 header+HCS bits are encoded along with additional 48 bits of the data.

21.4.3.3.4 Modulation

The scrambled and coded bit stream is converted into a stream of complex constellation points using differential binary phase shift keying (DBPSK) as follows.

The encoded bit stream $[c_0, c_1, c_2, c_3, c_4, \ldots]$ is converted the nondifferential stream $s(k) = 2c_k - 1$. The differential sequence is created by setting $d(k) = s(k) \times d(k-1)$. For the differential encoding purposes $d(-1)$ is defined to be 1. $s(0)$ is the first bit of the encoded header bits.

21.4.3.3.5 Spreading

The constellation points are spread using the sequence $Ga_{32}(n)$, which is defined in 21.11.

The waveform for the modulated and spread data field is

$$r_{DATA}(nT_c) = \left(Ga_{32}(n \bmod 32) \cdot d\left(\left\lfloor \frac{n}{32} \right\rfloor\right)\right) \exp\left(j\pi\frac{n}{2}\right), n = 0,1,2,\ldots$$

where $\lfloor x \rfloor$ means the largest integer smaller than a real number x and $d(k)$ is the modulated constellation point k.

21.4.4 Performance requirements

21.4.4.1 Transmit requirements

21.4.4.1.1 Introduction

Transmitter performance requirements of the CPHY are defined in 21.4.4.1.2.

21.4.4.1.2 Transmit EVM

The transmit EVM accuracy test shall be performed by instrumentation capable of converting the transmitted signal into a stream of complex samples, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, dc offsets, phase noise, etc. The instrumentation shall perform carrier lock, symbol timing recovery, and amplitude adjustment while making the measurements. The instrumentation shall incorporate a rake receiver or equalizer to minimize error resulting from multipath. If used, the equalizer shall be trained using information in the preamble (STF and/or CEF). For the CPHY EVM, the signal is first de-spread using Ga_{32}. The EVM is then calculated on the resulting symbols according to the formula below:

$$EVM = 20\log_{10}\left(\sqrt{\left(\frac{1}{N_s P_{avg}}\sum_{i=1}^{N_S}\left[(I_i - I_i^*)^2 + (Q_i - Q_i^*)^2\right]\right)}\right)$$

where N_S is the number of symbols to be measured and N_s should be greater than 511, P_{avg} is the average power of the constellation, (I_i, Q_i) is the complex coordinates of the measured symbol i, and (I_i^*, Q_i^*) is the complex coordinates of the ideal constellation point for the measured symbol i.

The test equipment should use a root-raised cosine filter with roll-off factor of 0.25 for the pulse shaping filter when conducting EVM measurement.

The transmit pulse shaping used is left to the implementer.

The EVM shall not exceed a data-rate dependent value according to Table 21-12.

Table 21-12—EVM requirement for control PHY

MCS index	Description	EVM value [dB]
0	CPHY Modulation	–6

21.4.4.2 Receive requirements

21.4.4.2.1 Introduction

Subclause 21.4.4.2 describes the performance requirement from the CPHY receiver.

21.4.4.2.2 CCA

The start of a valid DMG control PHY transmission at a receive level greater than the minimum sensitivity for control PHY (–78 dBm) shall cause CCA to indicate busy with a probability > 90% within 3 μs.

21.5 DMG OFDM PHY

21.5.1 Introduction

Transmission and reception of OFDM PHY PPDUs is optional.

21.5.2 Frame format

An OFDM frame is composed of the Short Training Field (STF), the channel estimation field (CE), the Header, OFDM symbols and optional training fields (see 21.10.2.2.2), as shown in Figure 21-10.

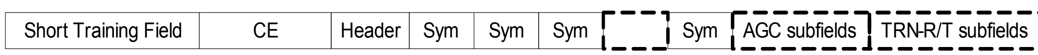


Figure 21-10—OFDM frame format

21.5.3 Transmission

21.5.3.1 Header

21.5.3.1.1 General

In the OFDM PHY, the preamble is followed by the PLCP header. The PLCP header consists of several fields that define the details of the PPDU being transmitted. The encoding and modulation of the header is described in 21.5.3.1.4.

The header fields are described in Table 21-13.

Table 21-13—OFDM header fields

Field name	Number of bits	Start bit	Description
Scrambler Initialization	7	0	Bits X1–X7 of the initial scrambler state.
MCS	5	7	Index into the Modulation and Coding Scheme table.
Length	18	12	Number of data octets in the PSDU. Range 1–262 143.

Table 21-13—OFDM header fields *(continued)*

Field name	Number of bits	Start bit	Description
Additional PPDU	1	30	Contains a copy of the parameter ADD-PPDU from the TXVECTOR. A value of 1 indicates that this PPDU is immediately followed by another PPDU with no IFS or preamble on the subsequent PPDU. A value of 0 indicates that no additional PPDU follows this PPDU.
Packet Type	1	31	See definition of Packet Type field in Table 21-11.
Training Length	5	32	Corresponds to the TXVECTOR parameter TRN-LEN. If the Beam Tracking Request field is 0, the Training Length field indicates the length of the training field. The use of this field is defined in 21.10.2.2.3. A value of 0 indicates that no training field is present in this PPDU. If the Beam Tracking Request field is 1 and the Packet Type field is 1, the Training Length field indicates the length of the training field. If the Packet Type field is 0, the Training Length field indicates the length of the training field requested for receive training.
Aggregation	1	37	Set to 1 to indicate that the PPDU in the data portion of the packet contains an A-MPDU; otherwise, set to 0.
Beam Tracking Request	1	38	Corresponds to the TXVECTOR parameter BEAM_TRACKING_REQUEST. Set to 1 to indicate the need for beam tracking (9.35.7); otherwise, set to 0. The Beam Tracking Request field is reserved when the Training Length field is 0.
Tone Pairing Type	1	39	Set to 0 to indicate Static Tone Pairing (21.5.3.2.4.6.2); Set to 1 to indicate Dynamic Tone Pairing (21.5.3.2.4.6.3). Only valid if MCS field value is in the range of 13 to 17; otherwise reserved.
DTP Indicator	1	40	Bit flip used to indicate DTP update. Only valid when the Tone Pairing Type field is 1 and the MCS field value is in the range of 13 to 17; otherwise reserved.

Table 21-13—OFDM header fields *(continued)*

Field name	Number of bits	Start bit	Description
Last RSSI	4	41	Contains a copy of the parameter LAST_RSSI from the TXVECTOR. When set to 0, this field is reserved and ignored by the receiver. The value is an unsigned integer: — Values of 2 to 14 represent power levels (–71+value×2) dBm. — A value of 15 represents a power greater than or equal to –42 dBm. — A value of 1 represents a power less than or equal to –68 dBm. Value of 0 indicates that the previous packet was not received a SIFS period before the current transmission.
Turnaround	1	45	As defined in Table 21-1.
Reserved	2	46	Set to 0, ignored by receiver
HCS	16	48	Header check sequence. Definition of this field calculation is in 21.5.3.1.3.

All the numeric fields are encoded in unsigned binary, least significant bit first.

Reserved bits are set to 0 by the transmitter and shall be ignored by the receiver.

If the Additional PPDU field is equal to 1, the Training Length field shall be set to 0.

21.5.3.1.2 Modulation and coding scheme

The modulation and coding scheme (MCS) field specifies the modulation and code rate used in the PPDU. The modulation and coding schemes for OFDM modulations are defined in Table 21-14.

Table 21-14—Modulation and coding scheme for OFDM

MCS index	Modulation	Code rate	N_{BPSC}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)
13	SQPSK	1/2	1	336	168	693.00
14	SQPSK	5/8	1	336	210	866.25
15	QPSK	1/2	2	672	336	1386.00
16	QPSK	5/8	2	672	420	1732.50
17	QPSK	3/4	2	672	504	2079.00
18	16-QAM	1/2	4	1344	672	2772.00
19	16-QAM	5/8	4	1344	840	3465.00
20	16-QAM	3/4	4	1344	1008	4158.00
21	16-QAM	13/16	4	1344	1092	4504.50

Table 21-14—Modulation and coding scheme for OFDM *(continued)*

MCS index	Modulation	Code rate	N_{BPSC}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)
22	64-QAM	5/8	6	2016	1260	5197.50
23	64-QAM	3/4	6	2016	1512	6237.00
24	64-QAM	13/16	6	2016	1638	6756.75

A device that supports OFDM shall support MCSs 13-17 for both Tx and Rx.

21.5.3.1.3 Generation of the HCS bits

Calculation of the HCS for bits 0-47 of the header is defined in 21.3.7.

21.5.3.1.4 Header encoding and modulation

The header is encoded using a single OFDM symbol. The bits are scrambled and encoded as follows:

1) The 64 header bits ($b_1, b_2, \ldots, b_{LH}$), where LH = 64, are scrambled as described in 21.3.9, starting from the eighth bit, to create $\mathbf{q}=(q_1,q_2,\ldots,q_{LH})$.
2) The sequence $\mathbf{q}$ is padded with 440 zeros to obtain a total of 504 bits, $(q_1,q_2,\ldots,q_{LH},0_{LH+1},0_{LH+2},\ldots 0_{504})$, which are then encoded using the rate-3/4 LDPC code as described in 21.5.3.2.3.3. 168 parity bits, $p_1,p_2,\ldots,p_{168}$, are generated.
3) A sequence $\mathbf{c_1}$ is generated as $(q_1,q_2,\ldots,q_{LH},p_9,p_{10},\ldots p_{168})$.
4) A sequence $\mathbf{c_2}$ is generated as $(q_1,q_2,\ldots,q_{LH},p_1,p_2,\ldots p_{84}, p_{93},p_{94},\ldots p_{168})$ XORed with a one-time pad sequence generated using the scrambler defined in 21.3.9, with the shift register is initialized to all ones.
5) A sequence $\mathbf{c_3}$ is generated as $(q_1,q_2,\ldots,q_{LH},p_1,p_2,\ldots p_{160})$ XORed with the continuation of the one-time pad sequence generated in step 4).
6) The sequences $\mathbf{c_1},\mathbf{c_2}$ and $\mathbf{c_3}$ are concatenated to form the 672-bit sequence $\mathbf{c}=(c_1,c_2,c_3,\ldots,c_{672})=(\mathbf{c_1},\mathbf{c_2},\mathbf{c_3})$.
7) The 672-bit sequence, **c**, is then mapped as QPSK as described in 21.5.3.2.4.3, pilots are inserted as described in 21.5.3.2.5 and the resulting sequence $d_0, d_1, \ldots, d_{SD-1}$ is modulated as an OFDM symbol as follows:

$$r_{Header}(qT_S) = \frac{1}{\sqrt{N_{Tones}}} w_{T_{SYM}}(qT_S) \sum_{k=-N_{SR}}^{N_{SR}} (D_k + p_1 P_k) \exp\left(j2\pi k \Delta_F (qT_S - T_{GI})\right)$$

where p_1 and P_k are defined in 21.5.3.2.5 and D_k is defined in 21.5.3.2.6.

21.5.3.2 Data field

21.5.3.2.1 General

The data field consists of the payload data of the PSDU and possible padding. The data are padded with zeros, scrambled, encoded and modulated as described in the following subclauses. The amount of padding is defined in 21.5.3.2.3.

21.5.3.2.2 Scrambler

The operation of the scrambler is defined in 21.3.9. The scrambling of the data field continues the scrambling of the header with no reset.

21.5.3.2.3 Encoding

21.5.3.2.3.1 General

The data are encoded by a systematic LDPC encoder. LDPC is a block code. Each block of bits $(b_1, b_2,...,b_k)$ is concatenated with a block of parity bits $(p_1,p_2,....,p_{n-k})$ to create a codeword $\mathbf{c}=(b_1, b_2,...,b_k,p_1,p_2,....,p_{n-k})$ such that $\mathbf{Hc}^\mathbf{T}=\mathbf{0}$. $\mathbf{H}$ is an $(n\text{-}k)\times n$ parity check matrix. The block size n is 672 bits. The code rate, R, is equal to k/n. The set of code rates is defined in Table 21-15. The parity check matrices are defined in 21.5.3.2.3.2. The encoding process is defined in 21.5.3.2.3.3.

Table 21-15—LDPC code rates

Code rate	Codeword size	Number of data bits
1/2	672	336
5/8	672	420
3/4	672	504
13/16	672	546

21.5.3.2.3.2 Parity check matrices

See 21.3.8.

21.5.3.2.3.3 LDPC encoding process

The LDPC encoding process is composed of several steps including determining the number of padding bits, padding with zeros and the coding of every word.

1) First the total number of padding bits N_{PAD} is calculated, using the number of LDPC codeword N_{CW} and the number of OFDM symbols N_{SYM}:

$$N_{CW} = \left\lceil \frac{Length \times 8}{L_{CW} \times R} \right\rceil$$

$$N_{SYM} = \left\lceil \frac{N_{CW} \times L_{CW}}{N_{CBPS}} \right\rceil$$

$$\textit{if BRP packet and } N_{SYM} < \text{aBRPminOFDMblocks}; N_{SYM} = \text{aBRPminOFDMblocks}$$

$$N_{PAD} = R \times N_{SYM} \times N_{CBPS} - Length \times 8$$

Recalculate $\mathrm{N_{CW}} = \mathrm{N}_{SYM} \cdot \frac{\mathrm{N_{CBPS}}}{\mathrm{L_{CW}}}$

where L_{CW}=672 is the LDPC codeword length, *Length* is the length of the PSDU defined in the header field, R is the code rate and N_{CBPS} is the number of code bits per symbol as defined in the MCS table.

2) The PSDU is concatenated with N_{PAD} zeros. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU.

3) The output stream of the scrambler is broken into blocks of $L_{CWD}= R\times L_{CW}$ bits such as the *m'th* data word is $\left(b_1^{(m)}, b_2^{(m)}, \ldots, b_{L_{CWD}}^{(m)}\right)$.
4) To each data word, $n\text{-}k=L_{CW}\text{-}R\times L_{CW}$ parity bits $\left(p_1^{(m)}, p_2^{(m)}, \ldots, p_{n-k}^{(m)}\right)$ are added to create the codeword $\mathbf{c}^{(m)} = \left(b_1^{(m)}, b_2^{(m)}, \ldots, b_{L_{CWD}}^{(m)}, p_1^{(m)}, \ldots p_{n-k}^{(m)}\right)$ such that $\mathbf{H}\,\mathbf{c}^{(m)^{\mathrm{T}}} = \mathbf{0}$.
5) The codewords are the concatenated one after the other to create the coded bits stream $\left(c_1, c_2, \ldots c_{N_{SYM}\times N_{CBPS}}\right)$.

21.5.3.2.4 Modulation mapping

21.5.3.2.4.1 General

The coded bits are mapped to complex constellation points for the modulation specified in the MCS as described in the following subclauses.

21.5.3.2.4.2 SQPSK modulation

In SQPSK (Spread QPSK) modulation, the input stream is broken into groups of N_{CBPS} bits – $\left(c_0^{(q)}, c_1^{(q)}, \ldots, c_{N_{CBPS}-1}^{(q)}\right)$. Each pair of bits $\left(c_{2k}^{(q)}, c_{2k+1}^{(q)}\right), k = 0,1,\ldots, N_{CBPS}/2 - 1$ is converted into a complex constellation point $d_k^{(q)} = \frac{1}{\sqrt{2}}\left(\left(2c_{2k}^{(q)} - 1\right) + j\left(2c_{2k+1}^{(q)} - 1\right)\right)$. This generates the constellation points for half the OFDM subcarriers. For the other subcarriers, $d_{P(k)}^{(q)} = \mathrm{conj}\left(d_k^{(q)}\right)$ for $k = 0,1,\ldots, N_{CBPS}/2 - 1$ where the indices *P(k),* in the range of $N_{CBPS}/2$ *to* N_{CBPS}-1*,* are as defined in 21.5.3.2.6.

21.5.3.2.4.3 QPSK modulation

a) The input stream is broken into groups of N_{CBPS} bits – $\left(c_0^{(q)}, c_1^{(q)}, \ldots, c_{N_{CBPS}-1}^{(q)}\right)$. Each group of four bits $\left(c_{4k}^{(q)}, c_{4k+1}^{(q)}, c_{4k+2}^{(q)}, c_{4k+3}^{(q)}\right)$ is converted into two complex constellation points $x_{2k}^{(q)} = \frac{1}{\sqrt{2}}\left(\left(2c_{4k}^{(q)} - 1\right) + j\left(2c_{4k+2}^{(q)} - 1\right)\right), x_{2k+1}^{(q)} = \frac{1}{\sqrt{2}}\left(\left(2c_{4k+1}^{(q)} - 1\right) + j\left(2c_{4k+3}^{(q)} - 1\right)\right)$. The block $\left(x_0^{(q)}, x_1^{(q)}, \ldots, x_{N_{CBPS}/2-1}^{(q)}\right)$ is created.
b) Each pair of constellation points $\left(x_{2k}^{(q)}, x_{2k+1}^{(q)}\right), k = 0,1\ldots, N_{SD}/2 - 1$ is converted into $\left[d_k^{(q)}, d_{P(k)}^{(q)}\right]^T = Q\left[x_{2k}^{(q)}, x_{2k+1}^{(q)}\right]^T$ where the matrix $Q = \frac{1}{\sqrt{5}}\begin{bmatrix} 1 & 2 \\ -2 & 1 \end{bmatrix}$ and the indices *P(k),* in the range of N_{SD} */2 to* N_{SD}-1*,* are as defined in 21.5.3.2.5.
c) The output is the stream of blocks $\left(d_0^{(q)}, d_1^{(q)}, \ldots, d_{N_{SD}-1}^{(q)}\right), \quad q = 1,\ldots, N_{SYM}$.

21.5.3.2.4.4 16-QAM modulation

The input stream is broken into groups of N_{CBPS} bits $\left(c_0^{(q)}, c_1^{(q)}, \ldots, c_{N_{CBPS}-1}^{(q)}\right)$. Each group of eight bits $\left(c_{4k}^{(q)}, c_{4k+1}^{(q)}, c_{4k+2}^{(q)}, c_{4k+3}^{(q)}, c_{4k+2N_{SD}}^{(q)}, c_{4k+1+2N_{SD}}^{(q)}, c_{4k+2+2N_{SD}}^{(q)}, c_{4k+3+2N_{SD}}^{(q)}\right)$ for $k = 0,1,2,\ldots, N_{SD}/2 - 1$ is converted into two complex constellation points $\left(x_{2k}^{(q)}, x_{2k+1}^{(q)}\right)$ such that

$$x_{2k}^{(q)} = \frac{1}{\sqrt{10}}\left\{\left[\left(4c_{4k}^{(q)} - 2\right) - \left(2c_{4k}^{(q)} - 1\right)\left(2c_{4k+1}^{(q)} - 1\right)\right] + j\left[\left(4c_{4k+2}^{(q)} - 2\right) - \left(2c_{4k+2}^{(q)} - 1\right)\left(2c_{4k+3}^{(q)} - 1\right)\right]\right\} \text{and}$$

$$x_{2k+1}^{(q)} = \frac{1}{\sqrt{10}}\left\{\left[\left(4c_{4k+2N_{SD}}^{(q)} - 2\right) - \left(2c_{4k+2N_{SD}}^{(q)} - 1\right)\left(2c_{4k+1+2N_{SD}}^{(q)} - 1\right)\right] + j\left[\left(4c_{4k+2+2N_{SD}}^{(q)} - 2\right) - \left(2c_{4k+2+2N_{SD}}^{(q)} - 1\right)\left(2c_{4k+3+2N_{SD}}^{(q)} - 1\right)\right]\right\}$$

The output is the stream of blocks $\left(x_0^{(q)}, x_1^{(q)}, x_2^{(q)}, \ldots, x_{N_{SD}-1}^{(q}\right), q = 0,1,2,\ldots N_{SYM} - 1$.

21.5.3.2.4.5 64-QAM modulation

The input stream is broken into groups of N_{CBPS} bits $\left(c_0^{(q)}, c_1^{(q)}, \ldots, c_{N_{CBPS}-1}^{(q)}\right)$. The constellation point for the k'th subcarrier in the q'th symbol is

$$d_k^{(q)} = \tfrac{1}{\sqrt{42}}\left(\left(8c_{6m}^{(q)} - 4\right) - \left(2c_{6m}^{(q)} - 1\right)\left(4c_{6m+1}^{(q)} - 2\right) + \left(2c_{6m}^{(q)} - 1\right)\left(2c_{6m+1}^{(q)} - 1\right)\left(2c_{6m+2}^{(q)} - 1\right)\right) +$$
$$+\, j\,\tfrac{1}{\sqrt{42}}\left(\left(8c_{6m+3}^{(q)} - 4\right) - \left(2c_{6m+3}^{(q)} - 1\right)\left(4c_{6m+4}^{(q)} - 2\right) + \left(2c_{6m+3}^{(q)} - 1\right)\left(2c_{6m+4}^{(q)} - 1\right)\left(2c_{6m+5}^{(q)} - 1\right)\right)$$
$$m = 112\left(k \bmod 3\right) + \lfloor k/3 \rfloor, k = 0, 1, \ldots, N_{SD} - 1$$

NOTE—This mapping provides interleaving between three LDPC codewords on a subcarrier basis.

The mapping is shown in Figure 21-11.

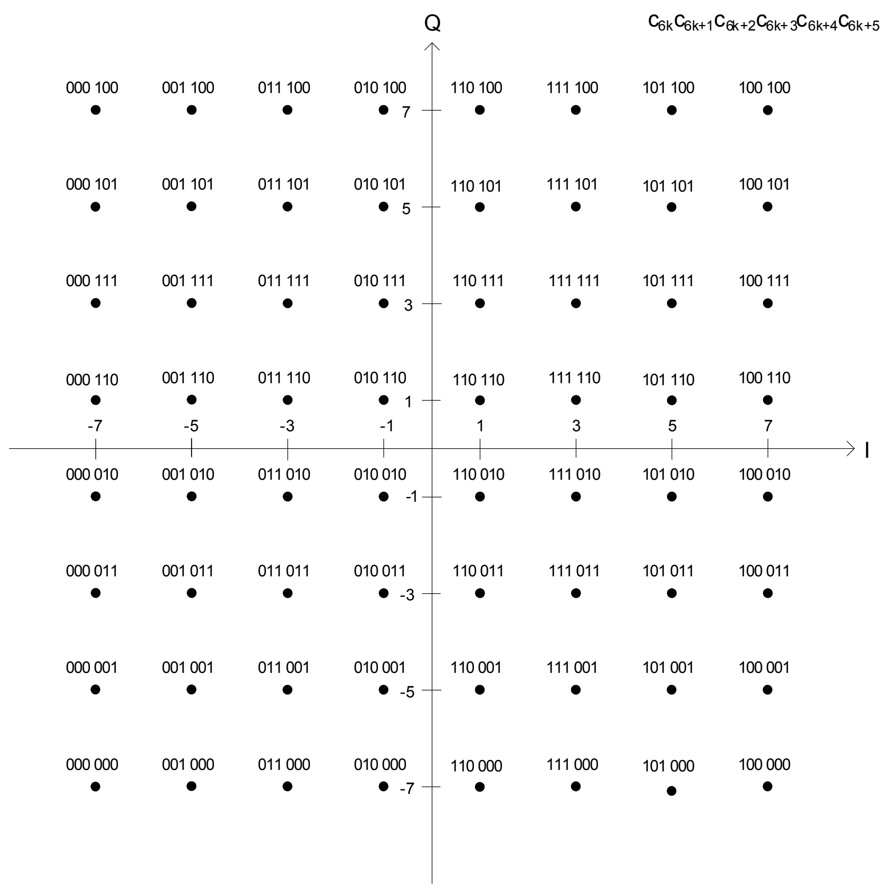


Figure 21-11—64-QAM modulation mapping

21.5.3.2.4.6 Tone pairing for SQPSK and QPSK

21.5.3.2.4.6.1 General

When SQPSK or QPSK modulations are employed in OFDM, bit sequences are mapped to pairs of symbols $\left(d_k^{(q)}, d_{P(k)}^{(q)}\right)$ where k is in the range of $0 \le k \le N_{SD}/2 - 1$ and $P(k)$ is in the range of $N_{SD}/2 \le P(k) \le N_{SD} - 1$ in order to exploit frequency diversity. The indices *k* and *P(k)* determine which pair of OFDM subcarriers each pair of symbols are carried on.

All DMG PHYs shall support Static Tone Pairing (STP*)* where a constant mapping between *k* and *P(k)* is employed. The PHY header is always encoded using STP.

A STA may employ Dynamic Tone Pairing (DTP) where the mapping between *k* and *P(k)* are determined by the receiving STA and fed back to the transmitting STA. An STA may use DTP when transmitting to a DTP-capable STA, from which it has received DTP feedback.

21.5.3.2.4.6.2 Static tone pairing (STP)

When applied to the payload, STP is indicated by the Tone Pairing Type field in the PHY header set to 0. STP is always applied to the PHY header.

When STP is applied, the QPSK or SQPSK symbol-pair indices *k* and *P(k)* are such that

$$P(k) = k + \frac{N_{SD}}{2} \text{ for } k = 0,1,2,\ldots,\frac{N_{SD}}{2} - 1$$

21.5.3.2.4.6.3 Dynamic tone pairing (DTP)

When applied, DTP is indicated by the Tone Pairing Type field in the PHY header set to 1. DTP can be applied only to the payload of a PPDU employing MCS 13-17.

When DTP is applied, the SQPSK symbol-pair indices, *k* and *P(k),* are such that

$$P(k) = \text{ToneIndexOffset}\left(\left\lfloor \frac{k}{N_{TPG}} \right\rfloor\right) + \text{mod}\left(k, N_{TPG}\right) \quad \text{for } k = 0,1,2,\ldots,\frac{N_{SD}}{2} - 1$$

where

N_{TPG} denotes the number of tones per group

ToneIndexOffset(l) denotes the starting index of the *l*-th group of tone pairs, for $l = 0,1,2,\ldots,\frac{N_{SD}}{N_{TPG}} - 1$

The values of N_{TPG} and ToneIndexOffset(l) for $l = 0,1,2,\ldots,\frac{N_{SD}}{N_{TPG}} - 1$ are derived from the DTP Report element (8.4.2.148) included in the last received DTP Report frame (8.5.20.9).

The number of tone-pairs per group, $N_{TPG,}$ is derived as

$$N_{TPG} = \frac{N_{SD}}{2N_G}$$

where

N_G is the number of DTP groups, which is equal to 42

The tone index offsets, ToneIndexOffset(l), are derived as

$$\text{ToneIndexOffset}(l) = N_{TPG} \times \text{GroupPairIndex}(l) + N_{SD}/2$$

where

GroupPairIndex(l) is the value of the GroupPairIndex(l) subfield of the DTP Report element

21.5.3.2.5 Pilot sequence

Pilot tones are inserted at tones -150, -130, -110, -90, -70, -50, -30, -10, 10, 30, 50, 70, 90, 110, 130,150. The values of the pilots at these tones is [-1, 1, -1, 1, 1, -1, -1, -1, -1, -1, 1, 1, 1, -1, 1, 1], respectively. The pilot sequence P is created by creating a sequence of zeros corresponding to tones $-N_{SR}$ to N_{SR}. The pilots are then inserted at the corresponding tones with the values specified above.

At OFDM symbol n the pilot sequence is multiplied by the value $2\times p_n-1$, where p_n is the value generated by the shift register defined in 21.5.3.2.2 if $x_1,x_2,\ldots x_7$ are all set to 1 at the first OFDM symbol.

21.5.3.2.6 OFDM modulation

The stream of complex constellation points d_k is broken into groups of N_{SD} points $d_{m,n}$ where $m=1,2,\ldots,N_{SD}$ and $n=1,2,\ldots,N_{SYM}$. The baseband signal for the data phase is

$$r_{DATA}(qT_S)=\frac{1}{\sqrt{N_{Tones}}}\sum_{n=1}^{N_{SYM}} w_{T_{SYM}}(qT_S-(n-1)T_{SYM})\sum_{k=-N_{SR}}^{N_{SR}}(D_{k,n}+p_{n+1}P_k)\exp(j2\pi k\Delta_F(qT_S-(n-1)T_{SYM}-T_{GI}))$$

where

p_n, P are defined in 21.5.3.2.5

$N_{Tones}=N_{ST}-N_{DC}$ is the number of active subcarriers

$$D_{k,n}=\begin{cases}0 & k=0,\pm1,\pm10,\pm30,\pm50,\pm70,\pm90,\pm110,\pm130,\pm150\\ d_{M(k),n} & \text{Otherwise}\end{cases}$$

$$M(k)=\begin{cases}k+178 & -177\le k\le -151\\ k+177 & -149\le k\le -131\\ k+176 & -129\le k\le -111\\ k+175 & -109\le k\le -91\\ k+174 & -89\le k\le -71\\ k+173 & -69\le k\le -51\\ k+172 & -49\le k\le -31\\ k+171 & -29\le k\le -11\\ k+170 & -9\le k\le -2\\ k+167 & 2\le k\le 9\\ k+166 & 11\le k\le 29\\ k+165 & 31\le k\le 49\\ k+164 & 51\le k\le 69\\ k+163 & 71\le k\le 89\\ k+162 & 91\le k\le 109\\ k+161 & 111\le k\le 129\\ k+160 & 131\le k\le 149\\ k+159 & 151\le k\le 177\end{cases}$$

The header symbol uses p_n with $n=1$.

21.5.4 Performance requirements

21.5.4.1 Transmit requirements

21.5.4.1.1 Introduction

This subclause describes the performance requirement from the OFDM PHY transmitter.

21.5.4.1.2 Transmit EVM

The transmit EVM accuracy test shall be performed by instrumentation capable of converting the transmitted signal into a stream of complex samples, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, dc offsets, phase noise, etc.

The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or an equivalent procedure:

a) Start of frame shall be detected.
b) Transition from short sequences to channel estimation sequences shall be detected, and fine timing (with one sample resolution) shall be established.
c) Frequency offsets shall be estimated and corrected.
d) The frame shall be de-rotated according to estimated frequency offset.
e) The complex channel response coefficients shall be estimated for each of the subcarriers using information contained in the preamble (STF and/or CEF).
f) For each of the OFDM symbols: transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, derotate the subcarrier values according to estimated phase, and divide each subcarrier value with a complex estimated channel response coefficient.
g) For subcarrier, compute the Euclidean distance to the ideal location for the symbol, or pilot.
h) Compute the RMS average of all errors in a packet. It is given by

$$EVM = 20\log_{10}\left(\frac{1}{N_f}\sum_{i=1}^{N_f}\sqrt{\left(\frac{\sum_{j=1}^{N_{SYM}}\sum_{k\in K}\left[\left(I(i,j,k)-I^*(i,j,k)\right)^2+\left(Q(i,j,k)-Q^*(i,j,k)\right)^2\right]}{\left(N_{ST}-N_{DC}\right)N_{SYM}P_0}\right)}\right)$$

where

N_f	is the number of frames
i	is the frame index
k	is the carrier index
K	is the set of pilot and data subcarriers $\{1,2, \ldots, (N_{SR}-1), (N_{SR}+N_{DC}), (N_{SR}+N_{DC}+1), \ldots, N_{ST}\}$
j	is the symbol index
N_{SYM}	is the number of symbols
N_{ST}	is the total number of subcarriers
I^*,Q^*	is the ideal constellation point for I and Q, respectively
P_0	is the average power of the constellation (I^*,Q^*) computed over the i^{th} frame

The measurements shall occur only on the OFDM symbols, the measurement shall be performed on at least 10 frames with 16 symbols at least in each of them. Random data shall be used.

The EVM RMS error shall not exceed an MCS dependent value as found in Table 21-16.

Table 21-16—EVM requirements for OFDM

MCS index	Modulation	Coding rate	EVM value [dB]
13	SQPSK	1/2	–7
14	SQPSK	5/8	–9
15	QPSK	1/2	–10
16	QPSK	5/8	–11
17	QPSK	3/4	–13
18	16QAM	1/2	–15
19	16QAM	5/8	–17
20	16QAM	3/4	–19
21	16QAM	13/16	–20
22	64QAM	5/8	–22
23	64QAM	3/4	–24
24	64QAM	13/16	–26

21.5.4.1.3 Tx flatness

When using the OFDM PHY and only while transmitting OFDM symbols, the average energy of the OFDM Symbols constellations in each of the subcarriers with indices –146 to –2 and +2 to +145 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the subcarriers with indices –147 to –177 and +147 to +177 shall deviate no more than +2/–4 dB from the average energy of subcarriers with indices –177 to –2 and +2 to +177.

21.5.4.1.4 Time of Departure accuracy

The Time of Departure accuracy test evaluates TIME_OF_DEPARTURE against aTxPmdTxStartRMS and aTxPmdTxStartRMS against TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH as defined in Annex T with the following test parameters:

— MULTICHANNEL_SAMPLING_RATE is 2640x10^6 sample/s
— FIRST_TRANSITION_FIELD is Short Training field
— SECOND_TRANSITION_FIELD is Channel Estimation field
— TRAINING_FIELD is Channel Estimation field
— TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH is 80 ns

NOTE—The indicated windowing applies to the time of departure accuracy test equipment, and not the transmitter or receiver.

21.5.4.2 Receive requirements

21.5.4.2.1 Introduction

Subclause 21.5.4.2 describes the performance requirement for an OFDM receiver.

21.5.4.2.2 CCA

The start of a valid DMG OFDM PHY or DMG SC PHY transmission at a receive level greater than the minimum sensitivity for MCS 1 (–68 dBm) shall cause CCA to indicate busy with a probability >90% within 1 µs.

21.6 DMG SC PHY

21.6.1 Introduction

Transmission and reception of SC PHY PPDUs is mandatory for select MCSs.

21.6.2 Frame format

A SC frame is composed of the Short Training Field (STF), the channel estimation field (CE), the Header, SC blocks and optional training fields, as shown in Figure 21-12.

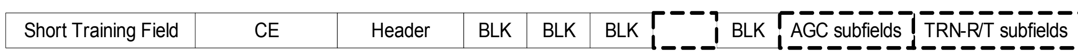


Figure 21-12—SC frame format

21.6.3 Transmission

21.6.3.1 Header

21.6.3.1.1 General

In the SC PHY, the preamble is followed by the header. The header consists of several fields that define the details of the PPDU to be transmitted. The encoding and modulation of the header is described in 21.6.3.1.4.

The header fields are described in Table 21-17.

Table 21-17—SC header fields

Field name	Number of bits	Start bit	Description
Scrambler Initialization	7	0	Bits X1–X7 of the initial scrambler state.
MCS	5	7	Index into the Modulation and Coding Scheme table
Length	18	12	Number of data octets in the PSDU. Range 1–262 143
Additional PPDU	1	30	Contains a copy of the parameter ADD-PPDU from the TXVECTOR. A value of 1 indicates that this PPDU is immediately followed by another PPDU with no IFS or preamble on the subsequent PPDU. A value of 0 indicates that no additional PPDU follows this PPDU.
Packet Type	1	31	See definition of Packet Type field in Table 21-11.

Table 21-17—SC header fields *(continued)*

Field name	Number of bits	Start bit	Description
Training Length	5	32	Corresponds to the TXVECTOR parameter TRN-LEN. If the Beam Tracking Request field is 0, the Training Length field indicates the length of the training field. The use of this field is defined in 21.10.2.2.3. A value of 0 indicates that no training field is present in this PPDU. If the Beam Tracking Request field is 1 and the Packet Type field is 1, the Training Length field indicates the length of the training field. If the Packet Type field is 0, the Training Length field indicates the length of the training field requested for receive training.
Aggregation	1	37	Set to 1 to indicate that the PPDU in the data portion of the packet contains an A-MPDU; otherwise, set to 0.
Beam Tracking Request	1	38	Corresponds to the TXVECTOR parameter BEAM_TRACKING_REQUEST. Set to 1 to indicate the need for beam tracking (9.35.7); otherwise, set to 0. The Beam Tracking Request field is reserved when the Training Length field is 0.
Last RSSI	4	39	Contains a copy of the parameter LAST_RSSI from the TXVECTOR. When set to 0, this field is reserved and ignored by the receiver. The value is an unsigned integer: Values of 2 to 14 represent power levels (–71+value×2) dBm. A value of 15 represents a power greater than or equal to –42 dBm. A value of 1 represents a power less than or equal to –68 dBm. Value of 0 indicates that the previous packet was not received a SIFS period before the current transmission.
Turnaround	1	43	As defined in Table 21-1.
Reserved	4	44	Set to 0, ignored by the receiver
HCS	16	48	Header check sequence

All the numeric fields are encoded in unsigned binary, least significant bit first.

Reserved bits are set to 0 by the transmitter and shall be ignored by the receiver.

If the Additional PPDU field is equal to 1, the Training Length field shall be set to 0.

21.6.3.1.2 Modulation and coding scheme

The modulation and coding scheme defines the modulation and code rate that is used in the PPDU. The modulation and coding schemes for SC are defined in Table 21-18.

MCS 4 and below are mandatory for each Tx and Rx of a device. MCS 5-12 are optional.

Table 21-18—Modulation and coding scheme for SC

MCS index	Modulation	N_{CBPS}	Repetition	Code rate	Data rate (Mbps)
1	π/2-BPSK	1	2	1/2	385
2	π/2-BPSK	1	1	1/2	770
3	π/2-BPSK	1	1	5/8	962.5
4	π/2-BPSK	1	1	3/4	1155
5	π/2-BPSK	1	1	13/16	1251.25
6	π/2-QPSK	2	1	1/2	1540
7	π/2-QPSK	2	1	5/8	1925
8	π/2-QPSK	2	1	3/4	2310
9	π/2-QPSK	2	1	13/16	2502.5
10	π/2-16QAM	4	1	1/2	3080
11	π/2-16QAM	4	1	5/8	3850
12	π/2-16QAM	4	1	3/4	4620

21.6.3.1.3 Generation of the HCS bits

Calculation of the HCS for bits 0-47 of the header is defined in 21.3.7.

21.6.3.1.4 Header encoding and modulation

The header is encoded using a two SC block of N_{CBPB} (see Table 21-20) symbols with N_{GI} guard symbols. The bits are scrambled and encoded as follows:

1) The input header bits (b_1, b_2, …, b_{LH}), where LH = 64, are scrambled as described in 21.3.9, starting from the eighth bit. to create $\mathbf{d_{1s}}=(q_1,q_2,\ldots,q_{LH})$
2) The LDPC codeword $c = (q_1,q_2,\ldots,q_{LH},0_1,0_2,\ldots,0_{504\text{-}LH},p_1,p_2,\ldots,p_{168})$ is created by concatenating 504-LH zeros to the LH bits of $\mathbf{d_{1s}}$ and then generating the parity bits $p_1,p_2,\ldots,p_{168}$ such that $\mathbf{Hc}^\mathbf{T} = \mathbf{0}$, where **H** is the parity check matrix for the rate 3/4 LDPC code specified in 21.6.3.2.3.2.
3) Remove bits LH+1 through 504 and bits 665 through 672 of the codeword **c** to create the sequence $\mathbf{cs1}=(q_1,q_2,\ldots,q_{LH},p_1,p_2,\ldots,p_{160})$.
4) Remove bits LH+1 through 504 and bits 657 through 664 of the codeword **c** to create the sequence $cs2 = (q_1,q_2,\ldots,q_{LH},p_1,p_2,\ldots,p_{152},p_{161},p_{162},\ldots,p_{168})$ and then XOR with a PN sequence that is generated from the LFSR used for data scramblings defined in 21.3.9. The LFSR is initialized to the all ones vector.
5) **cs1** and **cs2** are concatenated to form the sequence (**cs1**, **cs2**). The resulting 448 bits are then mapped as $\pi/2$-BPSK as described in 21.6.3.2.4.2. The N_{GI} guard symbols are then prepended to the resulting N_{CBPB} symbols as described in 21.6.3.2.5.

The same resulting N_{CBPB} symbols are multiplied by -1 and repeated, and then prepended with NGI guard symbols as described in 21.6.3.2.5. The resulting sequence is then appended after the sequence created in step 5).

21.6.3.2 Data field

21.6.3.2.1 General

The data field consists of the payload data of the PSDU and possible padding. The data are padded with zeros, scrambled, encoded and modulated as described in the following subclauses. The amount of padding is defined in 21.6.3.2.3.

21.6.3.2.2 Scrambler

The operation of the scrambler is defined in 21.3.9. The scrambling of the PSDU continues the scrambling of the header with no reset of the scrambler.

21.6.3.2.3 Encoding

21.6.3.2.3.1 General

The data are encoded by a systematic LDPC encoder. The LDPC is a block code. Each block of information bits $(b_1, b_2,...,b_k)$ is concatenated with a block of parity bits $(p_1,p_2,....,p_{n-k})$ to create a codeword $\mathbf{c}=(b_1, b_2,...,b_k,p_1,p_2,....,p_{n-k})$ such that $\mathbf{Hc}^\mathbf{T}=\mathbf{0}$, where $\mathbf{H}$ is the $(n\text{-}k)\times n$ party check matrix. The block size n is 672 bits. The code rate, R, is equal to k/n. The set of code rates is defined in Table 21-19. The parity check matrices are defined in 21.6.3.2.3.2. The encoding process is defined in 21.6.3.2.3.3.

Table 21-19—LDPC code rates

Code rate	Codeword size	Number of data bits
1/2	672	336
5/8	672	420
3/4	672	504
13/16	672	546

21.6.3.2.3.2 Parity check matrices

See 21.3.8.

21.6.3.2.3.3 LDPC encoding process

The LDPC encoding process is composed of several steps that includes deciding the number of shortening/ repetition bits in every codeword, the shortening itself, the coding of each word and then any repetition of bits.

1) First the total number of data pad bits N_{DATA_PAD} is calculated, using the number of LDPC codewords N_{CW}:

$$N_{CW} = \left\lceil \frac{Length \cdot 8}{\frac{L_{CW}}{\rho} \cdot R} \right\rceil$$

$$if\ BRP\ packet\ and\ N_{CW} < N_{CW\min};\ N_{CW} = N_{CW\min}$$

$$N_{DATA\_PAD} = N_{CW} \cdot \frac{L_{CW}}{\rho} \cdot R - Length \cdot 8$$

where L_{CW}=672 is the LDPC codeword length, *Length* is the length of the PSDU defined in the header field (in octets), ρ is the repetition factor (1 or 2), and *R* is the code rate. $N_{CW\ min}$ is defined for BRP packets in Table 21-23.

The scrambled PSDU is concatenated with N_{DATA_PAD} zeros. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU input bits.

2) The procedure for converting the scrambled PSDU data to LDPC codewords depends on the repetition factor.
   a) If ρ = 1,
      i) The output stream of the scrambler is broken into blocks of $L_{CWD} = L_{CW} \times R$ bits such that the m^{th} data word is $\left(b_1^{(m)}, b_2^{(m)}, \ldots b_{L_{CWD}}^{(m)}\right), m \le N_{CW}$.
      ii) To each data word, $n\text{-}k = L_{CW}\text{-}R \times L_{CW}$ parity bits $\left(p_1^{(m)}, p_2^{(m)}, \ldots, p_{n-k}^{(m)}\right)$ are added to create the codeword $\mathbf{c}^{(m)} = \left(b_1^{(m)}, b_2^{(m)}, \ldots, b_{L_{CWD}}^{(m)}, p_1^{(m)}, \ldots p_{n-k}^{(m)}\right)$ such that $\mathbf{H}\,\mathbf{c}^{(m)^{\mathrm{T}}} = \mathbf{0}$
   b) If ρ = 2,
      i) The data bits in each codeword $\left(b_1, b_2, \ldots, b_{L_Z}\right)$ where $L_Z = L_{CW}/2\rho$ are concatenated with $L_{CW}/2\rho$ zeros to produce a sequence in length of $2L_Z \left(b_1, b_2, \ldots, b_{L_Z}, 0_1, 0_2, \ldots, 0_{L_Z}\right)$.
      ii) The LDPC codeword $\mathbf{c} = \left(b_1, b_2, \ldots, b_{L_Z}, 0_1, 0_2, \ldots, 0_{L_Z}, p_1, p_2, \ldots, p_{336}\right)$ is created by generating the parity bits $p_1, p_2, \ldots, p_{336}$ such that $\mathbf{H}\,\mathbf{c}^T = \mathbf{0}$, where **H** is the parity matrix for rate 1/2 LDPC coding specified in 21.3.8.
      iii) Replace bits $L_Z + 1$ through 336 of the codeword **c** with bits from the sequence $\left(b_1, b_2, \ldots, b_{L_Z}\right)$ XORed by a PN sequence that is generated from the LFSR used for data scrambling as defined in 21.3.9. The LFSR is initialized to the all ones vector and reinitialized to the same vector after every codeword.
3) The codewords are then concatenated one after the other to create the coded bits stream $\left(c_1, c_2, \ldots, c_{L_{CW} \cdot N_{CW}}\right)$.
4) The number of symbol blocks, N_{BLKS}, and the number of symbol block padding bits, N_{BLK_PAD}, are calculated:

$$N_{BLKS} = \left\lceil \frac{N_{CW} \cdot L_{CW}}{N_{CBPB}} \right\rceil$$

$$N_{BLK\_PAD} = N_{BLKS} \cdot N_{CBPB} - N_{CW} \cdot L_{CW}$$

where N_{CBPB} is the number of coded bits per symbol block, per Table 21-20 in 21.6.3.2.5.

5) The coded bit stream is concatenated with N_{BLK_PAD} zeros. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU input bits.

21.6.3.2.4 Modulation mapping

21.6.3.2.4.1 General

The coded and padded bit stream is converted into a stream of complex constellation points according to the modulation specified in the MCS table.

21.6.3.2.4.2 π/2-BPSK modulation

In π/2-BPSK modulation, the input bit stream is mapped according to the following equation: $\tilde{s}_k = 2 \cdot c_k - 1$, where c_k is the k^{th} input coded (or scrambled pad) bit. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{j \cdot \pi \cdot k / 2}$.

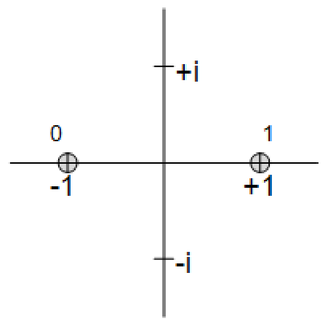


Figure 21-13—BPSK constellation bit encoding

NOTE—With appropriate choice of transmit filtering, π/2-BPSK is equivalent to a precoded pulse-shaped MSK (e.g., GMSK). The precoder is simply $b_{out,k} = b_{in,k} \oplus b_{in,k-1}, k = 0,1,...$, where $b_{in,k}$ is the scrambled input stream, $b_{in,-1}$ is 0, and $b_{out,k}$ is the input to the (G)MSK modulator.

21.6.3.2.4.3 π/2-QPSK modulation

In π/2-QPSK modulation, the input bit stream is grouped into sets of 2 bits and mapped according to the following equation: $\tilde{s}(k) = \frac{1}{\sqrt{2}}\left((2 \cdot c_{2k} - 1) + j(2c_{2k+1} - 1)\right)\exp\left(-j\frac{\pi}{4}\right)$, where k is the output symbol index, k = 0, 1, …. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{j \cdot \pi \cdot k / 2}$.

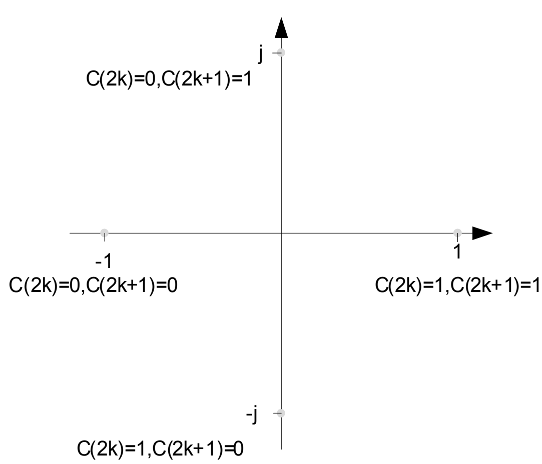


Figure 21-14—QPSK constellation bit encoding

21.6.3.2.4.4 π/2-16QAM modulation

In π/2-16QAM modulation, the input bit stream is grouped into sets of 4 bits and mapped according to the following equation:

$$\tilde{s}(k) = \frac{1}{\sqrt{10}}\{(4c_{4k}-2)-(2c_{4k}-1)(2c_{4k+1}-1)+j(4c_{4k+2}-2)-j(2c_{4k+2}-1)(2c_{4k+3}-1)\}$$

where k is the output symbol index, k =0, 1, …. Each output symbol is then rotated according to the following equation: $s(k)=\tilde{s}(k)\cdot e^{j\cdot\pi\cdot k/2}$. The constellation bit encoding is depicted on Figure 21-15.

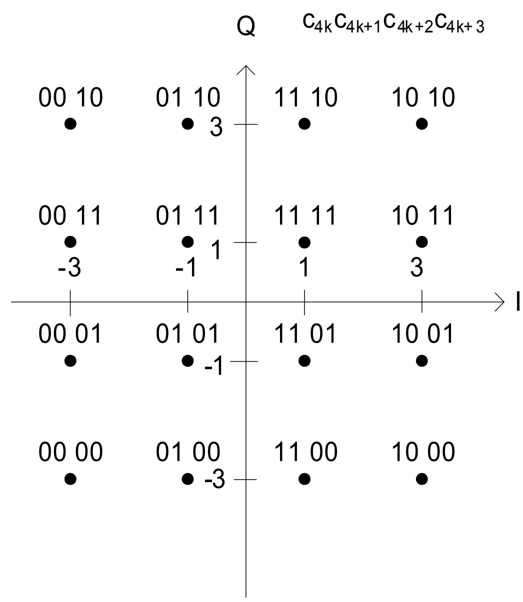


Figure 21-15—16-QAM constellation bit encoding

21.6.3.2.5 Symbol blocking and guard insertion

Each group of N_{CBPB} bits is pre-pended by π/2-BPSK symbols generated by the 64 point Golay sequence Ga_{64} defined in 21.11. N_{CBPB} values are shown in Table 21-20. The starting index for the first symbol for π/2 rotation is 0.

Table 21-20—Values of N_{CBPB}

Symbol mapping	N_{CBPB}
π/2-BPSK	448
π/2-QPSK	896
π/2-16QAM	1792

If the Additional PPDU field within the PLCP header is equal to 0, the final block transmitted is followed by the same Golay sequence guard interval. If the Additional PPDU field within the PLCP header is equal to 1, the final block transmitted of the last PPDU in an A-PPDU is followed by the same Golay sequence guard interval.

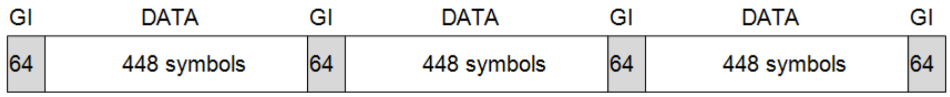


Figure 21-16—Block transmission

21.6.4 Performance requirements

21.6.4.1 Transmit requirements

21.6.4.1.1 Transmit EVM

The transmit EVM accuracy test shall be performed by instrumentation capable of converting the transmitted signal into a stream of complex samples, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, dc offsets, phase noise, etc.

The instrumentation shall perform carrier lock, symbol timing recovery and amplitude adjustment and equalization while making the measurements. The equalizer shall be trained using information in the SC preamble (STF and/or CEF). For the SC PHY EVM, measuring Ns samples at the sample rate, the measured symbols should not contain the first and the last hundred symbols of a given packet (ramp up/down). The EVM is calculated according to the formula below:

$$EVM = 20\log_{10}\left(\sqrt{\left(\frac{1}{N_s P_{avg}}\sum_{i=1}^{N_S}\left[\left(I_i - I_i^* - I_0\right)^2 + \left(Q_i - Q_i^* - Q_0\right)^2\right]\right)}\right)$$

where N_S is the number of samples to be measured and N_S shall be 1000, P_{avg} is the average power of the constellation, (I_i, Q_i) is the complex coordinates of the measured symbol i, (I_i^*, Q_i^*) is the complex coordinates of the ideal constellation point for the measured symbol i, and (I_0, Q_0) is the complex DC term chosen to minimize EVM.

The test equipment should use a root-raised cosine filter with roll-off factor of 0.25 for the pulse shaping filter when conducting EVM measurement.

The transmit pulse shaping used is left to the implementer.

The relative constellation error (EVM) shall not exceed an MCS dependent value according to Table 21-21.

Table 21-21—EVM requirements for SC PHY

MCS index	Modulation	Coding rate	EVM value [dB]
1	π/2-BPSK	1/2 with repetition	–6
2	π/2-BPSK	1/2	–7
3	π/2-BPSK	5/8	–9
4	π/2-BPSK	3/4	–10
5	π/2-BPSK	13/16	–12

Table 21-21—EVM requirements for SC PHY *(continued)*

MCS index	Modulation	Coding rate	EVM value [dB]
6	π/2-QPSK	1/2	–11
7	π/2-QPSK	5/8	–12
8	π/2-QPSK	3/4	–13
9	π/2-QPSK	13/16	–15
10	π/2-16QAM	1/2	–19
11	π/2-16QAM	5/8	–20
12	π/2-16QAM	3/4	–21

21.6.4.1.2 Time of Departure accuracy

The Time of Departure accuracy test evaluates TIME_OF_DEPARTURE against aTxPmdTxStartRMS and aTxPmdTxStartRMS against TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH as defined in Annex T with the following test parameters:

- MULTICHANNEL_SAMPLING_RATE is 1760x10^6 sample/s
- FIRST_TRANSITION_FIELD is Short Training field
- SECOND_TRANSITION_FIELD is Channel Estimation field
- TRAINING_FIELD is Channel Estimation field
- TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH is 80 ns

NOTE—The indicated windowing applies to the time of departure accuracy test equipment, and not the transmitter or receiver.

21.6.4.2 Receive requirements

21.6.4.2.1 Introduction

This subclause describes the receiver requirements of the DMG SC PHY.

21.6.4.2.2 CCA

The start of a valid DMG SC PHY transmission at a receive level greater than the minimum sensitivity for MCS 1 (–68 dBm) shall cause CCA to indicate busy with a probability > 90% within 1 µs. The receiver shall hold the carrier sense signal busy for any signal 20 dB above the minimum sensitivity for MCS 1.

21.7 DMG low-power SC PHY

21.7.1 Introduction

The DMG low-power SC PHY is an optional SC mode that can provide lower processing power requirements for DMG transceivers.

21.7.2 Transmission

21.7.2.1 Preamble

The DMG low-power SC PHY uses the same preamble as the DMG SC PHY.

21.7.2.2 Header

21.7.2.2.1 General

The DMG low-power SC PHY header fields are the same fields as in the DMG SC PHY (see Table 21-17 in 21.6.3.1).

The DMG low-power SC PHY modulation and coding schemes are listed in Table 21-22.

Table 21-22—Low-power SC modulation and coding schemes

MCS	Modulation	Effective code rate	Coding scheme	N_{CPB}	Rate (Mbps)
25	π/2-BPSK	13/28	RS(224,208)+Block-Code(16,8)	392	626
26	π/2-BPSK	13/21	RS(224,208)+Block-Code(12,8)	392	834
27	π/2-BPSK	52/63	RS(224,208)+SPC(9,8)	392	1112
28	π/2-QPSK	13/28	RS(224,208)+Block-Code(16,8)	392	1251
29	π/2-QPSK	13/21	RS(224,208)+Block-Code(12,8)	392	1668
30	π/2-QPSK	52/63	RS(224,208)+SPC(9,8)	392	2224
31	π/2-QPSK	13/14	RS(224,208)+Block-Code(8,8)	392	2503

21.7.2.2.2 Header encoding and modulation

The low-power SC PHY header is encoded using the following scheme:

1) The header is scrambled as described in 21.3.9.
2) The resulting 8 octets are encoded using a RS(24,8) generating 24 octets.
3) The resulting 24 octets are encoded in the block code (16,8) described in 21.7.2.3.3.3 generating 48 octets.
4) One zero octet is appended to the end of the 48 octets generating 49 octets.
5) Each set of 7 octets is interleaved using a uniform interleaver defined in step 6) of 21.7.2.3.3.
6) The resulting 49 octets are blocked as described in 21.7.2.3.5 and transmitted using π/2-BPSK as described in 21.6.3.2.4.2.

21.7.2.3 Data field

21.7.2.3.1 General

The data field consists of the payload data of the PSDU and possible padding. The data are padded with zeros, scrambled, encoded and modulated as described in the following subclauses.

21.7.2.3.2 Scrambler

The operation of the scrambler is defined in 21.3.9. The scrambling of the PSDU continues the scrambling of the header with no reset of the scrambler. The padding bits are also scrambled.

21.7.2.3.3 Encoding

21.7.2.3.3.1 General

Data is encoded using an outer RS(224,208) block code and a short inner code. The inner code is a (16,8) block code for MCSs 25 and 28, a (12,8) block code for MCSs 26 and 29, and a (9,8) single parity check (SPC) block code for MCSs 27 and 30 and the identity block-code for MCS 31. The encoding is further detailed in the following steps:

1) First, the number of block padding bits is calculated:
   a) The total number of Reed Solomon codewords is $N_{RS} = \lceil Length/208 \rceil$ and the total number of RS encoded symbols is given by $Length + N_{RS} \times 16$;
   b) After Reed Solomon encoding, the data is encoded with a short block code (*N*,8) where *N* can take one of the following values 8, 9, 12, or 16 depending on the MCS as shown in Table 21-22. Therefore:
      i) The total number of encoded bits is $N_{EB} = N \times (Length + N_{RS} \times 16)$;
      ii) The total number of 512 (in length) blocks (each containing 392 data symbols) is $N_{BLKS} = \lceil N_{EB}/(N_{CBPS} \times 392) \rceil$. If BRP packet and $N_{BLKS} < N_{BLK\_MIN}$, $N_{BLKS} = N_{BLKS\_MIN}$ where $N_{BLKS\_MIN} = 18$. The total number of zero block padding bits is $N_{BLK\_PAD} = N_{BLKS} \times N_{CBPS} \times 392 - N_{EB}$.
2) The data is broken into blocks of length 208×8 bits (except for possibly the last block).
3) Each block is encoded using the RS(224,208) block code as described in 21.7.2.3.3.2, except perhaps the last block, which is encoded by a shortened version of the code (i.e., if the last block length is K, the shortened block code is RS(16+K,K).
4) The Reed Solomon encoded data stream is further encoded using the block code(N,8) as described in 21.7.2.3.3.3.
5) The coded bit stream is concatenated with N_{BLK_PAD} zeros. They are scrambled with the continuation of the scrambler sequence that scrambled the PSDU input bits.
6) Each set of 7 octets is interleaved using a uniform interleaver of 7 rows and 8 columns. The 7 octets are written row wise and read column wise, i.e., the index *i* of a bit after interleaving is related to the index *k* of a bit before interleaving by the following rule:
   $i = 8 \times (k \bmod 7) + floor(k/7), k = 0,1,\ldots,55$ where the function floor(.) denotes the largest integer not exceeding the function parameter.
7) The resulting bit stream is modulated and then blocked as described in 21.7.2.3.4 and 21.7.2.3.5.

21.7.2.3.3.2 RS encoding

The RS block code is based on the polynomial

$$g(x) = \prod_{k=1}^{16} (x + \alpha^k)$$

Where $\alpha = 0x02$ is a root of the primitive polynomial $p(x) = 1 + x^2 + x^3 + x^4 + x^8$. We assume that an octet $b_0\ b_1\ b_2\ b_3\ b_4\ b_5\ b_6\ b_7$ (b_0 is the LSB) represented by the polynomial
$M = b_7x^7 + b_6x^6 + b_5x^5 + b_4x^4 + b_3x^3 + b_2x^2 + b_1x + b_0$.

The RS is a systematic block code. Given a block of octets $\mathbf{m}=(m_{M-1},m_{M-2},\ldots m_0)$, the additional parity octets $\mathbf{r}=(r_{15},r_{14},\ldots r_0)$ is calculated by setting $\mathbf{r}(x)=x^{16}\mathbf{m}(x)\bmod g(x)$, where $\mathbf{r}(x)=\sum_{k=0}^{15} r_k x^k$ and $\mathbf{m}(x)=\sum_{k=0}^{M-1} m_k x^k$ and where the calculation is performed over $GF(2^8)$. The parity octets $\mathbf{r}$ are appended to the uncoded block $\mathbf{m}$ to generate the encoded RS block $(m_{M-1},m_{M-2},\ldots m_0,r_{15},r_{14},\ldots,r_0)$.

21.7.2.3.3.3 (N,8) Block-coding

Every octet $\mathbf{b}_{1\times 8}=[b_0b_1b_2b_3b_4b_5b_6b_7]$ is encoded into an N-bit codeword $\mathbf{c}_{1\times N}=[\mathbf{b}_{1\times 8}\quad \mathbf{p}_{1\times(N-8)}]$ such that $\mathbf{c}_{1\times N}=\mathbf{b}_{1\times 8}\mathbf{G}_{8\times N}$, where the generator matrix $\mathbf{G}_{8\times N}$ is given by the following expressions for N = 8, 9, 12, *and* 16, respectively:

G_{8x8} is the identity matrix.

$$\mathbf{G}_{8\times 9}=\begin{bmatrix}100000001\\010000001\\001000001\\000100001\\000010001\\000001001\\000000101\\000000011\end{bmatrix}$$

$$\mathbf{G}_{8\times 12}=\begin{bmatrix}100000001100\\010000001010\\001000000101\\000100000011\\000010001011\\000001001101\\000000101110\\000000010111\end{bmatrix}$$

$$G_{8x16}=\begin{bmatrix}1\,0\,0\,0\,0\,0\,0\,0\,0\,1\,1\,0\,1\,0\,1\,0\\0\,1\,0\,0\,0\,0\,0\,0\,0\,0\,1\,1\,0\,1\,0\,1\\0\,0\,1\,0\,0\,0\,0\,0\,1\,0\,0\,1\,1\,0\,1\,0\\0\,0\,0\,1\,0\,0\,0\,0\,0\,1\,0\,0\,1\,1\,0\,1\\0\,0\,0\,0\,1\,0\,0\,0\,1\,0\,1\,0\,0\,1\,1\,0\\0\,0\,0\,0\,0\,1\,0\,0\,0\,1\,0\,1\,0\,0\,1\,1\\0\,0\,0\,0\,0\,0\,1\,0\,1\,0\,1\,0\,1\,0\,0\,1\\0\,0\,0\,0\,0\,0\,0\,1\,1\,1\,0\,1\,0\,1\,0\,0\end{bmatrix}$$

21.7.2.3.4 Modulation

The same π/2-BPSK described in 21.6.3.2.4.2 and π/2-QPSK described in 21.6.3.2.4.2 are used in the DMG low-power SC PHY.

21.7.2.3.5 Blocking

The blocking for the low-power SC is illustrated in Figure 21-17. The data is partitioned into blocks of length 512 wherein each 512-block is constructed from 8 subblocks. Each subblock is of length 64. The first subblock is a G_{64}, which is the π/2-BPSK symbols sequence generated by the 64 point Golay sequence Ga_{64} defined in 21.11. The starting index for the first symbol π/2 rotation is 0, and subblocks 2 to 8 are constructed in the same way, i.e., a data portion of 56 symbols followed by a guard interval of 8 symbols. The last 512-block in the transmission shall be followed by Ga_{64}. Note that each 512-block carries 392 symbols of data and 120 symbols of guard.

The G_8 guard interval is a copy of the last 8 samples of Ga_{64}.

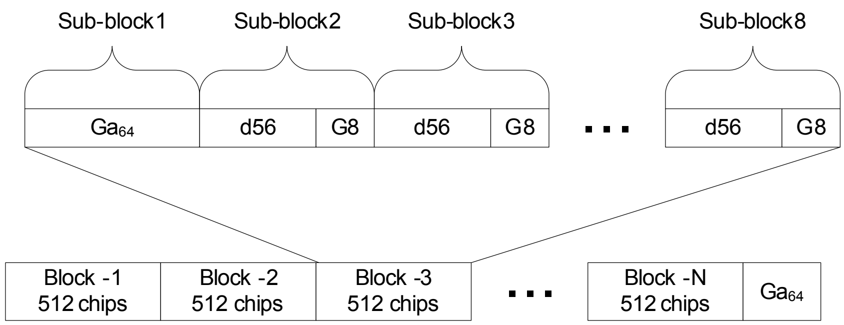


Figure 21-17—Blocking for low-power SC

NOTE—A STA may estimate the channel impulse response from the CEF, and decides whether to equalize using the 512-block or the short 64-subblock. For example, if the channel impulse response energy is almost concentrated in 8 taps, a 64-equalizer can be used; otherwise, a 512-equalizer is used.

21.8 PLCP transmit procedure

The PLCP transmit procedure is shown in Figure 21-18. In order to transmit data, a PHY-TXSTART.request primitive shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME, as specified in 21.12. Other transmit parameters, such as MCS and transmit power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 21.2.2.

The PLCP shall then issue a PMD_TXSTART.request primitive, and transmission of the PLCP preamble shall start, based on the parameters passed in the PHY-TXSTART.request primitive. The preamble format (control PHY, SC or OFDM) depend on the MCS in the PHY_TXSTART.req. The PLCP shall calculate the length of the packet according the MCS and the length specified in the PHY_TXSTART.request primitive, adding padding bits if necessary.

The PHY continues with the encoding and transmission of the header according to the PHY_TXSTART.req(TXVECTOR) parameters. The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The data are encoded as described in 21.4.3.2.3, 21.5.3.2.3, and 21.6.3.2.3. The encoded data are then modulated as described in 21.4, 21.5, 21.6, and 21.7, depending on the MCS requested in the PHY_TXSTART.req. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHY-TXSTART shall be disabled by receiving a PHY-TXEND.request primitive.

Transmission of the PSDU is completed with the transmission of the last bits of the (encoded) PSDU. If no TRN-T/R fields are specified in the PHY-TXSTART.req, the PLCP shall issue PMD-TXEND after the transmission of the last bits. If TRN-T and TRN-R are requested in the PHY-TXSTART.req, the transmission continues with the transmission of AGC subfields and TRN-T/R subfields. The PCLP issues the PMD-TXEND after the transmission of the last TRN-T/R subfield, and then it issues a PHY_TXEND.confirm primitive to the MAC. The packet transmission shall be completed, and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request primitive is acknowledged with a PHY-TXEND.confirm primitive from the PHY.

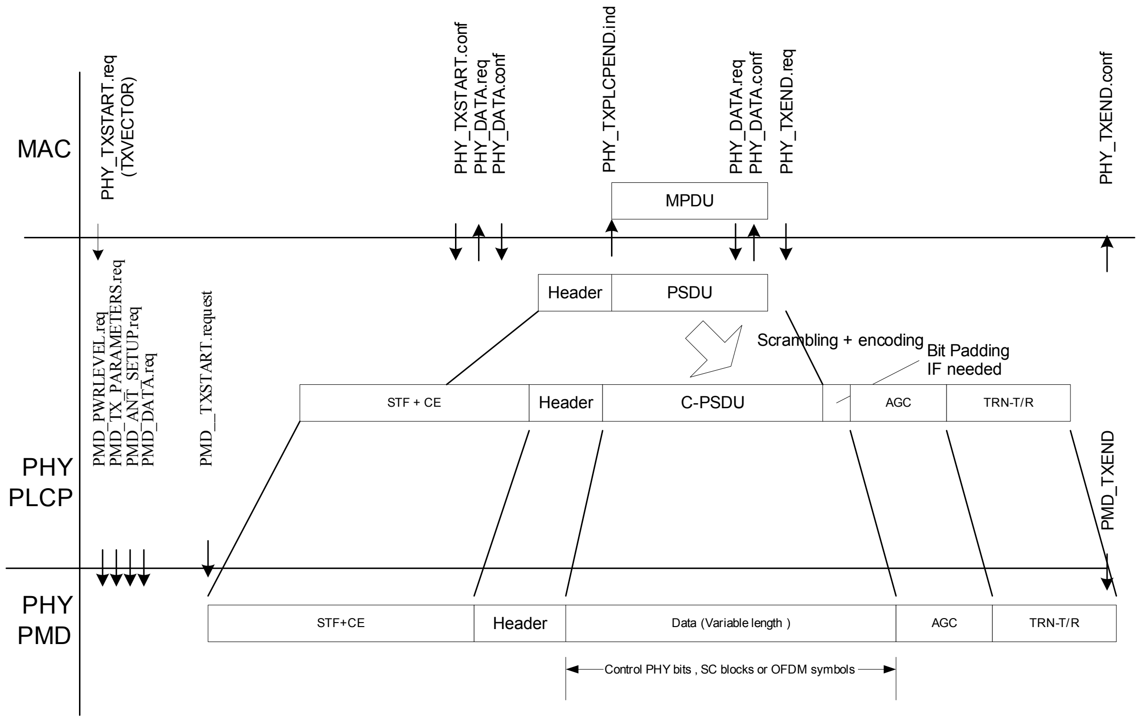


Figure 21-18—PLCP transmit procedure

A typical transmit state machine is shown in Figure 21-19.

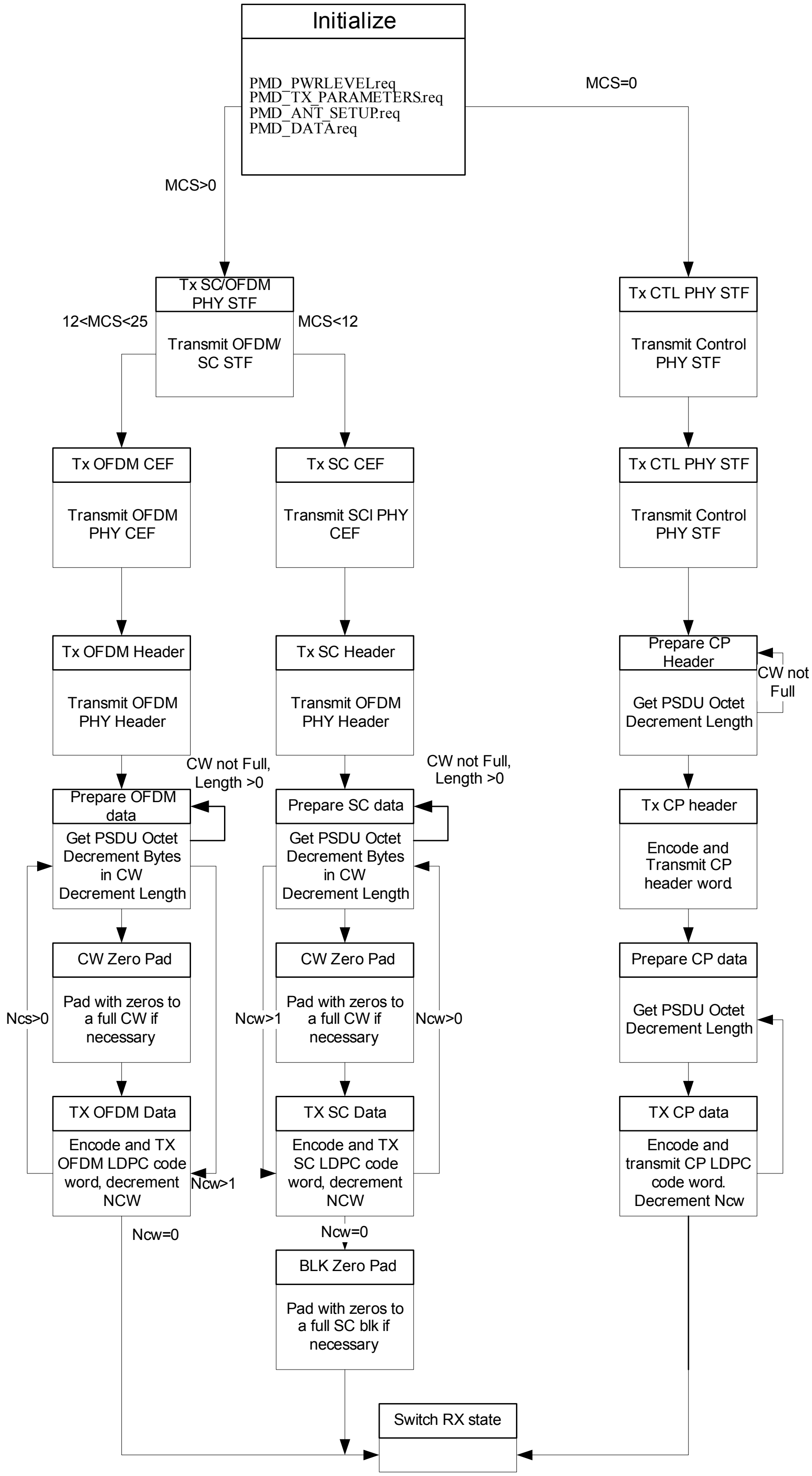


Figure 21-19—Typical Tx state machine (Training Length=0 is assumed; some optional features such as SC low-power PHY are not shown)

21.9 PLCP receive procedure

A typical PLCP receive procedure is shown in Figure 21-20.

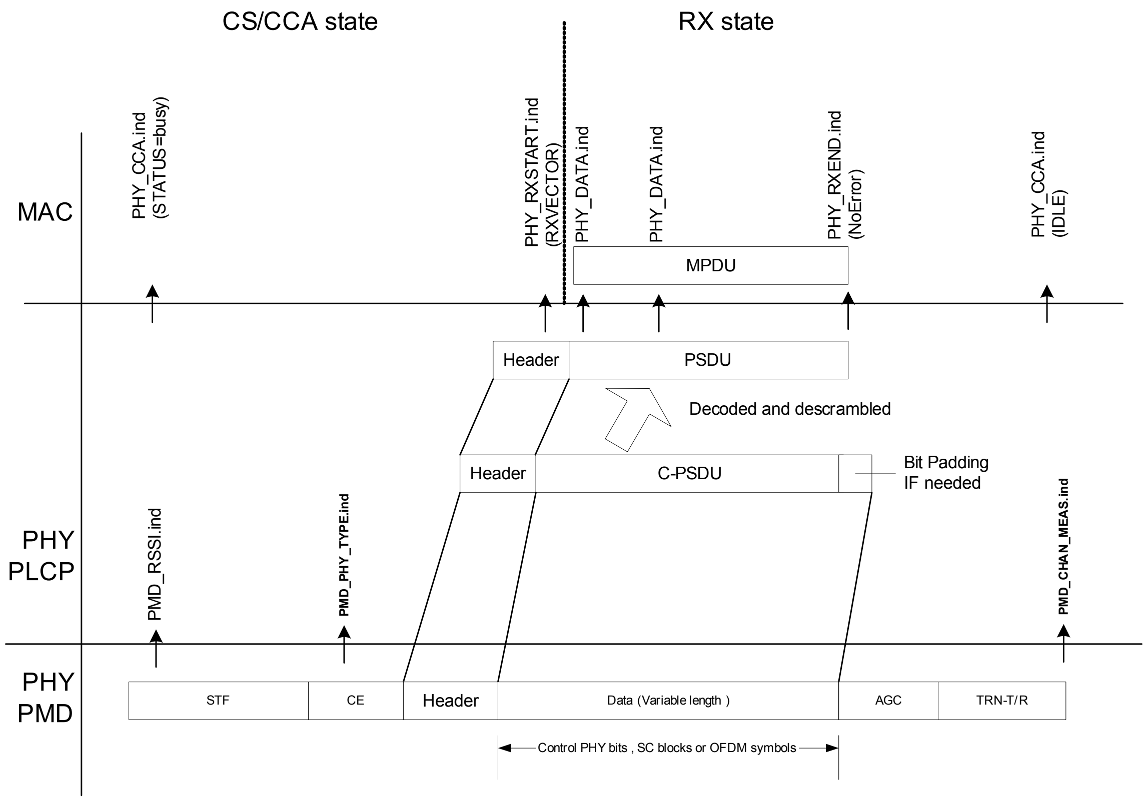


Figure 21-20—PLCP receive procedure

Upon receiving the STF, PMD_RSSI.ind shall report received signal strength to the PCLP, this indicates activity to the MAC through PHY_CCA.ind(BUSY).

After the PHY-CCA.indication(BUSY) is issued, the PHY entity shall search for the CE field and begin receiving the CE field. During the reception of the CE field, the PMD indicates to the PLCP the type of PHY of the packet. The PHY demodulates the header according to the PHY type determined during the PLCP. If the CE field indicated a SC PHY, the receiver is capable of receiving low-power SC PHY, and dot11LowPowerSCPHYActivated is true, then the PHY shall attempt to demodulate both a SC header and an SC low-power header. The PLCP shall decode the header and indicate to the PMD the MCS, length and other parameters needed for the demodulation of the packet. At the end of the data portion of the packet, the PHY shall indicate PHY_RXEND.ind(No_Error) to the MAC. If the header indicated the presence of training field, the PMD shall continue to receive these training fields after the data portion of the packet. After the end of these fields, the PMD shall send the measurements to the PLCP using the PMD_CHAN_MEAS.ind. After the end of the training fields, the PHY shall indicate PHY_CCA.ind(Idle).

In the case of signal loss before the decoding of the header or in the case of an invalid header, the PHY shall maintain PHY_CCA.ind(BUSY) for any signal 20 dB higher from the receive sensitivity of MCS 1. In the case of signal loss after decoding of a valid header, the PHY shall indicate PHY_CCA.ind(BUSY) for the expected duration of the packet, including AGC and TRN-T/R fields.

A typical receive state machine is shown in Figure 21-21.

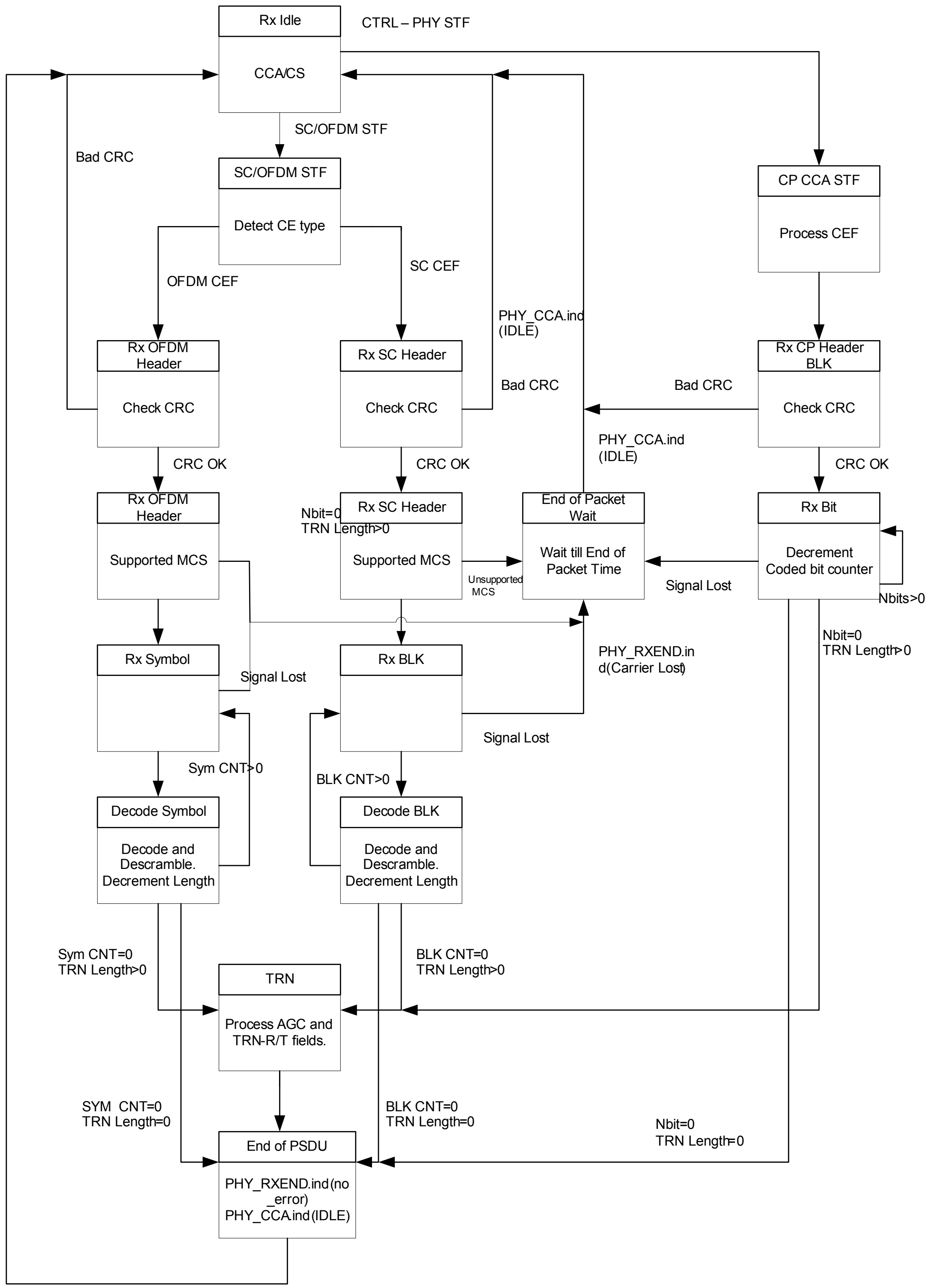


Figure 21-21—Typical Rx state machine
(some optional features such as low-power SC PHY are not shown)

21.10 Beamforming

21.10.1 Beamforming concept

Beamforming enables a pair of STAs to train their transmit and receive antennas for subsequent communication. A beamformed link is established following the successful completion of BF training, which is described in 9.35.

DMG STAs use a quasi-omni antenna pattern. The antenna gain of the main beam of a quasi-omni antenna pattern shall be at most 15 dB lower than the antenna gain in the main beam for a directional pattern.

21.10.2 Beamforming PHY frame format

21.10.2.1 TX sector sweep

The packets sent during TX sector sweep are control PHY packets as defined in 21.4.

21.10.2.2 Beam refinement

21.10.2.2.1 General

Beam refinement is a process where a STA can improve its antenna configuration (or antenna weight vectors) both for transmission and reception. If the SLS beamforming training did not include an RSS, as in the case where both devices have more than one transmit sector per antenna, beam refinement can serve as the first receive antenna configuration training. The procedure of beam refinement is described in 9.35.6.4.

In the beam refinement procedure, BRP packets are used to train the receiver and transmitter antenna. There are two types of BRP packets: BRP-RX packets and BRP-TX packets:

- BRP-RX packets are packets that have TRN-R training sequences appended to them. These packets enable receiver antenna weight vector training.
- BRP-TX packets are packets that have TRN-T training sequences appended to them. The transmitting STA may change antenna configuration at the beginning of each sequence. The receiving STA performs measurements on these sequences and sends feedback to the STA that transmits the BRP-TX packet.

21.10.2.2.2 BRP packet structure

Each BRP packet is composed of an STF, a CE field, and a data field followed by a training field containing an AGC training field and a receiver training field.

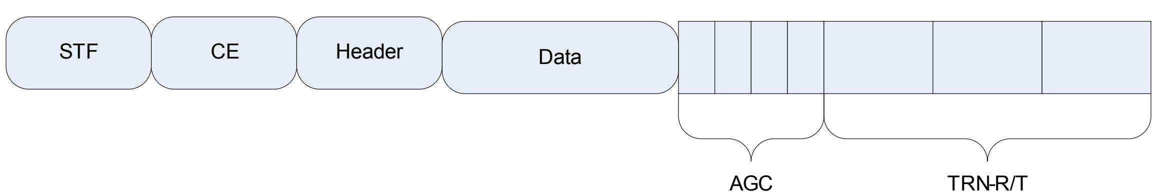


Figure 21-22—BRP packet structure

21.10.2.2.3 BRP packet header fields

The Packet Type and Training Length fields present within the SC header, control PHY header, LP SC PHY header, and OFDM header are used to indicate that a packet is BRP packet and the length of the training fields, respectively.

A value of 0x0 in the Packet Type field indicates a BRP-RX packet (TRN-R field is present).

A value of 0x1 in the Packet Type field indicates a BRP-TX packet (TRN-T field is present).

A value of N in the Training Length field indicates that the AGC has $4N$ subfields and that the TRN-R/T field has $5N$ subfields.

The value N in the Training Length field of a BRP-RX packet is equal to the value of the L-RX field requested by the intended receiver of the BRP-RX packet at a previously received BRP Request field (see 7.3a.4).

21.10.2.2.4 BRP packet duration

The minimum duration of the data field of a BRP packet when sent in an SC PHY is aBRPminSCblocks SC blocks (see 21.6.3.2.5) and, if needed, the data field of the packet shall be extended by extra zero padding to generate the required number of SC blocks. Table 21-23 contains the values of N_{CWmin} for each MCS necessary to compute the padding described in 21.6.3.2.3.3.

Table 21-23—Zero filling for SC BRP packets

MCS index	Modulation	N_{CBPS}	Repetition	Code rate	Data rate (Mbps)	N_{CWmin}
1	π/2-BPSK	1	2	1/2	385	12
2	π/2-BPSK	1	1	1/2	770	12
3	π/2-BPSK	1	1	5/8	962.5	12
4	π/2-BPSK	1	1	3/4	1155	12
5	π/2-BPSK	1	1	13/16	1251.25	12
6	π/2-QPSK	2	1	1/2	1540	23
7	π/2-QPSK	2	1	5/8	1925	23
8	π/2-QPSK	2	1	3/4	2310	23
9	π/2-QPSK	2	1	13/16	2502.5	23
10	π/2-16QAM	4	1	1/2	3080	46
11	π/2-16QAM	4	1	5/8	3850	46
12	π/2-16QAM	4	1	3/4	4620	46

The minimum duration of the data field of a BRP packet when sent in an OFDM PHY is aBRPminOFDMblocks OFDM blocks and, if needed, the data field of the packet shall be extended by extra zero padding to generate the required number of OFDM symbols.

The minimum duration of the data field of a BRP packet when sent with the low-power SC PHY is N_{BLKS_MIN} low-power SC blocks (see 21.7.2.3.3).

21.10.2.2.5 Beam refinement AGC field

The beam refinement AGC fields are composed of 4*N* repetitions of the sequence [Ga_{64} Ga_{64} Ga_{64} Ga_{64} Ga_{64}] when the packet is transmitted using the OFDM or SC PHY and [Gb_{64} Gb_{64} Gb_{64} Gb_{64} Gb_{64}] when the packet is transmitted using the control PHY. The sequences Ga_{64} and Gb_{64} are defined in 21.11. The sequences are transmitted using rotated π/2-BPSK modulation. Any transmit signal transients that occur due to this TX AWV configuration change shall completely settle by the end of the first Ga64 or Gb64 subsequence.

In a BRP-TX packet, the transmitter may change the TX AWV configuration at the beginning of each AGC subfield. The set of AWVs used for the AGC subfields should be the same as that used for the TRN-T subfields. In a BRP-RX packet, the transmitter shall use the same TX AWV as in the preamble and data fields of the packet.

21.10.2.2.6 Beam refinement TRN-R field

The TRN-R fields enable receiver AWV training. The TRN-R fields have the form shown in Figure 21-23.

CE	R_1	R_2	R_3	R_4	CE	R_5	R_6	R_7	R_8	…

Figure 21-23—TRN-R field definition

Each subfield CE matches the Channel Estimation field defined in 21.3.6.3. The 4N subfields R_1 through R_{4N} each consist of the sequence [Ga_{128} -Gb_{128} Ga_{128} Gb_{128} Ga_{128}]. The sequences Ga_{128} and Gb_{128} are defined in Table 21-24 and Table 21-25, respectively, in 21.11. The sequences are transmitted using rotated π/2-BPSK modulation.

21.10.2.2.7 Beam refinement TRN-T field

The TRN-T field enables transmitter AWV training. The TRN-T fields have the form shown in Figure 21-24.

CE	T_1	T_2	T_3	T_4	CE	T_5	T_6	T_7	T_8	…

Figure 21-24—TRN-T field definition

Each subfield CE matches the Channel Estimation field defined in 21.3.6.3. The 4N subfields T_1 through T_{4N} each consist of the sequence [Ga_{128} -Gb_{128} Ga_{128} Gb_{128} Ga_{128}]. The sequences Ga_{128} and Gb_{128} are defined in Table 21-24 and Table 21-25, respectively, in 21.11. The sequences are transmitted using rotated π/2-BPSK modulation. When transmitting the CE subfield, the transmitter shall use the same AWV as in the preamble and data fields of the packet. Any transmit signal transients that occur due to TX AWV configuration changes between subfields shall settle by the end of the first 64 samples of the subfield.

21.10.2.2.8 Channel measurement

The good autocorrelation properties of the Golay sequence enable reconstructing part of the impulse response of the channel between the transmitter and the receiver. The receiver should find the tap with largest amplitude in the channel during the CE field of the BRP-RX. It selects thereafter the set of taps that is measured around the tap with the largest amplitude, according to the value of dot11ChanMeasFBCKNtaps. It can select a contiguous set of taps or select a noncontiguous set of taps, and include the tap delays subfield as part of the subfield measurement. It then measures the phase and amplitude of the corresponding channel taps in each of the TRN-T field repetition (except for those using the CE AWV configuration). The beam refinement feedback subfield *k-1* is the relative amplitude and phase of this tap in the *k'th* repetition compared to this tap in the first TRN-T subfield.

21.10.2.2.9 BRP resampling in an OFDM packet

The BRP AGC, CE, and Tn/Rn fields are specified at the SC chip rate (T_c). When appended to an OFDM packet, the signal is resampled as defined in 21.3.3.2.

21.11 Golay sequences

The following Golay sequences are used in the preamble, in the single carrier guard interval and in beam refinement TRN-R/T and AGC fields: $Ga_{128}(n)$, $Gb_{128}(n)$, $Ga_{64}(n)$, $Gb_{64}(n)$, $Ga_{32}(n)$, $Gb_{32}(n)$. These are 3 pairs of complementary sequences. The subscript denotes the length of the sequences. These sequences are generated using the following recursive procedure:

$$
\begin{aligned}
A_0(n) &= \delta(n) \\
B_0(n) &= \delta(n) \\
A_k(n) &= W_k A_{k-1}(n) + B_{k-1}(n - D_k) \\
B_k(n) &= W_k A_{k-1}(n) - B_{k-1}(n - D_k)
\end{aligned}
$$

Note that $A_k(n), B_k(n)$ are zero for $n < 0$ and for $n \geq 2^k$.

$Ga_{128}(n)=A_7(128-n)$, $Gb_{128}(n)=B_7(128-n)$ when the procedure uses D_k = [1 8 2 4 16 32 64] (k=1,2,…,7) and W_k = [-1 -1 -1 -1 +1 -1 -1].

$Ga_{64}(n)=A_6(64-n)$, $Gb_{64}(n)=B_6(64-n)$ when the procedure uses D_k= [2 1 4 8 16 32] and W_k =[1 1 -1 -1 1 -1].

$Ga_{32}(n)=A_5(32-n)$, $Gb_{32}(n)=B_5(32-n)$ when the procedure uses D_k=[1 4 8 2 16] and W_k =[-1 1 -1 1 -1].

The sequences are defined in Table 21-24, Table 21-25, Table 21-26, Table 21-27, Table 21-28, and Table 21-29. The sequences in the tables are normative, the description above is informative.

Table 21-24—The sequence $Ga_{128}(n)$

The Sequence $Ga_{128}(n)$, to be transmitted from left to right, up to down
+1 +1 -1 -1 -1 -1 -1 -1 -1 +1 -1 +1 +1 -1 -1 +1 +1 +1 -1 -1 +1 +1 +1 +1 -1 +1 -1 +1 -1 +1 +1 -1
-1 -1 +1 +1 +1 +1 +1 +1 +1 -1 +1 -1 -1 +1 +1 -1 +1 +1 -1 -1 +1 +1 +1 +1 -1 +1 -1 +1 -1 +1 +1 -1
+1 +1 -1 -1 -1 -1 -1 -1 -1 +1 -1 +1 +1 -1 -1 +1 +1 +1 -1 -1 +1 +1 +1 +1 -1 +1 -1 +1 -1 +1 +1 -1
+1 +1 -1 -1 -1 -1 -1 -1 -1 +1 -1 +1 +1 -1 -1 +1 -1 -1 +1 +1 -1 -1 -1 -1 +1 -1 +1 -1 +1 -1 -1 +1

Table 21-25—The sequence $Gb_{128}(n)$

The Sequence $Gb_{128}(n)$, to be transmitted from left to right, up to down
-1 -1 +1 +1 +1 +1 +1 +1 +1 -1 +1 -1 -1 +1 +1 -1 -1 -1 +1 +1 -1 -1 -1 -1 +1 -1 +1 -1 +1 -1 -1 +1
+1 +1 -1 -1 -1 -1 -1 -1 -1 +1 -1 +1 +1 -1 -1 +1 -1 -1 +1 +1 -1 -1 -1 -1 +1 -1 +1 -1 +1 -1 -1 +1
+1 +1 -1 -1 -1 -1 -1 -1 -1 +1 -1 +1 +1 -1 -1 +1 +1 +1 -1 -1 +1 +1 +1 +1 -1 +1 -1 +1 -1 +1 +1 -1
+1 +1 -1 -1 -1 -1 -1 -1 -1 +1 -1 +1 +1 -1 -1 +1 -1 -1 +1 +1 -1 -1 -1 -1 +1 -1 +1 -1 +1 -1 -1 +1

Table 21-26—The sequence $Ga_{64}(n)$

The Sequence $Ga_{64}(n)$, to be transmitted from left to right, up to down
-1 -1 +1 -1 +1 -1 -1 -1 +1 +1 -1 +1 +1 -1 -1 -1 -1 -1 +1 -1 +1 -1 -1 -1 -1 -1 +1 -1 -1 +1 +1 +1 -1 -1 +1 -1 +1 -1 -1 -1 +1 +1 -1 +1 +1 -1 -1 -1 +1 +1 -1 +1 -1 +1 +1 +1 +1 +1 -1 +1 +1 -1 -1 -1

Table 21-27—The sequence $Gb_{64}(n)$

The sequence $Gb_{64}(n)$, to be transmitted from left to right, up to down
+1 +1 -1 +1 -1 +1 +1 +1 -1 -1 +1 -1 -1 +1 +1 +1 +1 +1 -1 +1 -1 +1 +1 +1 +1 +1 -1 +1 +1 -1 -1 -1 -1 -1 +1 -1 +1 -1 -1 -1 +1 +1 -1 +1 +1 -1 -1 -1 +1 +1 -1 +1 -1 +1 +1 +1 +1 +1 -1 +1 +1 -1 -1 -1

Table 21-28—The sequence $Ga_{32}(n)$

The Sequence $Ga_{32}(n)$, to be transmitted from left to right
+1 +1 +1 +1 +1 -1 +1 -1 -1 -1 +1 +1 +1 -1 -1 +1 +1 +1 -1 -1 +1 -1 -1 +1 -1 -1 -1 -1 +1 -1 +1 -1

Table 21-29—The sequence $Gb_{32}(n)$

The Sequence $Gb_{32}(n)$, to be transmitted from left to right
-1 -1 -1 -1 -1 +1 -1 +1 +1 +1 -1 -1 -1 +1 +1 -1 +1 +1 -1 -1 +1 -1 -1 +1 -1 -1 -1 -1 +1 -1 +1 -1

21.12 DMG PLME

21.12.1 PLME_SAP sublayer management primitives

Table 21-30 lists the MIB attributes that may be accessed by the PHY entities and the intra-layer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 10.4.

21.12.2 DMG PHY MIB

All DMG PHY MIB attributes are defined in Annex C, with specific values defined in Table 21-30. The column titled "Operational semantics" in Table 21-30 contains two types: static and dynamic. Static MIB attributes are fixed and cannot be modified for a given PHY implementation. Dynamic MIB attributes can be modified by some management entity.

Table 21-30—DMG PHY MIB attribute default values

Managed object	Default value/range	Operational semantics
dot11PHYOperationTable		
dot11PHYtype	DMG	Static
dot11PHYDMGTable		
dot11LowPowerSCPHYImplemented	Boolean	Static
dot11LowPowerSCPHYActivated	Boolean	Dynamic

21.12.3 TXTIME calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated according to the following equations.

For the DMG OFDM PHY and for the DMG SC PHY (N_{TRN} is Training Length field defined in the header – see, for example, Table 21-13):

$$TXTIME = \begin{cases} T_{STF} + T_{CE} + T_{header} + T_{Data} & N_{TRN} = 0 \\ T_{STF} + T_{CE} + T_{header} + \max\{T_{Data}, (\alpha \times \beta + \gamma) \times T_C\} + N_{TRN} \times T_{TRN-Unit} & N_{TRN} > 0 \text{ and SC} \\ T_{STF} + T_{CE} + T_{header} + \max\{T_{Data}, \delta \times T_{SYM}\} + N_{TRN} \times T_{TRN-Unit} & N_{TRN} > 0 \text{ and OFDM} \end{cases}$$

where α =aBRPminSCblocks, β=aSCBlockSize, γ=aSCGILength, δ=aBRPminOFDMblocks, and $T_{TRN-Unit}$ = aBRPTRNBlo ck $\times T_C$.

For the DMG control PHY:

$$TXTIME = T_{STF-CP} + T_{CE-CP} + \left(11 \times 8 + \left(Length - 6\right) \times 8 + N_{CW} \times 168\right) \times T_C \times 32 +$$
$$N_{TRN} \times T_{TRN-Unit}$$

where N_{CW} calculation is defined in 21.4.3.3.3.

21.12.4 PHY characteristics

The static DMG PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 21-31. The definitions for these characteristics are given in 10.4.

Table 21-31—DMG PHY characteristics

PHY parameter	Value
aRIFSTime	1 µs
aSIFSTime	3 µs

Table 21-31—DMG PHY characteristics *(continued)*

PHY parameter	Value
aRxRFDelay	<< 1 µs
aRxPLCPDelay	Implementation dependent as long as the requirements of aSIFSTime and aSlotTtime are met.
aRxTxTurnaroundTime	< 1 µs
aCCATime	< 3 µs
aRxTxSwitchTime	< 1 µs
aPHY-RX-START-Delay	Control PHY: 10µs; SC and SC LP PHY: 3.6µs; OFDM PHY: 3.3µs
aMACProcessingDelay	Implementation dependent as long as the requirements of aSIFSTime and aSlotTtime are met.
aTxPLCPDelay	Implementation dependent as long as the requirements of aRxTxTurnaroundTime are met.
aTxRampOnTime	Implementation dependent as long as the requirements of aRxTxTurnaroundTime are met.
aTxRFDelay	Implementation dependent as long as the requirements of aRxTxTurnaroundTime are met.
aDataPreambleLength	1891 ns
aControlPHYPreambleLength	4291 ns
aSBIFSTime	1 µs
aSBIFSAccuracy	[0, +0.03] µs
aAirPropagationTime	< 100 ns
aDMGDetectionThres	–48 dBm
aBRPIFS	40 µs
aSlotTime	5 µs
aCWmin	15
aCWmax	1023
aBRPminSCblocks	18
aBRPminOFDMblocks	20
aBRPTRNBlock	4992
aSCGILength	64
aSCBlockSize	512
aPPDUMaxTime	2 ms
aPSDUMaxLength	262 143 octets

21.13 DMG PMD sublayer

21.13.1 Scope and field of application

The PMD services provided to the PLCP for the DMG PHY are described in this subclause. Also defined in this subclause are the functional, electrical, and RF characteristics required for interoperability of implementations conforming to this standard. The relationship of this standard to the entire DMG PHY is shown in Figure 21-25.

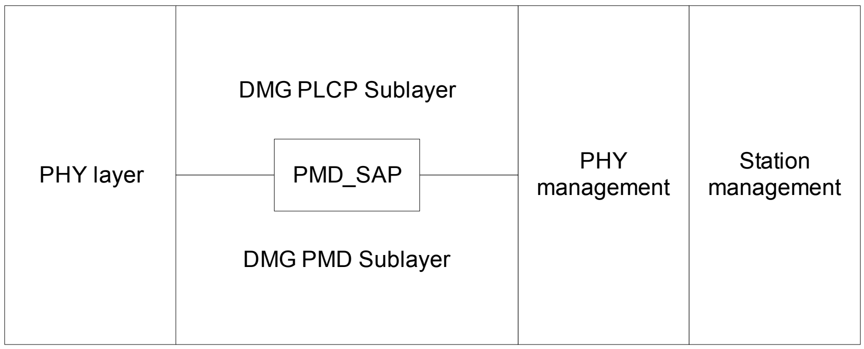


Figure 21-25—PMD layer reference model

21.13.2 Overview of service

The DMG PMD sublayer accepts PLCP sublayer service primitives and provides the actual means by which data are transmitted or received from the medium. The combined function of the DMG PMD sublayer primitives and parameters for the receive function results in a data stream, timing information, and associated receive signal parameters being delivered to the PLCP sublayer. A similar functionality is provided for data transmission.

21.13.3 Overview of interactions

The primitives provided by the DMG PMD fall into two basic categories:

a) Service primitives that support PLCP peer-to-peer interactions
b) Service primitives that have local significance and support sublayer-to-sublayer interactions

21.13.4 Basic service and options

21.13.4.1 Status of service primitives

All of the service primitives described in 21.13.4 are mandatory, unless otherwise specified.

21.13.4.2 PMD_SAP peer-to-peer service primitives

Table 21-32 indicates the primitives for peer-to-peer interactions.

Table 21-32—PMD_SAP peer-to-peer service primitives

Primitive	Request	Indicate	Confirm	Response
PMD_DATA	X	X	—	—

21.13.4.3 PMD_SAP sublayer-to-sublayer service primitives

Table 21-33 indicates the primitives for sublayer-to-sublayer interactions.

Table 21-33—PMD_SAP sublayer-to-sublayer service primitives

Primitive	Request	Indicate	Confirm	Response
PMD_TXSTART	X	—	—	—
PMD_TXEND	X	—	X	—
PMD_RCPI	—	X	—	—
PMD_TXPWRLVL	X	—	—	—
PMD_RSSI	—	X	—	—

21.13.5 PMD_SAP detailed service specification

21.13.5.1 Introduction to PMD_SAP service specification

Subclause 21.13.5 describes the services provided by each PMD primitive.

21.13.5.2 PMD_DATA.request

21.13.5.2.1 Function

This primitive defines the transfer of data from the PLCP sublayer to the PMD entity.

21.13.5.2.2 Semantics of the service primitive

This primitive shall provide the following parameters: PMD_DATA.request (TXD_UNIT)

The TXD_UNIT parameter shall be the n-bit combination of 0 and 1 for one modulation symbol. This parameter represents a single block of data that, in turn, shall be used by the PHY to be encoded into a transmitted symbol.

21.13.5.2.3 When generated

This primitive shall be generated by the PLCP sublayer to request transmission of one symbol.

21.13.5.2.4 Effect of receipt

The PMD performs transmission of the data.

21.13.5.3 PMD_DATA.indication

21.13.5.3.1 Function

This primitive defines the transfer of data from the PMD entity to the PLCP sublayer.

21.13.5.3.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_DATA.indication(RXD_UNIT)

The RXD_UNIT parameter shall be 0 or 1 and shall represent either a SIGNAL field bit or a data field bit after the decoding of the FEC by the PMD entity.

21.13.5.3.3 When generated

This primitive, generated by the PMD entity, forwards received data to the PLCP sublayer.

21.13.5.3.4 Effect of receipt

The PLCP sublayer decodes the bits that it receives from the PMD and either interprets them as part of its own signaling or passes them to the MAC sublayer as part of the PSDU after any necessary additional processing (e.g., descrambling).

21.13.5.4 PMD_TXSTART.request

21.13.5.4.1 Function

This primitive, generated by the PHY PLCP sublayer, initiates PPDU transmission by the PMD layer.

21.13.5.4.2 Semantics of the service primitive

This primitive has no parameters.

21.13.5.4.3 When generated

This primitive shall be generated by the PLCP sublayer to initiate the PMD layer transmission of the PPDU. The PHY-TXSTART.request primitive shall be provided to the PLCP sublayer prior to issuing the PMD_TXSTART command.

21.13.5.4.4 Effect of receipt

PMD_TXSTART initiates transmission of a PPDU by the PMD sublayer.

21.13.5.5 PMD_TXEND.request

21.13.5.5.1 Function

This primitive, generated by the PHY PLCP sublayer, ends PPDU transmission by the PMD layer.

21.13.5.5.2 Semantics of the service primitive

This primitive has no parameters.

21.13.5.5.3 When generated

This primitive shall be generated by the PLCP sublayer to terminate the PMD layer transmission of the PPDU.

21.13.5.5.4 Effect of receipt

PMD_TXEND terminates transmission of a PPDU by the PMD sublayer.

21.13.5.6 PMD_TXEND.confirm

21.13.5.6.1 Function

This primitive, generated by the PMD entity, indicates the end of PPDU transmission by the PMD layer. It is generated at the 1 μs boundary following the trailing boundary of the last symbol transmitted.

21.13.5.6.2 Semantics of the service primitive

This primitive has no parameters.

21.13.5.6.3 When generated

This primitive shall be generated by the PMD entity at the 1 μs boundary following the trailing boundary of the last symbol transmitted.

21.13.5.6.4 Effect of receipt

The PLCP sublayer determines that transmission of the last symbol of the PPDU is complete. This completion is used as a timing reference in the PLCP state machines.

21.13.5.7 PMD_RCPI.indication

21.13.5.7.1 Function

This primitive, generated by the PMD sublayer, provides the received channel power indicator to the PLCP and MAC entity.

21.13.5.7.2 Semantics of the service primitive

The primitive shall provide the following parameter: PMD_RCPI.indication(RCPI).

The RCPI is a measure of the channel power received by the DMG PHY. RCPI measurement and parameter values are defined in 21.3.10.

21.13.5.7.3 When generated

This primitive shall be generated by the PMD when the DMG PHY is in the receive state. It is generated at the end of the last received symbol.

21.13.5.7.4 Effect of receipt

This parameter shall be provided to the PLCP layer for information only. The RCPI might be used in conjunction with RSSI to measure input signal quality.

21.13.5.8 PMD_TXPWRLVL.request

21.13.5.8.1 Function

This primitive, generated by the PHY PLCP sublayer, selects the power level used by the PHY for transmission.

21.13.5.8.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_TXPWRLVL.request (TXPWR_LEVEL)

TXPWR_LEVEL selects which of the transmit power levels should be used for the current packet transmission. The number of available power levels shall be determined by the MIB parameter aNumberSupportedPowerLevels. The number of available power levels are determined by the PLCP.

21.13.5.8.3 When generated

This primitive shall be generated by the PLCP sublayer to select a specific transmit power. This primitive shall be applied prior to setting PMD_TXSTART into the transmit state.

21.13.5.8.4 Effect of receipt

PMD_TXPWRLVL immediately sets the transmit power level to the level given by TXPWR_LEVEL.

21.13.5.9 PMD_RSSI.indication

21.13.5.9.1 Function

This primitive, generated by the PMD sublayer, provides the receive signal strength to the PLCP and MAC entity.

21.13.5.9.2 Semantics of the service primitive

This primitive shall provide the following parameter: PMD_RSSI.indication (RSSI)

The RSSI shall be a measure of the RF energy received by the DMG PHY. RSSI indications of up to 8 bits (256 levels) are supported.

21.13.5.9.3 When generated

This primitive shall be generated by the PMD after the reception of the DMG training fields.

21.13.5.9.4 Effect of receipt

This parameter shall be provided to the PLCP layer for information only. The RSSI may be used as part of a CCA scheme.

Annex B

(normative)

Protocol Implementation Conformance Statement (PICS) proforma

B.4 PICS proforma

B.4.3 IUT configuration

Change the IUT configuration table as follows (note that the entire table is not shown here):

Item	IUT configuration	References	Status	Support
*CF2.1	Operation in an infrastructure BSS	4.3	CF2&(not CF25):M CF2&CF25:O	Yes ☐ No ☐ N/A ☐
*CF2.4	Operation in a PBSS	4.3.2a	CF2&(not CF25):O	
*CF2.4.1	Operation as a PCP	4.3.2a	CF2&CF25:M	Yes ☐ No ☐
*CF2.4.2	Operation *not* as a PCP	4.3.2a	CF2&CF25:M	Yes ☐ No ☐
* CF4	Direct sequence spread spectrum (DSSS) PHY for the 2.4 GHz band	–	O.2 CF7:M	Yes ☐ No ☐
* CF6	Orthogonal frequency division multiplexing (OFDM) PHY	–	O.2 CF16.2:M	Yes ☐ No ☐
* CF7	~~High-speed~~ High rate direct sequence spread spectrum (HR/DSSS) PHY	–	O.2 CF9:M	Yes ☐ No ☐
* CF9	Extended Rate PHY (ERP)	Clause 19	O.2 CF16.1:M	Yes ☐ No ☐
* CF10	Is spectrum management operation supported?	8.4.1.4, 10.6	(CF6 OR CF16.2 OR CF25):O	Yes ☐ No ☐
* CF11	Is operating classes capability implemented?	8.4.2.13, 18.3.8.4.2, 18.3.8.7, 18.4.2, Annex D, Annex E	(CF6 OR CF16.2 OR CF25)& CF8&CF10:O	Yes ☐ No ☐ N/A ☐
* CF12	Quality of service (QoS) supported	9.19, 9.21, 4.3.10, 4.3.15.3	O (CF16 OR CF21 OR CF22):M CF25:M	Yes ☐ No ☐ N/A ☐
* CF16.1	HT operation in 2.4 GHz band	Clause 20	CF16: O.6	Yes ☐ No ☐
* CF16.2	HT operation in 5 GHz band	Clause 20	CF16: O.6	Yes ☐ No ☐

Item	IUT configuration	References	Status	Support
* CF25	DMG features	8.4.2.130	O.2	Yes ☐ No ☐
* CF26	Multi-band operation	8.5.21, 10.32	At least two of CF4, CF6, CF15, CF17, CF25: O	Yes ☐ No ☐ N/A ☐
* CF27	Non-DMG STA		O.5	Yes ☐ No ☐ N/A ☐
* CF28	DMG STA		O.5	Yes ☐ No ☐ N/A ☐

B.4.4 MAC protocol

B.4.4.1 MAC protocol capabilities

Change the MAC protocol capabilities table as follows (note that the entire table is not shown):

Item	Protocol capability	References	Status	Support
PC1	Authentication service	4.5.4.2, 4.5.4.3, 11.1, 10.20, Annex J	(not CF2.3)&CF27: M	Yes ☐ No ☐
*PC4	Point coordinator (PC)	9.2, 9.4, Annex J	CF27&CF1:O	Yes ☐ No ☐ N/A ☐
*PC5	Contention-free (CF)-Pollable	9.2, 9.4, Annex J	CF27&CF2.1: O	Yes ☐ No ☐ N/A ☐
PC11.7	Passive scanning	10.1.4	(CF2.1 or CF2.2 or CF2.4.2):M	Yes ☐ No ☐ N/A ☐
PC11.8	Active scanning	10.1.4	(CF2.1 or CF2.2 or CF2.4.2):M	Yes ☐ No ☐ N/A ☐
PC12	Infrastructure power management	10.2.1, Annex J	CF27:M	Yes ☐ No ☐
PC14	Association and reassociation	4.5, 10.3, 10.3.5, 10.20, Annex J	(CF27 and not CF2.3):M	Yes ☐ No ☐ N/A ☐
PC34.1.2.3	Galois/Counter Mode with GMAC Protocol (GCMP) data confidentiality protocol	11.4.5	(CF25 and PC34):M	Yes ☐ No ☐ N/A ☐
PC34.1.13	RSNA rekeying	11.5.15	PC34:O	Yes ☐ No ☐ N/A ☐
PC34.1.14	Multi-band RSNA	11.5.19	CF26&PC34:M	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
PC35.12	QoS procedures for fast basic service set (BSS) transition	12.11	(CF12&PC35 or CF25&PC35): M	Yes ☐ No ☐ N/A ☐
*PC37	Power save multi-poll (PSMP)	8.5.12.4, 9.26	CF27:O	Yes ☐ No ☐
*PC40	Multi-band Operation	10.32	CF26:O	Yes ☐ No ☐ N/A ☐
*PC40.1	FST Setup	10.32.2.1, 10.32.2.2, 8.4.2.140, 8.5.21.2, 8.5.21.3, 8.5.21.5, 8.5.21.6, 8.4.2.153, 8.4.2.154	PC39:M	Yes ☐ No ☐ N/A ☐
PC40.2	FST TS switching	10.32.2.3, 8.5.3.2.2, 8.5.3.3.2, 8.5.3.4, 8.5.5.2, 8.5.5.3, 8.5.5.4, 8.4.2.32, 8.4.2.143	PC39.1:M	Yes ☐ No ☐ N/A ☐
PC40.3	FST Tear Down			
PC40.3.1	Transmission of FST Tear Down	10.32.3, 8.5.21.4	PC39.1:O	Yes ☐ No ☐ N/A ☐
PC40.3.2	Reception of FST Tear Down	10.32.3, 8.5.21.4	PC39.1:M	Yes ☐ No ☐ N/A ☐
PC41	MMSL cluster operation	10.33	O	Yes ☐ No ☐ N/A ☐
PC42	Quieting adjacent BSS operation	10.36	O	Yes ☐ No ☐ N/A ☐

B.4.4.2 MAC frames

Change the MAC frames table as follows:

Item	MAC frame	References	Status	Support
	Is the transmission of the following MAC frames supported?	Clause 8, Annex J		
FT1	Association Request	Clause 8	CF2.1:M CF2.4.2:O	Yes ☐ No ☐ N/A ☐
FT2	Association Response	Clause 8	(CF1 OR CF2.4.1):M	Yes ☐ No ☐ N/A ☐

Item	MAC frame	References	Status	Support
FT3	Reassociation Request	Clause 8	CF2.1:M CF2.4.2:O	Yes ☐ No ☐ N/A ☐
FT4	Reassociation Response	Clause 8	(CF1 OR CF2.4.1):M	Yes ☐ No ☐ N/A ☐
FT5	Probe Request	Clause 8	(CF2.1 OR CF2.2 OR CF2.4):M	Yes ☐ No ☐ N/A ☐
FT6	Probe Response	Clause 8	(not CF2.3):M	Yes ☐ No ☐ N/A ☐
FT7	Beacon	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FT8	ATIM	Clause 8	(CF2.1 OR CF2.2 OR CF2.4):M	Yes ☐ No ☐ N/A ☐
FT9	Disassociation	Clause 8	(not CF2.3):M	Yes ☐ No ☐ N/A ☐
FT10	Authentication	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FT11	Deauthentication	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FT12	Power save (PS)-Poll	Clause 8	CF27&CF2.1: M	Yes ☐ No ☐ N/A ☐
FT13	RTS	Clause 8	M	Yes ☐ No ☐
FT14	CTS	Clause 8	CF27:M	Yes ☐ No ☐
FT15	Acknowledgment (ACK)	Clause 8	M	Yes ☐ No ☐
FT16	CF-End	Clause 8	CF27&PC4:M CF28:M	Yes ☐ No ☐ N/A ☐
FT17	CF-End+CF-Ack	Clause 8	CF27&PC4:M	Yes ☐ No ☐ N/A ☐
FT18	Data	Clause 8	CF27:M	Yes ☐ No ☐
FT19	Data+CF-Ack	Clause 8	CF27&(PC4 OR PC5):M	Yes ☐ No ☐ N/A ☐
FT20	Data+CF-Poll	Clause 8	CF27&PC4.3: M	Yes ☐ No ☐ N/A ☐
FT21	Data+CF-Ack+CF-Poll	Clause 8	CF27&PC4.3: M	Yes ☐ No ☐ N/A ☐
FT22	Null	Clause 8	CF27:M	Yes ☐ No ☐
FT23	CF-Ack (no data)	Clause 8	CF27&(PC4 OR PC5):M	Yes ☐ No ☐ N/A ☐
FT24	CF-Poll (no data)	Clause 8	CF27&PC4.3: M	Yes ☐ No ☐ N/A ☐
FT25	CF-Ack+CF-Poll (no data)	Clause 8	CF27&PC4.3: M	Yes ☐ No ☐ N/A ☐

Item	MAC frame	References	Status	Support
FT26	Timing Advertisement frame	Clause 8	O	Yes ☐ No ☐ N/A ☐
FT27	QoS Data	Clause 8	CF28:M	Yes ☐ No ☐
FT28	QoS Null (no data)	Clause 8	CF28:M	Yes ☐ No ☐
FT29	BlockAckReq	Clause 8	CF28:M	Yes ☐ No ☐
FT30	BlockAck	Clause 8	CF28:M	Yes ☐ No ☐
FT31	Poll	Clause 8	CF28:M	Yes ☐ No ☐
FT32	SPR	Clause 8	CF28:M	Yes ☐ No ☐
FT33	Grant	Clause 8	CF28:M	Yes ☐ No ☐
FT34	DMG CTS	Clause 8	CF28:M	Yes ☐ No ☐
FT35	DMG DTS	Clause 8	CF28:M	Yes ☐ No ☐
FT36	SSW	Clause 8	CF28:M	Yes ☐ No ☐
FT37	SSW-Feedback	Clause 8	CF28:M	Yes ☐ No ☐
FT38	SSW-ACK	Clause 8	CF28:M	Yes ☐ No ☐
FT39	DMG Beacon	Clause 8	CF28:M	Yes ☐ No ☐
	Is the reception of the following MAC frames supported?	Clause 8, Annex J		
FR1	Association Request	Clause 8	(CF1 OR CF2.4.1):M	Yes ☐ No ☐ N/A ☐
FR2	Association Response	Clause 8	(CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
FR3	Reassociation Request	Clause 8	(CF1 OR CF2.4.1):M	Yes ☐ No ☐ N/A ☐
FR4	Reassociation Response	Clause 8	(CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
FR5	Probe Request	Clause 8	(not CF2.3):M	Yes ☐ No ☐ N/A ☐
FR6	Probe Response	Clause 8	(not CF2.3):M	Yes ☐ No ☐ N/A ☐
FR7	Beacon	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FR8	ATIM	Clause 8	(CF2.2 OR CF2.4):M	Yes ☐ No ☐ N/A ☐
FR9	Disassociation	Clause 8	(not CF2.3):M	Yes ☐ No ☐ N/A ☐
FR10	Authentication	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FR11	Deauthentication	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FR12	PS-Poll	Clause 8	CF27&CF1:M	Yes ☐ No ☐ N/A ☐

Item	MAC frame	References	Status	Support
FR13	RTS	Clause 8	M	Yes ☐ No ☐
FR14	CTS	Clause 8	CF27:M	Yes ☐ No ☐
FR15	ACK	Clause 8	M	Yes ☐ No ☐
FR16	CF-End	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FR17	CF-End+CF-Ack	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FR18	Data	Clause 8	CF27:M	Yes ☐ No ☐
FR19	Data+CF-Ack	Clause 8	(not CF2.3):M CF27:M	Yes ☐ No ☐ N/A ☐
FR20	Data+CF-Poll	Clause 8	CF27&PC5:M	Yes ☐ No ☐ N/A ☐
FR21	Data+CF-Ack+CF-Poll	Clause 8	CF27&PC5:M	Yes ☐ No ☐ N/A ☐
FR22	Null	Clause 8	CF27:M	Yes ☐ No ☐
FR23	CF-Ack (no data)	Clause 8	CF27&(PC4 OR PC5):M	Yes ☐ No ☐ N/A ☐
FR24	CF-Poll (no data)	Clause 8	CF27&PC5:M	Yes ☐ No ☐ N/A ☐
FR25	CF-Ack+CF-Poll (no data)	Clause 8	CF27&PC5:M	Yes ☐ No ☐ N/A ☐
FR26	Timing Advertisement frame	Clause 8	O	Yes ☐ No ☐ N/A ☐
FR27	QoS Data	Clause 8	CF28:M	Yes ☐ No ☐
FR28	QoS Null (no data)	Clause 8	CF28:M	Yes ☐ No ☐
FR29	BlockAckReq	Clause 8	CF28:M	Yes ☐ No ☐
FR30	BlockAck	Clause 8	CF28:M	Yes ☐ No ☐
FR31	Poll	Clause 8	CF28:M	Yes ☐ No ☐
FR32	SPR	Clause 8	CF28:M	Yes ☐ No ☐
FR33	Grant	Clause 8	CF28:M	Yes ☐ No ☐
FR34	DMG CTS	Clause 8	CF28:M	Yes ☐ No ☐
FR35	DMG DTS	Clause 8	CF28:M	Yes ☐ No ☐
FR36	CF-End	Clause 8	CF28:M	Yes ☐ No ☐
FR37	SSW	Clause 8	CF28:M	Yes ☐ No ☐
FR38	SSW-Feedback	Clause 8	CF28:M	Yes ☐ No ☐
FR39	SSW-ACK	Clause 8	CF28:M	Yes ☐ No ☐
FR40	DMG Beacon	Clause 8	CF28:M	Yes ☐ No ☐

B.4.14 QoS base functionality

Change the QoS base functionality table as follows:

Item	Protocol capability	References	Status	Support
QB1	QoS frame format	~~8.3.1.2–8.3.1.4, 8.3.2.1, 8.3.3.2, 8.3.3.5–8.3.3.8, 8.3.3.10, 8.3.3.13~~	~~CF12:M~~	~~Yes ☐ No ☐ N/A ☐~~
QB1.1	QoS frame format	8.3.1.2–8.3.1.4, 8.3.2.1, 8.3.3.2, 8.3.3.5–8.3.3.8, 8.3.3.10, 8.3.3.13	CF27&CF12:M	Yes ☐ No ☐ N/A ☐
QB1.2	QoS frame format	8.3.1.2, 8.3.1.4, 8.3.1.8, 8.3.1.9, 8.3.1.11–8.3.1.19, 8.3.2.1, 8.3.4.1, 8.3.3.5–8.3.3.8, 8.3.3.10, 8.3.3.13	CF28&CF25:M	Yes ☐ No ☐ N/A ☐
QB2	Per traffic identifier (TID) duplicate detection	8.2.4.4, 8.2.4.5, 9.3.2.10	CF12 OR CF25:M	Yes ☐ No ☐ N/A ☐
QB3	Decode of no-acknowledgment policy in QoS data frames	8.2.4.5.4, 9.19.2.4, 9.19.2.5, 9.19.4.2, 9.19.4.3	CF12 OR CF25:M	Yes ☐ No ☐ N/A ☐
QB4	Block Acknowledgments (Block Acks)			
QB4.1	Immediate Block Ack	8.3.1.8.1, 8.3.1.8.2, 8.3.1.9.1, 8.3.1.9.2, 8.5.5, 9.21 (except 9.21.7 and 9.21.8), 10.5	CF12:O CF16 OR CF25:M	Yes ☐ No ☐ N/A ☐
QB4.2	Delayed Block Ack	8.3.1.8.1, 8.3.1.8.2, 8.3.1.9.1, 8.3.1.9.2, 8.5.5, 9.21 (except 9.21.7 and 9.21.8), 10.5	CF12:O	Yes ☐ No ☐ N/A ☐
QB4.3	Compressed Block Ack	~~8.3.1.8.3~~	~~CF12:O~~ ~~CF16:M~~	~~Yes o No o N/A o~~
QB4.3.1	Compressed Block Ack	8.3.1.8.3	CF12:O CF16 OR CF25:M	Yes ☐ No ☐ N/A ☐
QB4.3.2	Extended Compressed Block Ack	8.3.1.8.6	CF25:O	Yes ☐ No ☐ N/A ☐
QB4.4	MultiTID Block Ack	8.3.1.8.4	CF12:O CF16: M	Yes ☐ No ☐ N/A ☐

Item	Protocol capability	References	Status	Support
QB5	Automatic power-save delivery (APSD)	8.5.3, 10.2.1	(CF1&CF12):O (CF2&CF12):O	Yes ☐ No ☐ N/A ☐
QB6	Direct-link setup (DLS)	8.4.2.21, 8.5.4, 6.3.14, 10.7	(CF1&CF12): M (CF2.1&CF12): O	Yes ☐ No ☐ N/A ☐

B.4.15 QoS enhanced distributed channel access (EDCA)

Change the QoS EDCA table as follows:

Item	Protocol capability	References	Status	Support
QD1	Support for four transmit queues with a separate channel access entity associated with each	9.2.4.2, 9.19.2.1	CF27&CF12:M	Yes ☐ No ☐ N/A ☐
QD2	Per-channel access function differentiated channel access	9.19.2.2, 9.19.2.3, 9.19.2.5	CF27&CF12:M	Yes ☐ No ☐ N/A ☐
QD3	Multiple frame transmission support	9.19.2.4	CF12 OR CF25:O	Yes ☐ No ☐ N/A ☐
QD4	Maintenance of within-queue ordering, exhaustive retransmission when sending non-QoS data frames	9.19.2.6	CF12 OR CF25:M	Yes ☐ No ☐ N/A ☐
QD5	Interpretation of admission control mandatory (ACM) bit in EDCA Parameter Set element	8.4.2.15, 9.19.4.2	(CF2.1 & (CF12 OR CF25)):M (CF2.4.2 & CF25):M	Yes ☐ No ☐ N/A ☐
QD6	Contention-based admission control	9.19.4.2, 8.4.2.16, 8.4.2.17, 8.5.3.2–8.5.3.4, 10.4	(CF1 & (CF12 OR CF25)):O (CF2.1 & (CF12 OR CF25)):O (CF2.4.1 & CF25):O (CF2.4.2 & CF25):O	Yes ☐ No ☐ N/A ☐
QD7	Power management in an infrastructure BSS or in an IBSS	10.2	(CF1&CF12):O (CF2&CF12):O	Yes ☐ No ☐ N/A ☐
QD8	Default EDCA parameters for communications outside context of B~~B~~SS	8.4.2.31, 9.19.2.2	CF2.3:M	Yes ☐ No ☐ N/A ☐

B.4.17 Radio management extensions

Change the radio management extensions table as follows (note that the entire table is not shown here):

Item	Protocol capability	References	Status	Support
RM2.4	Link Measurement Report frame	~~8.5.7.5~~	~~CF13:M~~	~~Yes o No o N/A o~~
RM2.4.1	Link Measurement Report frame	8.5.7.5	CF27&CF13:M	Yes ☐ No ☐ N/A ☐
RM2.4.2	Link Measurement Report frame	8.5.7.5, 8.4.2.151, 8.4.2.152, 9.37	CF28&(CF13 AND CF25):M	Yes ☐ No ☐ N/A ☐
*RM10	Transmit Stream/Category Measurement Type	10.11, 10.11.9.8	(CF13 AND (CF12 OR CF25)):O	Yes ☐ No ☐ N/A ☐
RM14.1	Respond with RCPI element when requested	10.1.4.3.3	(CF13 AND (CF12 OR CF25) AND CF1):M	Yes ☐ No ☐ N/A ☐
RM14.2	Measurement of RCPI on Probe Request frames	10.1.4.3.3	(CF13 AND (CF12 OR CF25) AND CF1):O	Yes ☐ No ☐ N/A ☐
RM24	BSS Available Admission Capacity	8.4.2.45	(CF1 AND (CF12 OR CF25) AND CF13):M	Yes ☐ No ☐ N/A ☐
RM25	BSS AC Access Delay	8.3.3.2, 8.3.3.10, 8.4.2.46	CF27&(CF1 AND CF12 AND CF13):M	Yes ☐ No ☐ N/A ☐
RM26	BSS AC Access Delay	8.3.4.1, 8.3.3.10, 8.4.2.46	CF28&(CF1 AND CF25 AND CF13):M	Yes ☐ No ☐ N/A ☐
RM27	Directional channel quality measurement	10.11, 10.31		
RM27.1	Directional Channel Quality Request	8.4.2.23.16, 10.31	(CF13 AND DMG-M19):O	Yes ☐ No ☐ N/A ☐
RM27.2	Directional Channel Quality Response	8.4.2.24.15, 10.31	(CF13 AND DMG-M19):M	Yes ☐ No ☐ N/A ☐
RM28	Directional measurement type	10.11		
RM28.1	Directional Measurement Request	8.4.2.23.17	(CF13 AND CF25):O	Yes ☐ No ☐ N/A ☐
RM28.2	Directional Measurement Response	8.4.2.24.16	(CF13 AND CF25):O	Yes ☐ No ☐ N/A ☐
RM29	Directional statistics measurement type	10.11		

Item	Protocol capability	References	Status	Support
RM29.1	Directional Statistics Measurement Type	8.4.2.23.18	(CF13 AND CF25):O	Yes ☐ No ☐ N/A ☐
RM29.2	Directional Statistics Measurement Type	8.4.2.24.17	(CF13 AND CF25):O	Yes ☐ No ☐ N/A ☐

Insert the following subclauses, B.4.26 to B.4.26.2, after B.4.25:

B.4.26 DMG features

B.4.26.1 DMG MAC features

Item	Protocol capability	References	Status	Support
	Are the following MAC protocol features supported?			
DMG-M1	DMG capabilities signaling			
DMG-M1.1	DMG Capabilities element	8.4.2.137	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M1.2	Signaling of STA capabilities in Probe Request, (Re)Association Request frames	8.4.2.137, 8.3.3.9, 8.3.3.5, 8.3.3.7	(CF25 AND (CF2.1 OR CF2.2 OR CF2.4.2)):M	Yes ☐ No ☐ N/A ☐
DMG-M1.3	Signaling of STA and BSS capabilities in DMG Beacon, Probe Response, (Re)Association Response frames	8.4.2.137, 8.3.4.1, 8.3.3.10, 8.3.3.6, 8.3.3.8	(CF25 AND (CF1 OR CF2.4.1)):M	Yes ☐ No ☐ N/A ☐
DMG-M2	Signaling of DMG operation	8.3.2.138	(CF25 AND (CF1 OR CF2.4.1)):M	Yes ☐ No ☐ N/A ☐
DMG-M3	MSDU aggregation			
DMG-M3.1	Reception of Basic A-MSDUs	8.2.4.5, 8.3.2.2.2	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M3.2	Basic A-MSDU format	8.3.2.2.2	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M3.3	Basic A-MSDU content	8.3.2.2.2	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M3.4	Transmission of Basic A-MSDUs	8.3.2.2.2, 8.2.4.5	CF25:O	Yes ☐ No ☐ N/A ☐
*DMG-M3.5	Reception of Short A-MSDU	8.2.4.5, 8.3.2.2.3	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M3.6	Short A-MSDU format	8.3.2.2.3	(DMG-M3.5 OR DMG-M3.8):M	Yes ☐ No ☐ N/A ☐

B.4.26.1 DMG MAC features *(continued)*

Item	Protocol capability	References	Status	Support
DMG-M3.7	Short A-MSDU content	8.3.2.2.3	(DMG-M3.5 OR DMG-M3.8):M	Yes ☐ No ☐ N/A ☐
*DMG-M3.8	Transmission of Short A-MSDU	8.3.2.2.3, 8.2.4.5	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M3.9	Negotiation of Short A-MSDU usage	8.4.2.32	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M4	MPDU aggregation			
DMG-M4.1	Reception of A-MPDU	8.4.2.137.2, 10.3, 9.12.2, 8.4.2.148	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M4.2	A-MPDU format	8.6.1	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M4.3	A-MPDU content	8.6.3	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M4.4	Transmission of A-MPDU	8.4.2.111.2, 11.3, 8.4.2.148	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M5	A-PPDU aggregation	9.13a		
*DMG-M5.1	Reception of A-PPDU	8.4.2.137.2	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M5.2	A-PPDU format	21.5.2, 21.6.2	(DMG-M5.1 OR DMG-M5.3):M	Yes ☐ No ☐ N/A ☐
*DMG-M5.3	Transmission of A-PPDU	8.4.2.137.2	CF25:O	Yes ☐ No ☐ N/A ☐
*DMG-M6	Reverse direction aggregation exchanges	9.25, 8.4.2.137.2	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M6.1	Constraints regarding responses	9.25.4	DMG-M6:M	Yes ☐ No ☐ N/A ☐
DMG-M7	DMG channel access			
DMG-M7.1	ATI transmission			
DMG-M7.1.1	Transmission of Request	9.33.3	CF25 AND (CF1 OR CF2.4.1):O	Yes ☐ No ☐ N/A ☐
DMG-M7.1.2	Reception of Request	9.33.3	CF25 AND (CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M7.1.3	Transmission of Response	9.33.3	CF25 AND (CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M7.1.4	Reception of Response	9.33.3	CF25 AND (CF1 OR CF2.4.1):M	Yes ☐ No ☐ N/A ☐

B.4.26.1 DMG MAC features *(continued)*

Item	Protocol capability	References	Status	Support
DMG-M7.2	DTI transmission	9.33.4	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M7.3	Time allocation			
*DMG-M7.3.1	Service period (SP) allocation	9.33.6.2, 8.4.2.141, 8.4.2.143	CF25 AND (CF1 OR CF2.4.1):O	Yes ☐ No ☐ N/A ☐
*DMG-M7.3.2	CBAP allocation	9.33.6.3, 8.4.2.141	CF25 AND (CF1 OR CF2.4.1):O	Yes ☐ No ☐ N/A ☐
DMG-M7.3.3	Interpretation of allocation	9.33.6.2, 9.33.6.3, 8.4.2.141	CF25 AND (CF1 OR CF2.1 OR CF2.2 OR CF2.4.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
*DMG-M7.4	Contention-based access period	9.33.5, 9.33.6.3	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1	Distributed coordination function (DCF)			
DMG-M7.4.1.1	Network allocation vector (NAV) function	9.3.2.2, 9.3.4, 9.33.10	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.2	Interframe space usage and timing	9.3.2.4, 9.3.4, 9.3.7	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.3	Random Backoff function	9.3.3	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.4	DCF Access procedure	9.3, 9.3.4.2, 9.3.4.5	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.5	Random Backoff procedure	9.3, 9.3.4.3	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.6	Recovery procedures and retransmit limits	9.3.4.4	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.7	Request to send (RTS)/DMG clear to send (DMG CTS) procedure	9.3.2.5, 9.33.10, 9.3.2.6, 9.3.2.7	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.8	Directed MAC protocol data unit (MPDU) transfer	9.3.5	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.9	Group addressed MPDU transfer	9.3.6	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.10	MAC-level acknowledgment	9.3.2.3, 9.3.2.9	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.1.11	Duplicate detection and recovery	9.3.2.11	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.2	Enhanced DCF (EDCA)			

B.4.26.1 DMG MAC features *(continued)*

Item	Protocol capability	References	Status	Support
*DMG-M7.4.2.1	Support for one transmit queue with AC_BE access category	9.2.4.2, 9.19.2.1	DMG-M7.4:M	Yes ☐ No ☐ N/A ☐
DMG-M7.4.2.2	Support for four transmit queues with a separate channel access entity associated with each	9.2.4.2, 9.19.2.1	DMG-M7.4.2.1:O	Yes ☐ No ☐ N/A ☐
DMG-M7.4.2.3	AC_BE access category and differentiated channel access	9.19.2.2, 9.19.2.3, 9.19.2.5	DMG-M7.4.2.1:M	Yes ☐ No ☐ N/A ☐
DMG-M7.5	Pseudo-static allocation			
DMG-M7.5.1	Scheduling of pseudo-static allocation	9.33.6.2, 8.4.2.115, 8.4.2.143, 9.33.6.5, 10.4.13.2	DMG-M7.3.1:O	Yes ☐ No ☐ N/A ☐
DMG-M7.5.2	Operation within pseudo-static allocation	9.33.6.2, 9.33.6.4, 8.4.2.141, 8.4.2.143	CF25 AND (CF1 OR CF2.1 OR CF2.4.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M7.6	Guard time	9.33.6.5	DMG-M7.3.1:M	Yes ☐ No ☐ N/A ☐
DMG-M7.7	DMG protected period			
*DMG-M7.7.1	Establishment of DMG protected period with RTS at source DMG STA	9.33.6.6	DMG-M7.3.1:O	Yes ☐ No ☐ N/A ☐
*DMG-M7.7.2	Acceptance to establish DMG protected period with DMG CTS at destination DMG STA	9.33.6.6	DMG-M7.3.1:M	Yes ☐ No ☐ N/A ☐
DMG-M7.7.3	Transmission of DMG DTS at destination DMG STA	9.33.6.6	DMG-M7.7.2:O	Yes ☐ No ☐ N/A ☐
DMG-M7.7.4	Reception of DMG DTS at source DMG STA	9.33.6.6	DMG-M7.7.1:M	Yes ☐ No ☐ N/A ☐
DMG-M7.8	Service period recovery	9.33.6.7	DMG-M7.3.1&(CF1 OR CF2.4.1):O	Yes ☐ No ☐ N/A ☐
DMG-M7.9	Dynamic allocation of service period	9.33.7		
DMG-M7.9.1	Polling period (PP)	9.33.7.2, 8.4.2.142		
DMG-M7.9.1.1	Transmission of Poll	8.3.1.11	CF25 AND (CF1 OR CF2.4.1):O	Yes ☐ No ☐ N/A ☐
DMG-M7.9.1.2	Reception of Poll	8.3.1.11	CF25 AND (CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M7.9.1.3	Transmission of SPR	8.3.1.12	CF25 AND (CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐

B.4.26.1 DMG MAC features *(continued)*

Item	Protocol capability	References	Status	Support
DMG-M7.9.1.4	Reception of SPR	8.3.1.12	CF25 AND (CF1 OR CF2.4.1):M	Yes ☐ No ☐ N/A ☐
DMG-M7.9.2	Grant period (GP)	9.33.7.3		
DMG-M7.9.2.1	Transmission of Grant	8.3.1.13	CF25 AND (CF1 OR CF2.4.1):O	Yes ☐ No ☐ N/A ☐
DMG-M7.9.2.2	Reception of Grant	8.3.1.13	CF25 AND (CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M7.10	Dynamic truncation of service period	9.33.8		
DMG-M7.10.1	Transmission of CF-End	8.3.1.16	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M7.10.2	Reception of CF-End	8.3.1.16	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M7.11	Dynamic extension of service period	9.33.9		
DMG-M7.11.1	Transmission of SPR	8.3.1.12	CF25 AND (CF2.1 OR CF2.4.2):O	Yes ☐ No ☐ N/A ☐
DMG-M7.11.2	Reception of SPR	8.3.1.12	CF25 AND (CF1 OR CF2.4.1):M	Yes ☐ No ☐ N/A ☐
DMG-M7.11.3	Transmission of Grant	8.3.1.13	CF25 AND (CF1 OR CF2.4.1):O	Yes ☐ No ☐ N/A ☐
DMG-M7.11.4	Reception of Grant	8.3.1.13	CF25 AND (CF2.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M7.12	Isochronous and Asynchronous TS support			
DMG-M7.12.1	Isochronous operation	10.4.13.2, 8.4.2.141, 8.4.2.143	DMG-M7.3.1 AND (CF1 OR CF2.1 OR CF2.4.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M7.12.2	Asynchronous operation	10.4.13.3, 8.4.2.141, 8.4.2.143, 8.3.1.12	DMG-M7.3.1 AND (CF1 OR CF2.1 OR CF2.4.1 OR CF2.4.2):M	Yes ☐ No ☐ N/A ☐
DMG-M8	PCP/AP clustering			
DMG-M8.1	S-AP in centralized PCP/AP cluster	9.34	CF25:O	Yes ☐ No ☐ N/A ☐

B.4.26.1 DMG MAC features *(continued)*

Item	Protocol capability	References	Status	Support
DMG-M8.2	Except when centralized PCP/AP clusters on all channels supported by the PCP/AP in the operating class, join a centralized PCP/AP cluster or cease activity on channel	9.34.2.2	CF25 AND (CF1 OR CF2.4.1) AND NOT DMG-M8.1:M	Yes ☐ No ☐ N/A ☐
DMG-M8.3	Other PCP/AP clustering	9.34	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M9	DMG beamforming			
DMG-M9.1	Sector level sweep	9.35.2, 9.35.6.2	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M9.2	Beamforming in BTI	9.35.4	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M9.3	Beamforming in A-BFT	9.35.5	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M9.4	BRP setup	9.35.3.2	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M9.5	MID	9.35.6.3.3	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M9.6	BC	9.35.6.3.4	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M9.7	BRP			
*DMG-M9.7.1	BRP with BS-FBCK	9.35.3, 9.35.6.4	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M9.7.2	BRP with channel measurement	9.35.3, 9.35.6.4	DMG-M9.7.1:O	Yes ☐ No ☐ N/A ☐
DMG-M9.8	Beam tracking	9.35.7	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M10	DMG Block ACK with flow control	9.36, 8.4.2.137.2	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M11	DMG link adaptation	9.37	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M12	DMG dynamic tone pairing (DTP)	9.38, 8.4.2.137.2	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M13	Timing synchronization function (TSF) in a PBSS			
DMG-M13.1	Timing in a PBSS network	10.1.2.1, 10.1.5	CF2.4.1&CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M13.2	PBSS initialization	10.1.4	CF2.4.1&CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M14	Power management			
DMG-M14.1	STA power management without wakeup schedule	10.2.5.2.2, 10.2.5.2.4	CF25:M	Yes ☐ No ☐ N/A ☐

B.4.26.1 DMG MAC features *(continued)*

Item	Protocol capability	References	Status	Support
DMG-M14.2	STA power management with wakeup schedule	10.2.5.2.3, 10.2.5.2.4, 8.4.2.140	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M14.3	PCP power management	10.2.5.3, 8.4.2.140	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M15	Authentication and association			
DMG-M15.1	Association state	10.3.1	M	Yes ☐ No ☐
DMG-M15.2	STA association procedure	10.3.3.2	CF2.1 & CF25:M CF2.4.2 & CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M15.3	PCP/AP association procedure	10.3.3.3	CF1 & CF25:M CF2.4.1 & CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M15.4	Communicating PBSS information	10.3.5	(CF2.4.1 OR CF2.4.2) & CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M16	DMG beamformed link and BSS maintenance			
DMG-M16.1	Beamformed link maintenance			
*DMG-M16.1.1	Negotiation of dot11BeamLinkMaintenanceTime timer	8.4a.6	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M16.1.2	Beamformed link maintenance procedure	10.28.1	DMG-M16.1.1:O	Yes ☐ No ☐ N/A ☐
DMG-M16.2	PCP handover	10.28.2	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M17	DMG BSS Peer and Service Discovery	10.29	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M18	Changing DMG BSS parameters	10.30	CF25:O	Yes ☐ No ☐ N/A ☐
*DMG-M19	Spatial sharing and interference mitigation	10.31	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M20	DMG Coexistence with other DMG systems	10.34	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-M21	Traffic specification (TSPEC and DMG TSPEC) and associated frame formats	8.5.3	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M22	DMG frame formats			
DMG-M22.1	DMG Action field	8.5.20.1	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M22.2	Announce frame	8.5.22.2	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M22.3	Power Save Configuration	8.5.20.2, 8.5.20.3	CF25:M	Yes ☐ No ☐ N/A ☐

B.4.26.1 DMG MAC features *(continued)*

Item	Protocol capability	References	Status	Support
DMG-M22.4	Information Request/Response	8.5.20.4, 8.5.20.5	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M22.5	BRP	8.5.22.3	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-M22.6	Handover	8.5.20.6, 8.5.20.7	DMG-M16.2:M	Yes ☐ No ☐ N/A ☐
DMG-M22.7	DTP	8.5.20.8, 8.5.20.9	DMG-M12:M	Yes ☐ No ☐ N/A ☐
DMG-M22.8	DMG relay	8.5.20.10 – 8.5.20.24	DMG-M23:M	Yes ☐ No ☐ N/A ☐
DMG-M23	DMG relay	9.39, 10.35	CF25:O	Yes ☐ No ☐ N/A ☐

B.4.26.2 DMG PHY features

Item	Protocol capability	References	Status	Support
	Are the following PHY protocol features supported?			
DMG-P1	PHY operating modes			
DMG-P1.1	Operation according to Clause 21	21	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-P2	PLCP frame format			
*DMG-P2.1	Control PHY PLCP format	21.4	CF25:M	Yes ☐ No ☐ N/A ☐
*DMG-P2.2	SC PHY PLCP format	21.6	CF25:M	Yes ☐ No ☐ N/A ☐
*DMG-P2.3	OFDM PHY PLCP format	21.5	CF25:O	Yes ☐ No ☐ N/A ☐
*DMG-P2.4	Low-power SC PHY PLCP format	21.7	CF25:O	Yes ☐ No ☐ N/A ☐
DMG-P2.5	Modulation and coding schemes (MCS)			
DMG-P2.5.1	MCS 0 of control PHY		DMG-P2.1:M	Yes ☐ No ☐ N/A ☐
DMG-P2.5.2	MCS 1-12 of SC PHY			
DMG-P2.5.2.1	MCS 1-4		DMG-P2.2:M	Yes ☐ No ☐ N/A ☐
DMG-P2.5.2.2	MCS 5-12		DMG-P2.2:O	Yes ☐ No ☐ N/A ☐
DMG-P2.5.3	MCS 13-24 of OFDM PHY			

B.4.26.2 DMG PHY features *(continued)*

Item	Protocol capability	References	Status	Support
DMG-P2.5.3.1	MCS 13-17		DMG-P2.3:M	Yes ☐ No ☐ N/A ☐
DMG-P2.5.3.2	MCS 18-24		DMG-P2.3:O	Yes ☐ No ☐ N/A ☐
DMG-P2.5.4	MCS 25-31 of low-power SC PHY		DMG-P2.4:M	Yes ☐ No ☐ N/A ☐
DMG-P2.6	Common preamble format	21.3.6	CF25:M	Yes ☐ No ☐ N/A ☐
DMG-P2.7	Use of LDPC codes	21.3.8	CF25:M	Yes ☐ No ☐ N/A ☐

Annex C

(normative)

ASN.1 encoding of the MAC and PHY MIB

C.3 MIB Detail

Insert the following comment in numeric order in the "dot11smt OBJECT IDENTIFIER" list in the "Major sections" part of C.3:

```
-- Added for 802.11ad
-- dot11DMGSTAConfigTable            ::= { dot11smt 27 }
```

Insert the following comment at the end of the "MAC GROUPS" list in the "Major sections" of C.3:

```
-- Added for 802.11ad
-- dot11DMGOperationTable            ::= { dot11mac 8 }
-- dot11DMGCountersTable             ::= { dot11mac 9 }
```

Insert the following comment at the end of the "PHY GROUPS" list in the "Major sections" of C.3:

```
-- Added for 802.11ad
-- dot11PHYDMGTable                  ::= { dot11phy 19 }
-- dot11DMGBeamformingConfigTable    ::= { dot11phy 22 }
```

Change the end of the "Dot11StationConfigEntry" of the "dot11StationConfig TABLE" in C.3 as follows:

```
dot11RobustAVStreamingImplemented    TruthValue,
dot11MultibandImplemented            TruthValue
}
```

Change the definition of "dot11BeaconPeriod" in the "Dot11StationConfig TABLE" in C.3 as follows:

```
dot11BeaconPeriod OBJECT-TYPE
    SYNTAX Unsigned32 (1..65535)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by an external management entity.
       Changes take effect for the next MLME-START.request primitive.

       For non-DMG STAs, Tthis attribute specifies the number of TUs that
       a station uses for scheduling Beacon transmissions. For DMG STAs,
       this attribute specifies the number of TUs that a station uses for
       scheduling BTI and/or ATI in the beacon interval. This value is
```

```
        transmitted in Beacon and Probe Response frames."
    ::= { dot11StationConfigEntry 12 }
```

Insert the following object at the end of the "dot11StationConfig TABLE" element definitions in C.3:

```
dot11MultibandImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        Multiband Support Activated
        This attribute, when true, indicates that the STA
        is capable of operating in multiple bands.
        Otherwise, it is false. The default value
        of this attribute is false."
    DEFVAL { false }
    ::= {  dot11StationConfigEntry 144 }
```

Change the definitions of "dot11BeaconRprtPhyType," "dot11FrameRprtPhyType," and "dot11RMNeighborReportPhyType" in C.3 as follows:

```
dot11BeaconRprtPhyType OBJECT-TYPE
    SYNTAX INTEGER {
        fhss(1),
        dsss(2),
        irbaseband(3),
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7),
        dmg(8) }
    UNITS "dot11PHYType"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the SME when a measurement report is completed.

        This attribute indicates the PHY Type for this row of Beacon
        Report."
    ::= { dot11BeaconReportEntry 9 }

dot11FrameRprtPhyType OBJECT-TYPE
    SYNTAX INTEGER {
        fhss(1),
        dsss(2),
        irbaseband(3),
```

```
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7),
        dmg(8) }
    UNITS "dot11PHYType"
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the SME when a measurement report is completed.

        This attribute indicates the PHY used for frame reception in this
        row of the frame report."
    ::= { dot11FrameReportEntry 10 }

dot11RMNeighborReportPhyType OBJECT-TYPE
    SYNTAX INTEGER {
        fhss(1),
        dsss(2),
        irbaseband(3),
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7),
        dmg(8) }
    UNITS "dot11PHYType"
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the SME when a measurement report is completed.

        This attribute indicates the PHY Type of the neighbor AP
        identified by this BSSID."
    ::= { dot11RMNeighborReportEntry 15 }
```

Change the definition of "dot11PhyType" in the "dot11PhyOperation TABLE" in C.3 as follows:

```
dot11PHYType OBJECT-TYPE
    SYNTAX INTEGER {
        fhss(1),
        dsss(2),
        irbaseband(3),
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7),
        dmg(8) }
    MAX-ACCESS read-only
```

```
    STATUS current
    DESCRIPTION
       "This is a status variable.
       It is written by the PHY.

       This is an 8-bit integer value that identifies the PHY type
       supported by the attached PLCP and PMD. Currently defined values
       and their corresponding PHY types are:
       FHSS 2.4 GHz = 01, DSSS 2.4 GHz = 02, IR Baseband = 03,
       OFDM = 04, HRDSSS = 05, ERP = 06, HT = 07, DMG = 08"
    ::= { dot11PhyOperationEntry 1 }
```

Change the definition of "dot11EDCATableTXOPLimit" in the "SMT EDCA Config TABLE" in C.3 as follows:

```
dot11EDCATableTXOPLimit OBJECT-TYPE
    SYNTAX Unsigned32 (0..65535)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the MAC upon receiving an EDCA Parameter Set in a
       Beacon frame.
       Changes take effect as soon as practical in the implementation.

       This attribute specifies the maximum number of microseconds of an
       EDCA TXOP for a given AC. The default value for this attribute is
       1) 0 for all PHYs, if dot11EDCATableIndex is 1 or 2; this implies
       that the sender can send one MSDU in an EDCA TXOP,
       2) 3008 microseconds for Clause 18, Clause 21, and Clause 19 PHY
       and 6016 microseconds for Clause 17 PHY, if dot11EDCATableIndex is
       3,
       3) 1504 microseconds for Clause 18, Clause 21, and Clause 19) PHY
       and 3264 microseconds for Clause 17 PHY, if dot11EDCATableIndex is
       4."
    ::= { dot11EDCAEntry 5 }
```

Insert the following table ("dot11DMGSTAConfigTable") after the "dot11HTStationConfig TABLE" in C.3:

```
-- ********************************************************************
-- * dot11DMGSTAConfigTable TABLE
-- ********************************************************************

dot11DMGSTAConfigTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11DMGSTAConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
       "This is a table management object.
```



```
        The dot11DMGSTAConfig Table"
    ::= { dot11smt 27 }

dot11DMGSTAConfigEntry OBJECT-TYPE
    SYNTAX Dot11DMGSTAConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
       "This is an entry in the dot11DMGSTAConfig Table.
       ifIndex - Each IEEE 802.11 interface is represented by an
       ifEntry.  Interface tables in this MIB module are indexed
       by ifIndex."
    INDEX { ifIndex }
    ::= { dot11DMGSTAConfigTable 1 }

Dot11DMGSTAConfigEntry ::=
    SEQUENCE {
       dot11DMGOptionImplemented          TruthValue,
       dot11RelayActivated                TruthValue,
       dot11REDSActivated                 TruthValue,
       dot11RDSActivated                  TruthValue,
       dot11MultipleMACActivated          TruthValue,
       dot11ClusteringActivated           TruthValue
    }

dot11DMGOptionImplemented OBJECT-TYPE
       SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       DMG Capable Object
       This attribute, when true, indicates the STA is DMG
       capable.  This attribute, when false, indicates the STA is not
       DMG capable.  The default value of this attribute is false."
    DEFVAL { false }
    ::= { dot11DMGSTAConfigEntry 1 }

dot11RelayActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates the DMG STA is Relay
       capable.  This attribute, when false, indicates the STA is not
```

```
      Relay capable.  The default value of this attribute is false."
    DEFVAL { false }
    ::= { dot11DMGSTAConfigEntry 2 }

dot11REDSActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      This attribute, when true, indicates the DMG STA is capable
      of operating as a REDS. This attribute, when false, indicates
      the STA is not capable of operating as a REDS."
    DEFVAL { false }
    ::= { dot11DMGSTAConfigEntry 3 }

dot11RDSActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      This attribute, when true, indicates the DMG STA is capable
      of operating as a RDS. This attribute, when false, indicates
      the STA is not capable of operating as a RDS."
    DEFVAL { false }
    ::= { dot11DMGSTAConfigEntry 4 }

dot11MultipleMACActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      If dot11MultipleMACActivated is true, the STA is capable of
      managing more than one MAC address."
    DEFVAL { false }
    ::= { dot11DMGSTAConfigEntry 5 }

dot11ClusteringActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
```



```
        "This is a capability variable.
        Its value is determined by device capabilities.

        If dot11ClusteringActivated is true, the STA is capable of
        supporting PCP/AP Clustering."
    DEFVAL { false }
    ::= { dot11DMGSTAConfigEntry 6 }

-- **********************************************************************
-- * End of dot11DMGSTAConfigTable TABLE
-- **********************************************************************
```

Insert the following tables ("dot11 Phy DMG TABLE" and "dot11DMGBeamformingConfig TABLE") after the "dot11 Phy HT TABLE" in C.3:

```
-- **********************************************************************
-- * dot11 Phy DMG TABLE
-- **********************************************************************

dot11PHYDMGTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11PHYDMGEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Entry of attributes for dot11PhyDMGTable. Implemented as a table
        indexed on ifIndex to allow for multiple instances on an Agent."
    ::= { dot11phy 19 }

dot11PHYDMGEntry OBJECT-TYPE
    SYNTAX Dot11PHYDMGEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An entry in the dot11PHYDMGEntry Table. ifIndex - Each IEEE
        802.11 interface is represented by an ifEntry. Interface tables in
        this MIB module are indexed by ifIndex."
    INDEX {ifIndex}
    ::= { dot11PHYDMGTable 1 }

Dot11PHYDMGEntry ::=
    SEQUENCE {
        dot11LowPowerSCPHYImplemented       TruthValue,
        dot11LowPowerSCPHYActivated         TruthValue }

dot11LowPowerSCPHYImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
```

```
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the low power SC PHY is
       implemented."
    DEFVAL { false }
    ::= { dot11PHYDMGEntry 1 }

dot11LowPowerSCPHYActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by an external management entity.
       Changes take effect as soon as practical in the implementation.

       This attribute, when true, indicates that the low power SC PHY is
       activated."
    DEFVAL { false }
    ::= { dot11PHYDMGEntry 2 }

-- ********************************************************************
-- * End of dot11 PHY DMG TABLE
-- ********************************************************************

-- ********************************************************************
-- * dot11DMGBeamformingConfig TABLE
-- ********************************************************************

dot11DMGBeamformingConfigTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11DMGBeamformingConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
       "This is a Table management object.
        The dot11DMGBeamformingConfig Table"
    ::= { dot11phy 22 }

dot11DMGBeamformingConfigEntry OBJECT-TYPE
    SYNTAX Dot11DMGBeamformingConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
       "This is an entry in the dot11DMGBeamformingConfig Table.
       ifIndex - Each IEEE 802.11 interface is represented by an
       ifEntry.  Interface tables in this MIB module are indexed
       by ifIndex."
    INDEX { ifIndex }
    ::= { dot11DMGBeamformingConfigTable 1 }
```



```
Dot11DMGBeamformingConfigEntry ::=
    SEQUENCE {
       dot11MaxBFTime                     Unsigned32,
       dot11BFTXSSTime                    Unsigned32,
       dot11MaximalSectorScan             Unsigned32,
       dot11ABFTRTXSSSwitch               Unsigned32,
       dot11RSSRetryLimit                 Unsigned32,
       dot11RSSBackoff                    Unsigned32,
       dot11BFRetryLimit                  Unsigned32,
       dot11BeamLinkMaintenanceTime       Unsigned32,
       dot11AntennaSwitchingTime          Unsigned32,
       dot11ChanMeasFBCKNtaps             Unsigned32
    }

dot11MaxBFTime OBJECT-TYPE
    SYNTAX Unsigned32 (1..16)
    UNITS "Beacon Interval"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Maximum Beamforming Time (in units of beacon interval)."
    DEFVAL { 4 }
    ::= { dot11DMGBeamformingConfigEntry 1 }

dot11BFTXSSTime OBJECT-TYPE
    SYNTAX Unsigned32 (1..256)
    UNITS "milliseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Timeout until the initiator restarts ISS (in Milliseconds)."
    DEFVAL { 100 }
    ::= { dot11DMGBeamformingConfigEntry 2 }

dot11MaximalSectorScan OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    UNITS "Beacon Interval"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
```

```
       Changes take effect as soon as practical in the implementation.

       Maximal Sector Scan (in units of beacon interval)."
    DEFVAL { 8 }
    ::= { dot11DMGBeamformingConfigEntry 3 }

dot11ABFTRTXSSSwitch OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       A-BFT Transmit Sector Sweep Switch (in units of beacon interval)."
    DEFVAL { 4 }
    ::= { dot11DMGBeamformingConfigEntry 4 }

dot11RSSRetryLimit OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Responder Sector Sweep Retry Limit"
    DEFVAL { 8 }
    ::= { dot11DMGBeamformingConfigEntry 5 }

dot11RSSBackoff OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Responder Sector Sweep Backoff"
    DEFVAL { 8 }
    ::= { dot11DMGBeamformingConfigEntry 6 }

dot11BFRetryLimit OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
```

```
        "This is a control variable.
        It is written by the SME or an external management entity.
        Changes take effect as soon as practical in the implementation.

        Beamforming Retry Limit"
    DEFVAL { 8 }
    ::= { dot11DMGBeamformingConfigEntry 7 }

dot11BeamLinkMaintenanceTime OBJECT-TYPE
    SYNTAX Unsigned32 (0..64000000)
    UNITS "microseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by the MAC or SME.
        Changes take effect as soon as practical in the implementation.

        Beam Link Maintenance Time
        dot11BeamLinkMaintenanceTime = BeamLink_Maintenance_Unit *
        BeamLink_Maintenance_Value. Otherwise, the
        dot11BeamLinkMaintenanceTime is left undefined. An
        undefined value of the dot11BeamLinkMaintenanceTime indicates
        that the STA does not participate in beamformed link maintenance."
    DEFVAL { 0 }
    ::= { dot11DMGBeamformingConfigEntry 8 }

dot11AntennaSwitchingTime OBJECT-TYPE
    SYNTAX Unsigned32 (0..64000000)
    UNITS "microseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable. It is written by the MAC or SME.
        Changes take effect as soon as practical in the implementation."
    DEFVAL { 0 }
::= { dot11DMGBeamformingConfigEntry 9 }

dot11ChanMeasFBCKNtaps OBJECT-TYPE
    SYNTAX Unsigned32 (0..64000000)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable. It is written by the MAC or SME.
        Changes take effect as soon as practical in the implementation.

        Number of channel measurement taps."
    DEFVAL { 0 }
::= { dot11DMGBeamformingConfigEntry 10 }
```

```
-- **********************************************************************
-- * End of dot11DMGBeamformingConfig TABLE
-- **********************************************************************
```

Insert the following tables ("dot11DMGOperation TABLE" and "dot11DMGCounters TABLE") after the "dot11ResourceInfo TABLE" in C.3, i:

```
-- **********************************************************************
-- * dot11DMGOperation TABLE
-- **********************************************************************

dot11DMGOperationTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11DMGOperationEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
       "This is a Table management object.
        The dot11DMGOperation Table"
    ::= { dot11mac 8 }

dot11DMGOperationEntry OBJECT-TYPE
    SYNTAX Dot11DMGOperationEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
       "This is an entry in the dot11DMGBeamformingConfig Table.
       ifIndex - Each IEEE 802.11 interface is represented by an
       ifEntry.  Interface tables in this MIB module are indexed
       by ifIndex."
    INDEX { ifIndex }
    ::= { dot11DMGOperationTable 1 }

Dot11DMGOperationEntry ::=
    SEQUENCE {
       dot11MaxLostBeacons                  Unsigned32,
       dot11MinBHIDuration                  Unsigned32,
       dot11PSRequestSuspensionInterval     Unsigned32,
       dot11AssocRespConfirmTime            Unsigned32,
       dot11BroadcastSTAInfoDuration        Unsigned32,
       dot11NbrOfChangeBeacons              Unsigned32,
       dot11ImplicitHandoverLostBeacons     Unsigned32,
       dot11MinPPDuration                   Unsigned32,
       dot11SPIdleTimeout                   Unsigned32,
       dot11QABTimeout                      Unsigned32,
       dot11ClusterEnableTime               Unsigned32,
       dot11PNWarningThreshold              Unsigned32,
       dot11BeaconSPDuration                Unsigned32,
       dot11PNExhaustionThreshold           Unsigned32,
       dot11MaxNumberOfClusteringMonitoringPeriods Unsigned32,
       dot11DMGEcssPolicyDetailUpdateDurationMax   Unsigned32,
```



```
      dot11DMGEcssClusterReportDurationMin        Unsigned32,
      dot11DMGProbeDelay                 Unsigned32
    }

dot11MaxLostBeacons OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
      "This is a control variable.
      It is written by the SME or an external management entity.
      Changes take effect as soon as practical in the implementation.

      Maximum Number of Lost Beacons"
    DEFVAL { 4 }
    ::= { dot11DMGOperationEntry 1 }

dot11MinBHIDuration OBJECT-TYPE
    SYNTAX Unsigned32 (1..100000)
    UNITS "microseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
      "This is a control variable.
      It is written by the SME or an external management entity.
      Changes take effect as soon as practical in the implementation.

      Minimum Beacon Header Interval duration (in microseconds)"
    DEFVAL { 5000 }
    ::= { dot11DMGOperationEntry 2 }

dot11PSRequestSuspensionInterval OBJECT-TYPE
    SYNTAX Unsigned32 (1..64)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
      "This is a control variable.
      It is written by the SME or an external management entity.
      Changes take effect as soon as practical in the implementation.

      PS Request Suspension Interval (in units of beacon interval)"
    DEFVAL { 8 }
    ::= { dot11DMGOperationEntry 3 }

dot11AssocRespConfirmTime OBJECT-TYPE
    SYNTAX Unsigned32 (1..8000)
    UNITS "milliseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
```

```
        "This is a control variable.
        It is written by the SME or an external management entity.
        Changes take effect as soon as practical in the implementation.

        Association Response Confirmation Time (in Milliseconds)."
    DEFVAL { 1000 }
    ::= { dot11DMGOperationEntry 4 }

dot11BroadcastSTAInfoDuration OBJECT-TYPE
    SYNTAX Unsigned32 (1..512)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by the SME or an external management entity.
        Changes take effect as soon as practical in the implementation.

        Broadcast STA Information Duration (in units of beacon interval)."
    DEFVAL { 32 }
    ::= { dot11DMGOperationEntry 5 }

dot11NbrOfChangeBeacons OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by the SME or an external management entity.
        Changes take effect as soon as practical in the implementation.

        Number of Change Beacons (in units of beacon interval)."
    DEFVAL { 4 }
    ::= { dot11DMGOperationEntry 6 }

dot11ImplicitHandoverLostBeacons OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by the SME or an external management entity.
        Changes take effect as soon as practical in the implementation.

        Implicit Handover Lost Beacons (in units of beacon interval)."
    DEFVAL { 8 }
    ::= { dot11DMGOperationEntry 7 }

dot11MinPPDuration OBJECT-TYPE
    SYNTAX Unsigned32 (1..100000)
    UNITS "microseconds"
```



```
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       The MinPPDuration subfield indicates the minimum duration of the
       PP and GP as part of the dynamic allocation of service period
       mechanism (in microseconds)."
    DEFVAL { 200 }
    ::= { dot11DMGOperationEntry 8 }

dot11SPIdleTimeout OBJECT-TYPE
    SYNTAX Unsigned32 (1..100000)
    UNITS "microseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       The SPIdleTimeout subfield indicates time during which a STA
       expects to receive a frame from its partner STA
       (in microseconds)."
    DEFVAL { 200 }
    ::= { dot11DMGOperationEntry 9 }

dot11QABTimeout OBJECT-TYPE
    SYNTAX Unsigned32 (1..64000)
    UNITS "milliseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Quiet Adjacent BSS Operation Timeout (in milliseconds)"
    DEFVAL { 1000 }
    ::= { dot11DMGOperationEntry 10 }

dot11ClusterEnableTime OBJECT-TYPE
    SYNTAX Unsigned32 (1..32)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
```

```
      Changes take effect as soon as practical in the implementation.

      Frequency with which a non-PCP/non-AP is allowed to retransmit a
      cluster request element to its PCP/AP (in units of beacon
      interval)."
   DEFVAL { 8 }
   ::= { dot11DMGOperationEntry 11 }

dot11PNWarningThreshold OBJECT-TYPE
   SYNTAX Unsigned32 (1..4294967295)
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by the SME or an external management entity.
      Changes take effect as soon as practical in the implementation.

      Threshold used for generating a warning to the MLME about a
      potential PN exhaustion (in units of packet number)."
   DEFVAL { 4294967295 }
   ::= { dot11DMGOperationEntry 12 }

dot11BeaconSPDuration OBJECT-TYPE
   SYNTAX Unsigned32 (1..100000)
   UNITS "microseconds"
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by the SME or an external management entity.
      Changes take effect as soon as practical in the implementation.

      The size of a Beacon SP used for PCP/AP clustering (in
      microseconds)."
   DEFVAL { 600 }
   ::= { dot11DMGOperationEntry 13 }

dot11PNExhaustionThreshold OBJECT-TYPE
   SYNTAX Unsigned32 (1..4294967295)
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by the SME or an external management entity.
      Changes take effect as soon as practical in the implementation.

      Threshold used for indicating an imminent PN exhaustion (in units
      of packet number)."
   DEFVAL { 4294967295 }
   ::= { dot11DMGOperationEntry 14 }
```



```
dot11MaxNumberOfClusteringMonitoringPeriods OBJECT-TYPE
    SYNTAX Unsigned32 (1..16)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Number of clustering monitoring periods until determination of the
       loss of an S-PCP/S-AP."
    DEFVAL { 3 }
    ::= { dot11DMGOperationEntry 15 }

dot11DMGEcssPolicyDetailUpdateDurationMax OBJECT-TYPE
    SYNTAX Unsigned32 (10..30000)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Maximum duration in units of TU between attempts by a member PCP/
       AP in a centralized PCP/AP cluster to receive a DMG Beacon frame
       from the S-AP of the centralized PCP/AP cluster"
    DEFVAL { 1000 }
    ::= { dot11DMGOperationEntry 16 }

dot11DMGEcssClusterReportDurationMin OBJECT-TYPE
    SYNTAX Unsigned32 (100..36000000)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by the SME or an external management entity.
       Changes take effect as soon as practical in the implementation.

       Minimum duration in units of TU between the transmission of
       interference reports by a member PCP/AP in a centralized PCP/AP
       cluster to the S-AP of the centralized PCP/AP cluster"
    DEFVAL { 1000 }
    ::= { dot11DMGOperationEntry 17 }

dot11DMGProbeDelay OBJECT-TYPE
    SYNTAX Unsigned32 (0..10000)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
```

```
      "This is a control variable.
      It is written by the SME or an external management entity.
      Changes take effect as soon as practical in the implementation.

      Delay, in microseconds, to be used by a DMG STA prior to
      transmitting a Probe frame."
    DEFVAL { 0 }
    ::= { dot11DMGOperationEntry 18 }

-- **********************************************************************
-- * End of dot11DMGOperation TABLE
-- **********************************************************************

-- **********************************************************************
-- * dot11DMGCounters TABLE
-- **********************************************************************

dot11DMGCountersTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11DMGCountersEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This is a Table management object.
        The dot11DMGCountersTable Table"
    ::= { dot11mac 9 }

dot11DMGCountersEntry OBJECT-TYPE
    SYNTAX Dot11DMGCountersEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
      "This is an entry in the dot11DMGCountersTable Table.
      ifIndex - Each IEEE 802.11 interface is represented by an
      ifEntry.  Interface tables in this MIB module are indexed
      by ifIndex."
    INDEX { ifIndex }
    ::= { dot11DMGCountersTable 1 }

Dot11DMGCountersEntry ::=
    SEQUENCE {
      dot11RSNAStatsGCMPReplays             Unsigned32,
      dot11RSNAStatsRobustMgmtGCMPReplays   Unsigned32
    }

dot11RSNAStatsGCMPReplays OBJECT-TYPE
    SYNTAX Unsigned32 (0..4294967295)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
      "This is a status variable.
```



```
       It is written by the SME or an external management entity.

       Counter for the number of times an MPDU of type Data is discarded
       due to PN violation."
    DEFVAL { 0 }
    ::= { dot11DMGCountersEntry 1 }

dot11RSNAStatsRobustMgmtGCMPReplays OBJECT-TYPE
    SYNTAX Unsigned32 (0..4294967295)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a status variable.
       It is written by the SME or an external management entity.

       Counter for the number of times an MPDU of type Management is
       discarded due to PN violation."
    DEFVAL { 0 }
    ::= { dot11DMGCountersEntry 2 }

-- ******************************************************************
-- * End of dot11DMGCounters TABLE
-- ******************************************************************
```

Insert the following groups ("dot11DMGComplianceGroup," "dot11DMGOperationsComplianceGroup," "dot11DMGBeamformingComplianceGroup," and "dot11DMGCountersComplianceGroup") into the "Groups - units of conformance" section after "dot11PasswordAuthComplianceGroup" (dot11Groups 62) in C.3:

```
dot11DMGComplianceGroup OBJECT-GROUP
    OBJECTS {dot11MultibandImplemented, dot11DMGOptionImplemented,
       dot11RelayActivated, dot11REDSActivated, dot11RDSActivated,
       dot11RSNAProtectedManagementFramesActivated,
       dot11MultipleMACActivated,
       dot11ClusteringActivated,
       dot11LowPowerSCPHYImplemented,
       dot11LowPowerSCPHYActivated
       }
    STATUS current
    DESCRIPTION
       "Attributes that configure the DMG Group for IEEE 802.11."
    ::= { dot11Groups 64 }

dot11DMGOperationsComplianceGroup OBJECT-GROUP
    OBJECTS {dot11MaxLostBeacons, dot11MinBHIDuration,
       dot11PSRequestSuspensionInterval, dot11AssocRespConfirmTime,
       dot11BroadcastSTAInfoDuration, dot11NbrOfChangeBeacons,
       dot11ImplicitHandoverLostBeacons, dot11MinPPDuration,
       dot11SPIdleTimeout, dot11QABTimeout, dot11ClusterEnableTime,
```

```
        dot11PNWarningThreshold, dot11BeaconSPDuration,
        dot11PNExhaustionThreshold,
        dot11MaxNumberOfClusteringMonitoringPeriods,
        dot11DMGEcssPolicyDetailUpdateDurationMax,
        dot11DMGEcssClusterReportDurationMin,
        dot11DMGProbeDelay
        }
    STATUS current
    DESCRIPTION
        "Attributes that configure the DMG Operation for IEEE 802.11."
    ::= { dot11Groups 65 }

dot11DMGBeamformingComplianceGroup OBJECT-GROUP
    OBJECTS {dot11MaxBFTime, dot11BFTXSSTime, dot11MaximalSectorScan,
        dot11ABFTRTXSSSwitch, dot11RSSRetryLimit, dot11RSSBackoff,
        dot11BFRetryLimit, dot11BFTXSSTime, dot11BeamLinkMaintenanceTime
        }
    STATUS current
    DESCRIPTION
        "Attributes that configure the DMG Beamforming functionality
        for IEEE 802.11."
    ::= { dot11Groups 66 }

dot11DMGCountersComplianceGroup OBJECT-GROUP
    OBJECTS {dot11RSNAStatsGCMPReplays,
        dot11RSNAStatsRobustMgmtGCMPReplays
        }
    STATUS current
    DESCRIPTION
        "Attributes that are used as counters for a DMG capable Station
        for IEEE 802.11."
    ::= { dot11Groups 67 }
```

Insert the following groups after "GROUP dot11TransmitBeamformingGroup" in the "dot11Compliance" module of the "Compliance Statements" section of C.3:

```
GROUP dot11DMGComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when the object
        dot11PHYType has the value of DMG.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup"
```



```
GROUP dot11DMGOperationsComplianceGroup
    DESCRIPTION
       "DMG Operations Compliance Group"

GROUP dot11DMGBeamformingComplianceGroup
    DESCRIPTION
       "DMG Beamforming Compliance Group"

GROUP dot11DMGCountersComplianceGroup
    DESCRIPTION
       "DMG Counters Compliance Group."
```

In the "dot11Compliance" module of the "Compliance Statements" section of C.3, insert the following text:

```
    dot11DMGComplianceGroup
```

as the last line for the description of mutually exclusive groups for the following groups:

```
dot11PhyDSSSComplianceGroup
dot11PhyIRComplianceGroup
dot11PhyFHSSComplianceGroup2
dot11PhyOFDMComplianceGroup3
dot11PhyHRDSSSComplianceGroup
dot11PhyERPComplianceGroup
dot11PhyHTComplianceGroup
```

Insert the following compliance statement ("Compliance Statements – DMG") after the "Compliance Statements – AVS" section in C.3:

```
-- ******************************************************************
-- * Compliance Statements - DMG
-- ******************************************************************

dot11DMGCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
       "The compliance statement for SNMPv2 entities that implement the
       IEEE 802.11 MIB for DMG operation."
    MODULE -- this module
    MANDATORY-GROUPS {
       dot11DMGComplianceGroup,
       dot11DMGOperationsComplianceGroup,
       dot11DMGBeamformingComplianceGroup,
       dot11DMGCountersComplianceGroup }
    ::= { dot11Compliances 9 }

-- ******************************************************************
-- * End of 802.11 MIB
-- ******************************************************************
```

END

Annex E

(normative)

Country elements and operating classes

E.1 Country information and operating classes

Insert the following row in numeric order into Table E-1, and update the last Reserved row accordingly:

Table E-1—Operating classes in the United States

Operating class	Global operating class (see Table E-4)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Behavior limits set
34	180	56.16	2160	1, 2, 3	—

Insert the following row in numeric order into Table E-2, and update the Reserved row accordingly:

Table E-2—Operating classes in Europe

Operating class	Global operating class (see Table E-4)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Behavior limits set
18	180	56.16	2160	1, 2, 3, 4	—

Insert the following row in numeric order into Table E-3, and update the Reserved row accordingly:

Table E-3—Operating classes in Japan

Operating class	Global operating class (see Table E-4)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Behavior limits set
59	180	56.16	2160	1, 2, 3, 4	—

Change Table E-4 as follows (note that the entire table is not shown here):

Table E-4—Global operating classes

Operating class	Nonglobal operating class(es)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Behavior limits set
128–179~~191~~	—	Reserved	Reserved	Reserved	Reserved
180	E-1-34, E-2-18, E-3-59	56.16	2160	1, 2, 3, 4	—
181–191	—	Reserved	Reserved	Reserved	Reserved

Annex H

(normative)

Usage of Ethertype 89-0d

Change Table H-1 as follows:

Table H-1—Payload Type field values

Protocol name	Payload type	Subclause
Remote Request/Response	1	12.10.3
TDLS	2	10.22.2
FST	3	10.32.5
Reserved	~~3~~4–255	

Annex L

(informative)

Change the annex title as follows:

Examples of encoding a frame for OFDM PHYs and DMG PHYs

Insert the following subclauses, L.4 to L.8.4.6 (including Figure L-1 to Figure L-17 and Table L-43 to Table L-46), after L.3.6:

L.4 DMG example data vectors

Subclauses L.5 to L.8 contain example data vectors for the DMG PHY (see Clause 21). All of the example data text files referenced by these subclauses are contained in a single ZIP file, DMGEncodingExamples.zip, that is embedded in document 11-12/0751r0 (see https://mentor.ieee.org/802.11/dcn/12/11-12-0751-00-00ad-dmg-encoding-examples.docx).

For each described node there is a cross-reference in this annex that is of the form

Reference: <**filename.txt**>

where the named text file is one of the files in the ZIP file embedded in 11-12/0751r0.

Depending on the node being illustrated, the text file may represent bit data, symbol data, or sample data:

- For bit data, the text file contains a time ordered sequence of 1 and 0 characters, separated by spaces and without any carriage control characters.
- For symbol data, the text file contains a time ordered sequence of signed integers, separated by spaces and without any carriage control characters.
- For sample data, the text file contains a time ordered sequence of complex values, formatted as ±<real>±<imag>j, separated by spaces and without any carriage control characters.

When referencing specific bits, symbols, or samples in the files, they are considered to be numbered starting from 1.

This formatting of the text files has been chosen to facilitate import into other tools. For example, the files can be read using the MATLAB `dlmread('filename')` command.

For CPHY, SC PHY and low-power (LP) SC PHY modulation samples, no spectrum shaping has been applied to the data because the implementation of spectrum shaping is not defined in this standard. For OFDM PHY modulation samples, no symbol shaping has been applied to the data because the implementation of OFDM symbol shaping is not defined in this standard.

L.5 DMG Example 1 – CPHY encoding

L.5.1 CPHY preamble

The CPHY preamble Short Training Field (STF) and Channel Equalization Field (CEF) are each constructed from a concatenation of real valued bipolar Golay sequences that is π/2-BPSK modulated.

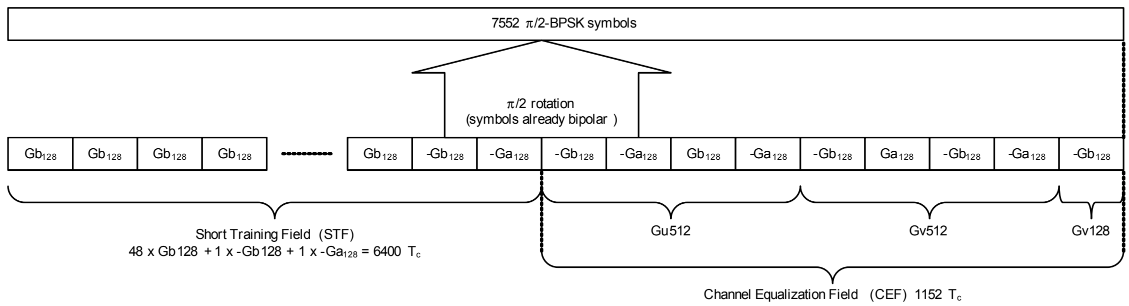


Figure L-1—CPHY preamble expressed in Ga_{128} and Gb_{128} sequences

The CPHY preamble is 7552 samples long.

Reference: **CPHY_Preamble Samples.txt**

L.5.2 CPHY header

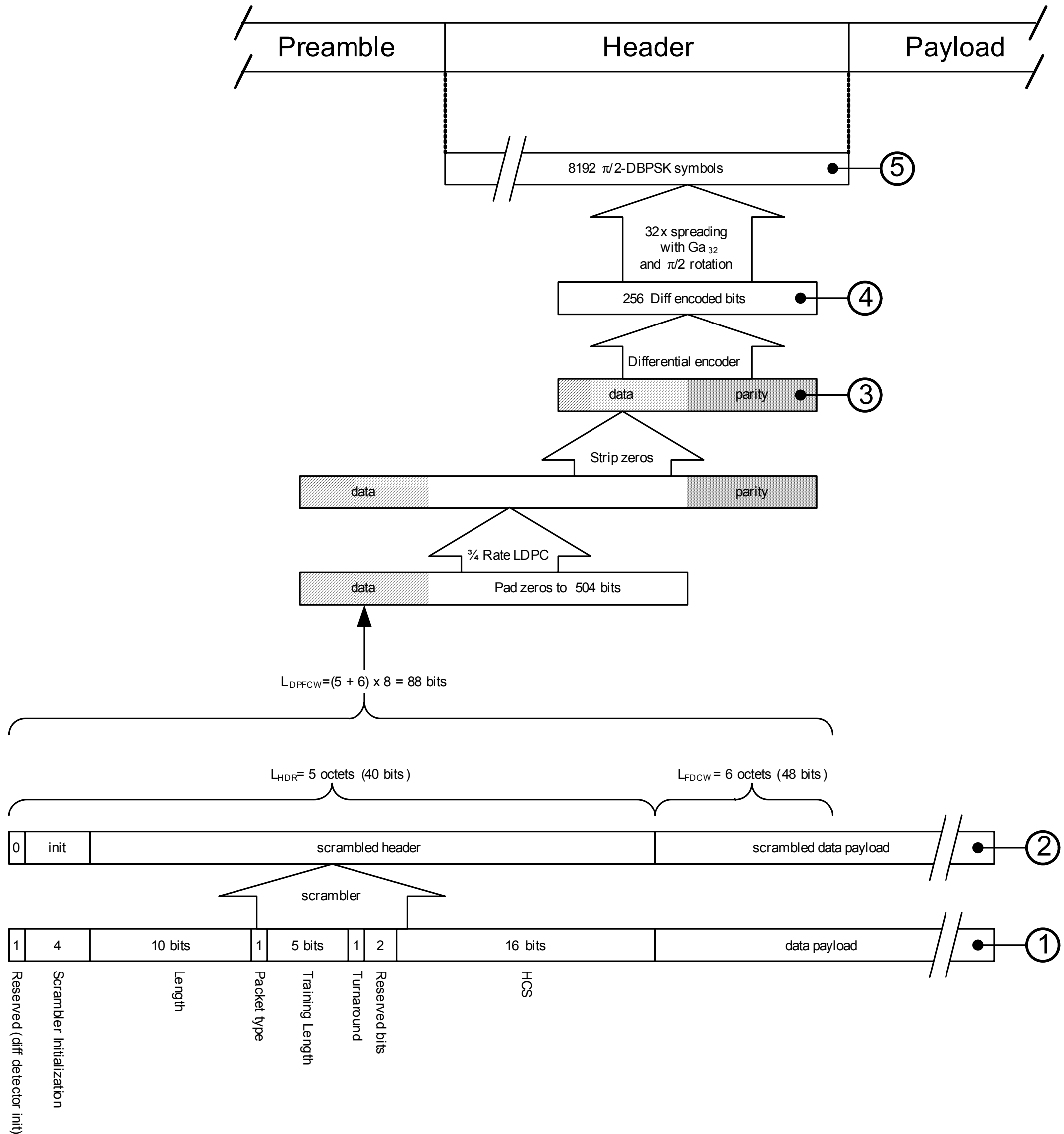


Figure L-2—CPHY header coding and modulation

L.5.2.1 CPHY header and payload bits

Figure L-2 node ①. The 5 octets of header data followed by the payload data. The first 6 octets of the data payload are used to complete the construction of the single LDPC codeword of the CPHY header. For this example, the CPHY header bit fields are set as listed in Table L-43.

Table L-43—CPHY header settings

Field	Value
Scrambler Initialization	2
Length	120
Packet Type	0
Training Length	0
Turnaround	0
Reserved bits	0

The data payload octets are provided by a count, modulo 256, starting at 0. The resulting header and payload sequence is 1000 bits long, of which the first 88 bits are encoded in the header modulation block. For this example, with a payload of 120 octets, $L_{DPFCW} = 88$, $L_{DPCW} = 152$ and $L_{DPLCW} = 152$.

These numbers illustrate that the payload is not simply packed 168 bits at a time into the LDPC encoding, with the last few bits (modulo 168) in the last packet getting disproportionate coding gain. The specified calculation ensures that the excess coding gain is spread evenly across all the packets, so the number of payload bits in each packet varies between approximately 120 and the maximum 168.

Reference: Bits 1 to 88 of the file **CPHY_Header and Payload bits.txt**

L.5.2.2 CPHY scrambled header and payload bits

Figure L-2 node ②. The 5 header plus 6 data = 11 octets after scrambling.

Reference: Bits 1 to 88 of the file **CPHY_Scrambled Header and Payload bits.txt**

L.5.2.3 CPHY LDPC encoded header bits

Figure L-2 node ③. In this example there are 7 LDPC codewords, the first (after zero stripping) produces 88 + 168 = 256 bits, the remaining 6 each produce 152 + 168 = 320 bits, so there is a total of 256 + 6 x 320 = 2176 bits after LDPC encoding, of which the first 256 bits correspond to the LDPC encoded header.

Reference: Bits 1 to 256 of the file **CPHY_LDPC Encoded Header and Payload bits.txt**

L.5.2.4 CPHY differentially encoded header symbols

Figure L-2 node ④. The 256 LDPC encoded header bits are differentially encoded.

Reference: Symbols 1 to 256 of the file **CPHY_Diff Encoded Header and Payload symbols.txt**

L.5.2.5 CPHY header samples

Figure L-2 node ⑤. The 256 differentially encoded bipolar symbol values are spread using the Ga_{32} Golay sequence, then $\pi/2$ rotated to produce 8192 chips at $F_c = 1760$ MHz.

Reference: Samples 1 to 8192 of the file **CPHY_Header and Payload samples.txt**

L.5.3 CPHY payload

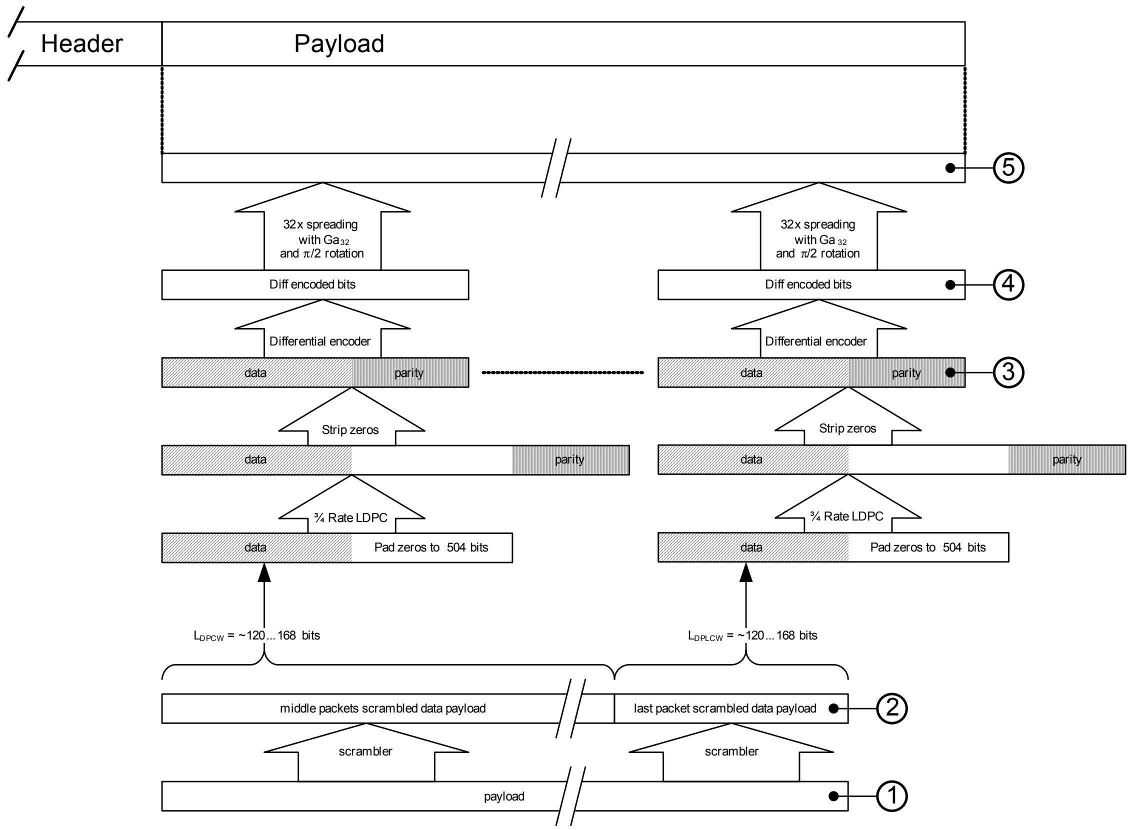


Figure L-3—CPHY payload coding and modulation

L.5.3.1 CPHY payload bits

Figure L-3 node ①.

Reference: Bits 89 to 1000 of the file **CPHY_Header and Payload bits.txt**

L.5.3.2 CPHY scrambled payload bits

Figure L-3 node ②.

Reference: Bits 89 to 1000 of the file **CPHY_Scrambled Header and Payload bits.txt**

L.5.3.3 CPHY LDPC encoded payload bits

Figure L-3 node ③.

Reference: Bits 257 to 2176 of the file **CPHY_LDPC Encoded Header and Payload bits.txt**

L.5.3.4 CPHY differentially encoded payload symbols

Figure L-3 node ④.

Reference: Symbols 257 to 2176 of the file **CPHY_Diff Encoded Header and Data symbols.txt**

L.5.3.5 CPHY payload samples

Figure L-3 node ⑤.

In this example, the 320 differentially encoded bipolar symbol values from each of the 6 payload bearing LDPC codewords, including the last one, gives a total of 6 x 320 = 1920 symbols which are then spread using the Ga_{32} Golay sequence and π/2 rotated to produce 61440 chips at Fc = 1.76 GHz.

Reference: Samples 8193 to 69632 of the file **CPHY_Header and Payload samples.txt**

L.6 DMG Example 2 – SC PHY encoding

L.6.1 sC PHY Preamble

The SCPHY preamble Short Training Field (STF) and Channel Equalization Field (CEF) are each constructed from a concatenation of real valued bipolar Golay sequences that is π/2-BPSK modulated.

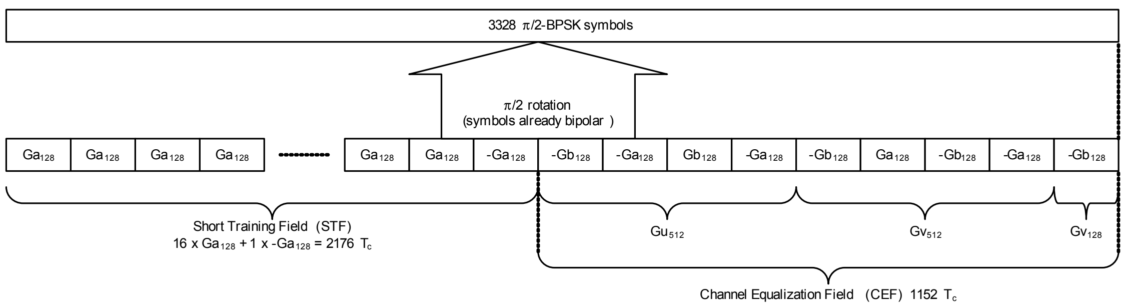


Figure L-4—SC PHY preamble expressed in Ga_{128} and Gb_{128} sequences

The preamble is 3328 samples long.

Reference: **SCPHY_Preamble Samples.txt**

L.6.2 SC PHY header

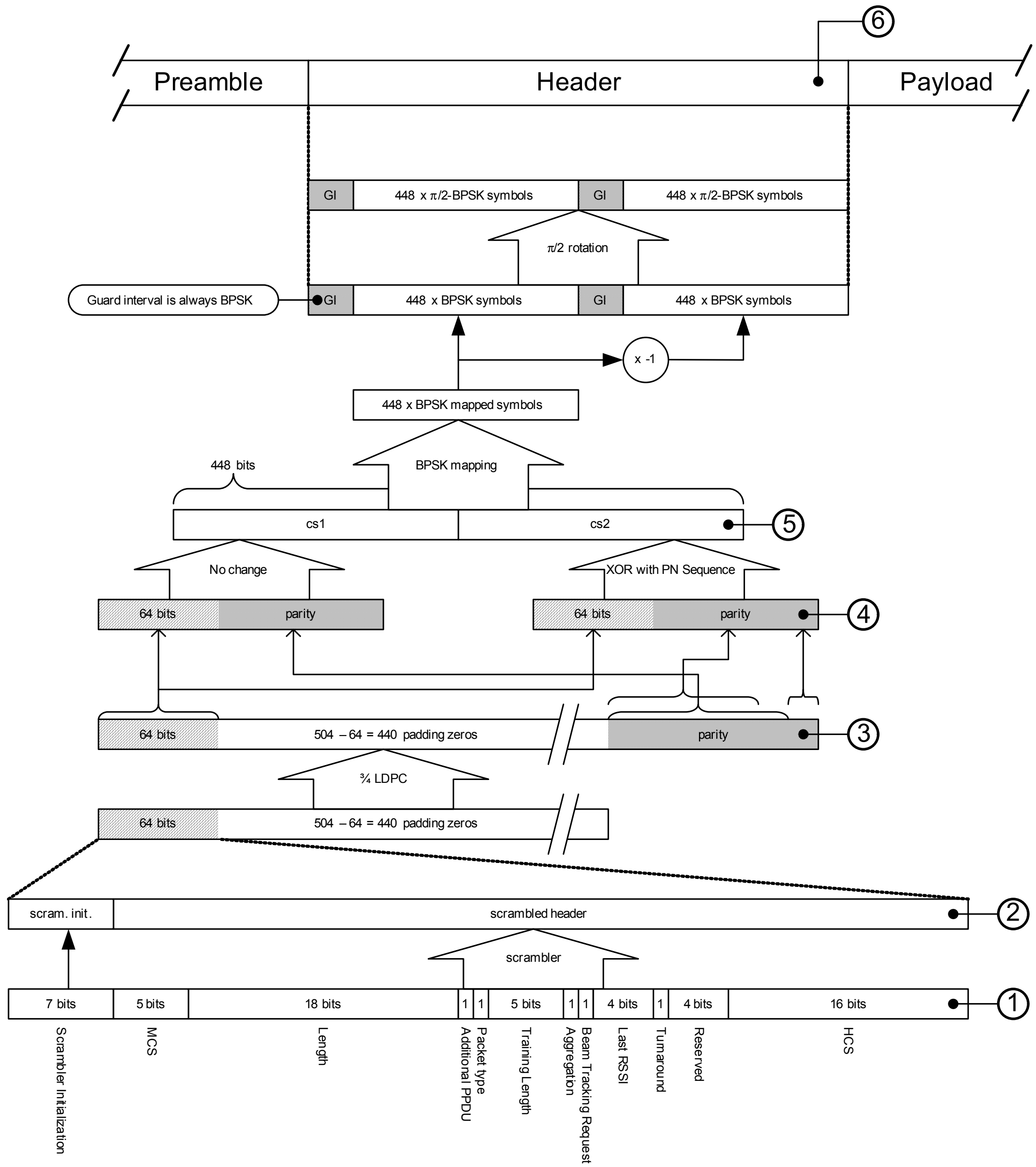


Figure L-5—SC PHY header coding and modulation

L.6.2.1 SC PHY header bits

Figure L-5 node ①. The 8 octets of header data. For this example, the SC PHY header bit fields are set as listed in Table L-44.

Reference: **SCPHY_MCS2_Header bits.txt**

Table L-44—SC PHY header settings

Field	Value
Scrambler Initialization	66
MCS	2
Length	1000
Additional PPDU	0
Packet Type	0
Training Length	0
Aggregation	0
Beam Tracking Request	0
Last RSSI	0
Turnaround	0
Reserved bits	0

L.6.2.2 SC PHY scrambled header bits

Figure L-5 node ②. The header bits after scrambling bits 8 to 64 of the header using the seed 66 (0x42).

Reference: **SCPHY_MCS2_Scrambled Header bits.txt**

L.6.2.3 SC PHY LDPC encoded header bits

Figure L-5 node ③. The scrambled header data after LDPC encoding but prior to zero stripping.

Reference: **SCPHY_MCS2_LDPC Encoded Header bits.txt**

L.6.2.4 SC PHY LDPC data shortened bits

Figure L-5 node ④. The dimension of SCPHY modulation blocks requires that the CS1 and CS2 sequences are each 224 bits long; this in turn requires that, in addition to the zeros, some of the parity bits are discarded in order to shorten the LDPC codewords to 224 bits.

The data for the second shortened LDPC codeword is given as they are before they are scrambled to provide CS2.

Reference: **SCPHY_MCS2_Shortened LDPC for CS1 bits.txt**

Reference: **SCPHY_MCS2_Shortened LDPC for CS2 bits.txt**

L.6.2.5 SC PHY CS1/CS2 sequence bits

Figure L-5 node ⑤. The 448 bit concatenated CS1/CS2 sequence including the PN scrambling of CS2.

Reference: **SCPHY_MCS2_Final CS1 CS2 Sequence bits.txt**

L.6.2.6 SC PHY header samples

Figure L-5 node ⑥. The fully modulated signal after BPSK mapping, duplication (with negation), Guard Interval addition and π/2 rotation are applied.

The 448 header bits are BPSK mapped to 448 modulation symbols and increased to 512 symbols by the addition of a 64 symbol Guard Interval. A second, negated, copy of the 448 modulation symbols is also increased to 512 symbols by the addition of a 64 symbol Guard Interval. The two 512 symbol blocks are concatenated and π/2 rotated to create 1024 samples.

Reference: **SCPHY_MCS2_Header Samples.txt**

L.6.3 SC PHY payload

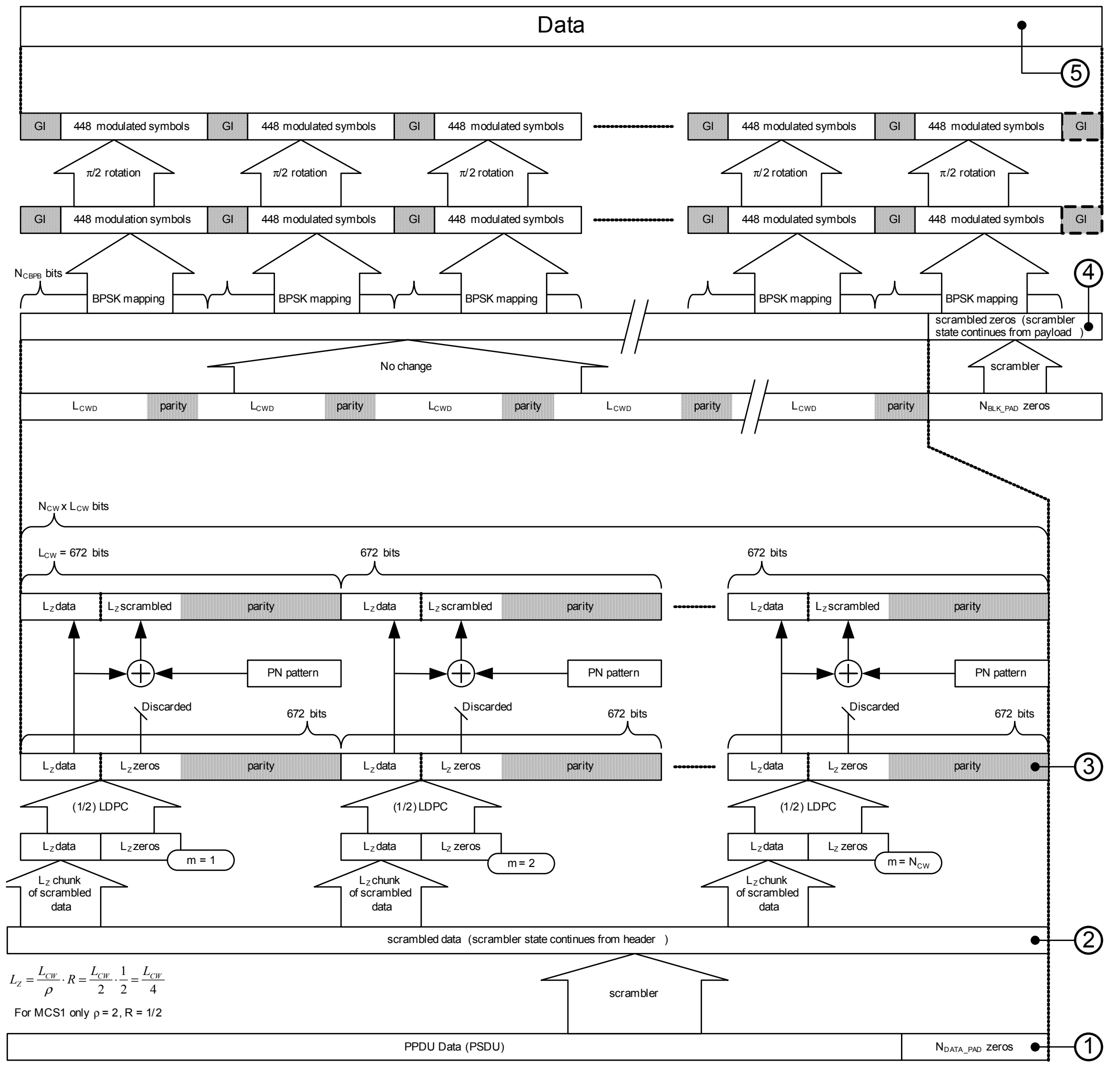


Figure L-6—SC PHY MCS1 payload coding and modulation

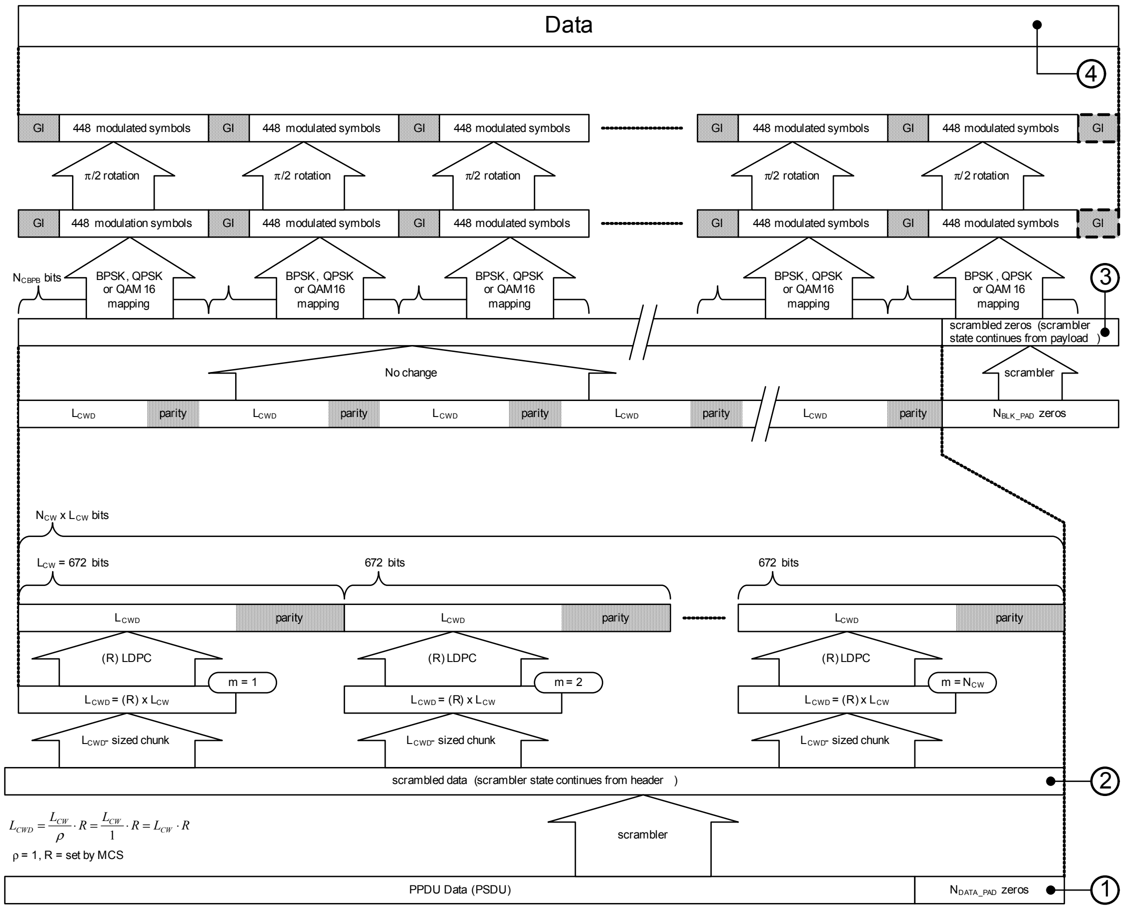


Figure L-7—SC PHY MCS2—MCS12 payload coding and modulation

L.6.3.1 SC PHY MCS1 payload

L.6.3.1.1 Payload bits

Figure L-6 node ①. The payload at node ① is a count, modulo 256, starting at 0.

For MCS1 each rate 1/2 LDPC codeword encodes 168 bits (with $\rho = 2$ repetition) so the payload padding calculation gives N_{CW} = 48 and N_{DATA_PAD} = 64.

There are 1000 × 8 = 8000 payload bits plus 64 padding bits giving a total of 8064 bits.

Reference: **SCPHY_MCS1_Payload bits.txt**

L.6.3.1.2 Scrambled payload bits

Figure L-6 node ②. All 8064 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY_MCS1_Scrambled Payload bits.txt**

L.6.3.1.3 1/2-rate LDPC encoded bits before scrambled duplication

Figure L-6 node ③. The rate 1/2 LDPC encoding of each block of $L_Z = 168$ scrambled payload bits plus $L_Z = 168$ padding zero bits. In this example, the 8064 actual payload bits are doubled, by repetition, to an effective payload of 16128 bits, then doubled again to 32256 bits by LDPC encoding.

This node, unique to MCS1, is the raw LDPC encoded payload bits before scrambled duplication.

Reference: **SCPHY_MCS1_LDPC Encoder Output bits.txt**

L.6.3.1.4 1/2-rate LDPC encoded bits after scrambled duplication

Figure L-6 node ④. The LDPC codewords after the $L_Z = 168$ zeros have been replaced by the $L_Z = 168$ re-scrambled data octets. The data at this node also includes the appended N_{BLK_PAD} scrambled zeros; however, in this example, $N_{BLK\_PAD} = 0$, so there are still 32256 bits.

Each 448 bits in the reference file is the $N_{CBPB} = 448$ bits required to build a modulation block of the MCS1 payload.

Reference: **SCPHY_MCS1_LDPC Encoded Payload Bits.txt**

L.6.3.1.5 Payload samples

Figure L-6 node ⑤. The modulated signal after BPSK Mapping, Guard Interval addition and π/2 rotation has been applied.

In this example, the 32256 encoded bits are divided into 72 × 448 bit blocks. BPSK mapping converts this to 72 × 448 modulation symbols which the Guard Interval increases to 72 × 512 modulation symbols. When the closing 64-symbol Guard Interval is added, it results in a total of 72 × 512 + 64 = 36928 payload samples.

Reference: **SCPHY_MCS1_Payload Samples.txt**

L.6.3.2 SC PHY MCS5 payload

L.6.3.2.1 Payload bits

Figure L-7 node ①. The payload at node ① is a count, modulo 256, starting at 0.

For MCS5 each rate 13/16 LDPC codeword encodes 546 bits so the payload padding calculation gives $N_{CW} = 15$ and $N_{DATA\_PAD} = 190$.

There are 1000 × 8 = 8000 payload bits plus 190 padding bits giving a total of 8190 bits.

Reference: **SCPHY_MCS5_Payload bits.txt**

L.6.3.2.2 Scrambled payload bits

Figure L-7 node ②. All 8190 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY_MCS5_Scrambled Payload bits.txt**

L.6.3.2.3 13/16-rate LDPC encoded payload bits

Figure L-6 node ③. The rate 13/16 LDPC encoding of each block of $L_{CWD} = 546$ scrambled payload bits. In this example, the 8190 payload bits are increased to 10080 bits by the LDPC encoding.

The data at this node also includes the appended $N_{\mathrm{BLK\_PAD}}$ scrambled zeros. In this example, $N_{\mathrm{BLK\_PAD}}$ = 224, so there are still a total of 10080 + 224 = 10304 bits.

Reference: **SCPHY_MCS5_LDPC Encoded Payload Bits.txt**

L.6.3.2.4 Payload samples

Figure L-7 node ④. The modulated signal after BPSK Mapping, Guard Interval addition and π/2 rotation has been applied.

In this example, the 10304 encoded bits are divided into 23 × 448 bit blocks. BPSK mapping converts this to 23 × 448 modulation symbols which the Guard Interval increases to 23 × 512 modulation symbols. When the closing 64-symbol Guard Interval is added, it results in a total of 23 × 512 + 64 = 11840 payload samples.

Reference: **SCPHY_MCS5_Payload Samples.txt**

L.6.3.3 SC PHY MCS7 payload

L.6.3.3.1 Payload bits

Figure L-7 node ①. The payload at node ① is a count, modulo 256, starting at 0.

For MCS7 each rate 5/8 LDPC codeword encodes 420 bits so the payload padding calculation gives N_{CW} = 20 and $N_{\mathrm{DATA\_PAD}}$ = 400.

There are 1000 × 8 = 8000 payload bits plus 400 padding bits giving a total of 8400 bits.

Reference: **SCPHY_MCS7_Payload bits.txt**

L.6.3.3.2 Scrambled payload bits

Figure L-6 node ②. All 8400 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY_MCS7_Scrambled Payload bits.txt**

L.6.3.3.3 5/8-rate LDPC encoded payload Bits

Figure L-7 node ③. The rate 5/8 LDPC encoding of each block of $L_{CWD} = 420$ scrambled payload bits. In this example, the 8400 payload bits are increased to 13440 bits by the LDPC encoding.

The data at this node also includes the appended $N_{\mathrm{BLK\_PAD}}$ scrambled zeros. In this example, $N_{\mathrm{BLK\_PAD}}$ = 0, so there are still a total of 13440 bits.

Reference: **SCPHY_MCS7_LDPC Encoded Payload Bits.txt**

L.6.3.3.4 Payload samples

Figure L-7 node ④. The modulated signal after QPSK Mapping, Guard Interval addition and π/2 rotation has been applied.

In this example, the 13440 encoded bits are divided into 15 × 896 bit blocks. QPSK mapping converts this to 15 × 448 modulation symbols which the Guard Interval increases to 15 × 512 modulation symbols. When the closing 64-symbol Guard Interval is added, it results in a total of 15 × 512 + 64 = 7744 payload samples.

Reference: **SCPHY_MCS7_Payload Samples.txt**

L.6.3.4 SC PHY MCS12 payload

L.6.3.4.1 Payload bits

Figure L-7 node ①. The payload at node ① is a count, modulo 256, starting at 0.

For MCS12 each rate 3/4 LDPC codeword encodes 504 bits so the payload padding calculation gives N_{CW} = 16 and $N_{\mathrm{DATA\_PAD}}$ = 64.

There are 1000 × 8 = 8000 payload bits plus 64 padding bits giving a total of 8064 bits.

Reference: **SCPHY_MCS12_Payload bits.txt**

L.6.3.4.2 Scrambled payload bits

Figure L-7 node ②. All 8064 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY_MCS12_Scrambled Payload bits.txt**

L.6.3.4.3 3/4-rate LDPC encoded payload bits

Figure L-7 node ③. The rate 3/4 LDPC encoding of each block of $L_{CWD} = 504$ scrambled payload bits. In this example, the 8064 payload bits are increased to 10752 bits by the LDPC encoding.

The data at this node also includes the appended $N_{\mathrm{BLK\_PAD}}$ scrambled zeros. In this example, $N_{\mathrm{BLK\_PAD}}$ = 0, so there are still a total of 10752 bits.

Reference: **SCPHY_MCS12_LDPC Encoded Payload Bits.txt**

L.6.3.4.4 Payload samples

Figure L-7 node ④. The modulated signal after 16QAM Mapping, Guard Interval addition and π/2 rotation has been applied.

In this example, the 10752 encoded bits are divided into 6 × 1792 bit blocks. 16QAM mapping converts this to 6 × 448 modulation symbols which the Guard Interval increases to 6 × 512 modulation symbols. When the closing 64-symbol Guard Interval is added, it results in a total of 6 × 512 + 64 = 3136 payload samples.

Reference: **SCPHY_MCS12_Payload Samples.txt**

L.7 DMG Example 3 – OFDM PHY encoding

L.7.1 OFDM PHY preamble

Figure L-8 illustrates that the OFDM PHY preamble is similar to the SC PHY preamble, but with the Gu_{512} and Gv_{512} parts of the CEF reversed. It is also resampled from 1.76 GSa/s to 2.64 GSa/s using the specified process of interpolation, resampling and decimation.

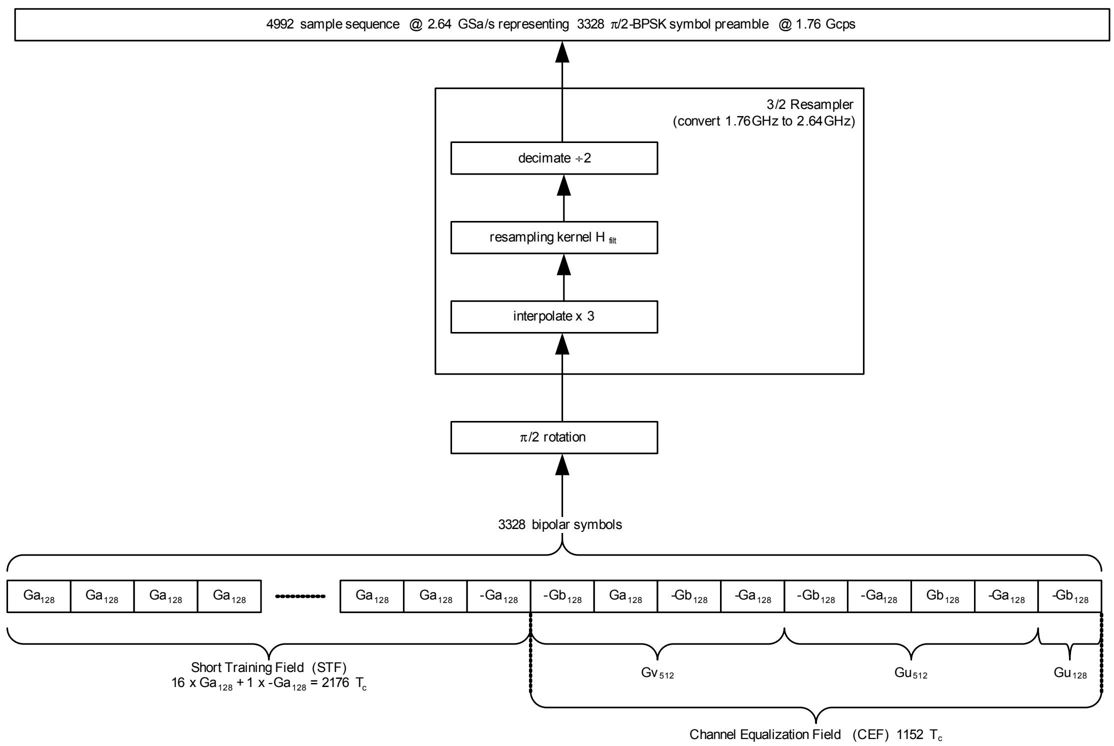


Figure L-8—OFDM PHY preamble

Thus the OFDM PHY preamble sample count increases from 3328 to 4992.

Reference: **OFDMPHY_Preamble Samples.txt**

L.7.2 OFDM PHY header coding

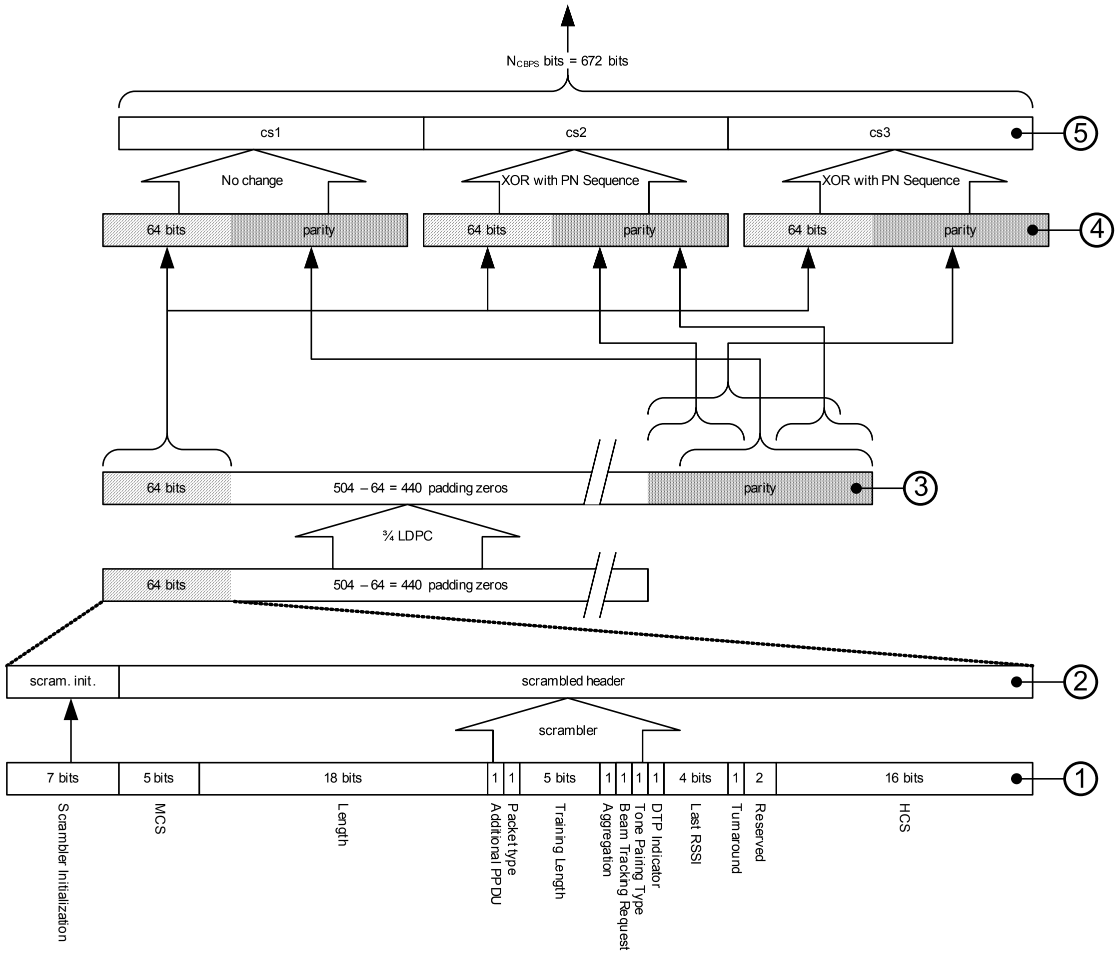


Figure L-9—OFDM PHY header coding

L.7.2.1 OFDM PHY header bits

Figure L-9 node ①. The 8 octets of header data.

For this example, the OFDM PHY header bit fields are set as listed in Table L-45.

Reference: **OFDMPHY_MCS13_Header bits.txt**

L.7.2.2 OFDM PHY scrambled header bits

Figure L-9 node ②. The header bits after scrambling bits 8 to 64 of the header using the seed 66 (0x42).

Reference: **OFDMPHY_MCS13_Scrambled Header bits.txt**

Table L-45—OFDM PHY header settings

Field	Value
Scrambler Initialization	66
MCS	13
Length	1000
Additional PPDU	0
Packet Type	0
Training Length	0
Aggregation	0
Beam Tracking Request	0
Tone Pairing Type	0
DTP Indicator	0
Last RSSI	0
Turnaround	0
Reserved bits	0

L.7.2.3 OFDM PHY LDPC encoded header bits

Figure L-9 node ③. The scrambled header bits after LDPC encoding but prior to zero stripping.

Reference: **OFDMPHY_MCS13_LDPC Encoded Header Bits.txt**

L.7.2.4 OFDM PHY LDPC data shortened bits

Figure L-9 node ④. The dimension of OFDM PHY modulation symbols requires that the CS1, CS2 and CS3 sequences are each 224 bits long; this in turn requires that, in addition to the zeros, some of the parity bits are discarded in order to shorten the LDPC codewords to 224 bits.

The data for the second and third shortened LDPC codewords are given as they are before they are scrambled to provide CS2 and CS3.

Reference: **OFDMPHY_MCS13_Shortened LDPC for CS1 bits.txt**

Reference: **OFDMPHY_MCS13_Shortened LDPC for CS2 bits.txt**

Reference: **OFDMPHY_MCS13_Shortened LDPC for CS3 bits.txt**

L.7.2.5 OFDM PHY CS1/CS2/CS3 sequence bits

Figure L-9 node ⑤. The 672 bit concatenated CS1/CS2/CS3 sequence including the PN scrambling of CS2 and CS3.

Reference: **OFDMPHY_MCS13_Final CS1 CS2 CS3 Sequence bits.txt**

L.7.3 OFDM PHY header modulation

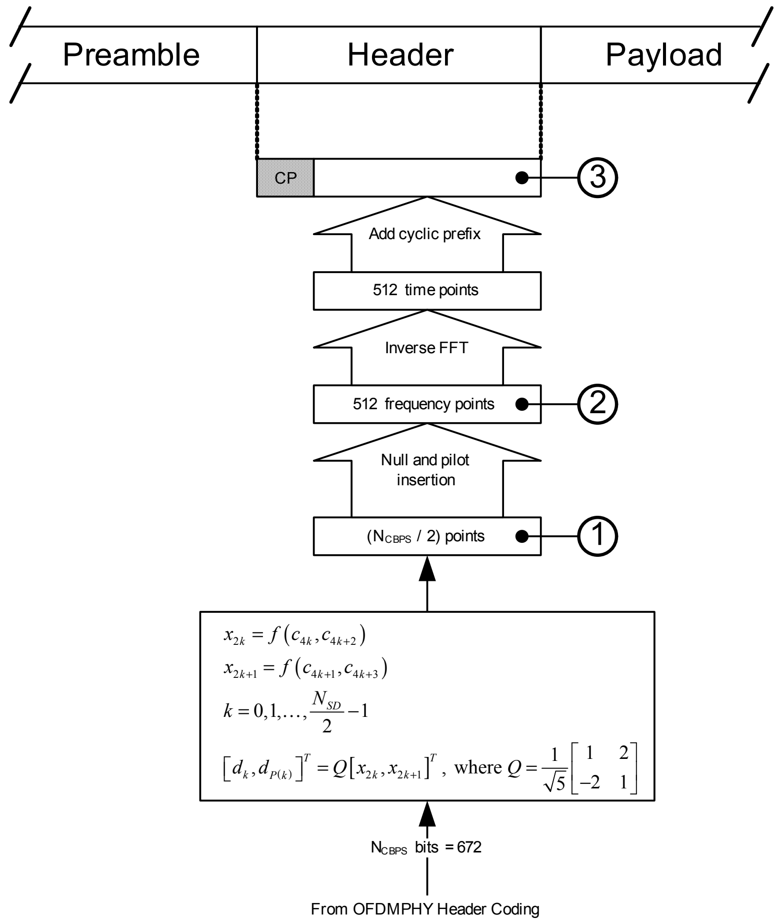


Figure L-10—OFDM PHY header modulation

L.7.3.1 Constellation mapped data points

Figure L-10 node ①. The LDPC encoded data is converted in the specified manner to 336 QPSK constellation point values prior to assignment to data carriers (in the same order as the data they were derived from). Note that because of the action of the Q matrix, these points look like 16QAM when plotted.

Reference: Samples 1 to 336 of the file **OFDMPHY_MCS13_Constellation Mapped Data Points.txt**

L.7.3.2 IFFT input samples including data, pilot, DC and null carriers

Figure L-10 node ②. At this node the data points have been mapped to the data carriers, the pilots, DC and null carriers have been assigned, and the resulting 512 point frequency domain vector is in the correct order for input to the inverse Fourier transform, i.e., with positive frequencies in the first 256 locations and negative frequencies in the second 256 locations.

Reference: Samples 1 to 512 of the file **OFDMPHY_MCS13_FFT Input Samples.txt**

L.7.3.3 Header samples

Figure L-10 node ③. At this node the signal has been inverse Fourier transformed to produce a time record and the cyclic prefix has been appended to create the 640 sample OFDM symbol.

Reference: **OFDMPHY_MCS13_Header Samples.txt**

L.7.4 OFDM PHY payload coding

As illustrated in Figure L-11, the LDPC encoding for the OFDM PHY case is identical to the SC PHY case, so no additional LDPC vectors are strictly necessary. However, the equations for computing the zero padding at the end of the payload are different from the SC PHY case so bit vectors for nodes 1, 2 and 3 are provided.

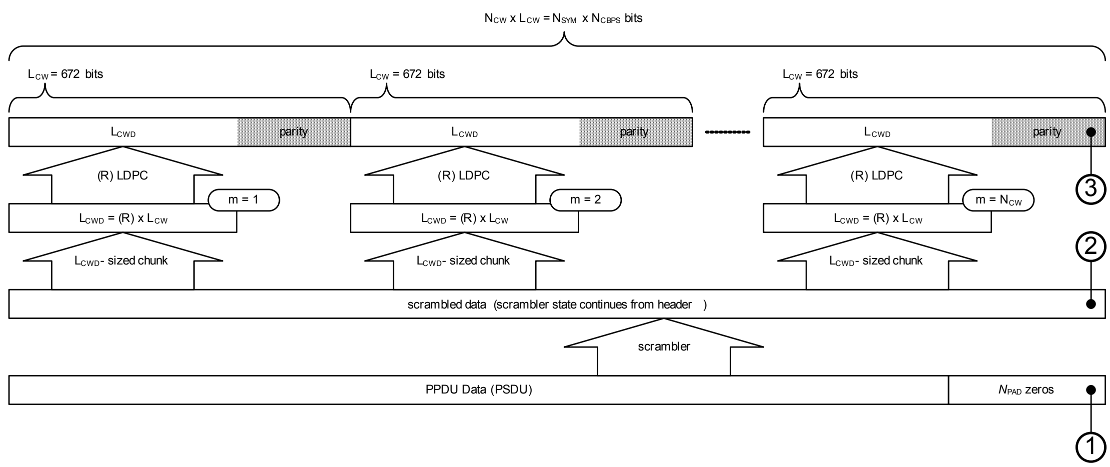


Figure L-11—OFDM PHY payload coding

L.7.5 OFDM PHY MCS14 payload modulation

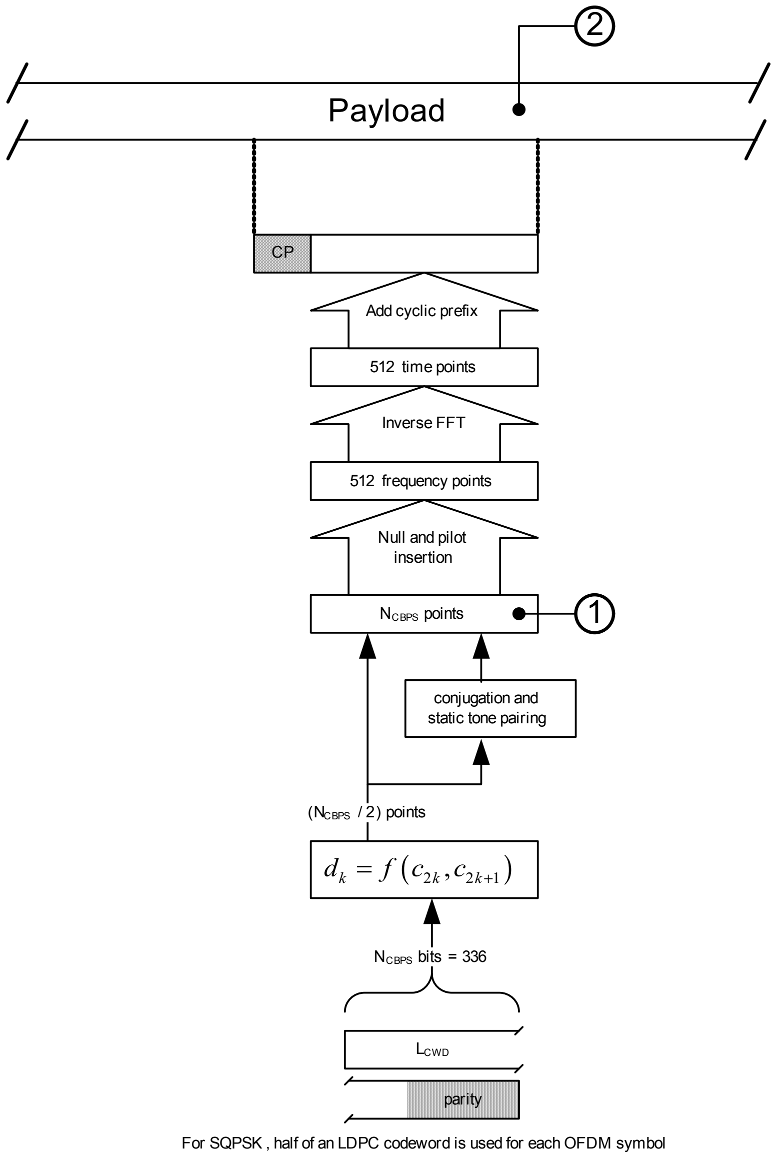


Figure L-12—OFDM PHY SQPSK payload modulation

L.7.5.1 Payload bits

Figure L-11 node ①. The payload comprises 1000 × 8 bits. With N_{CBPS} = 336 and rate 5/8 LDPC coding the OFDM PHY zero padding N_{PAD} = 400, so the padded payload comprises 8400 bits.

Reference: **OFDMPHY_MCS14_ Payload bits.txt**

L.7.5.2 Scrambled payload bits

Figure L-11 node ②. All 8400 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY_MCS14_Scrambled Payload bits.txt**

L.7.5.3 LDPC encoded payload bits

Figure L-11 node ③. For this example, with N_{CBPS} = 336 and rate 5/8 LDPC coding there are 20 LDPC codewords or 20 × 672 = 13440 bits at this node.

Reference: **OFDMPHY_MCS14_LDPC Encoded Payload bits.txt**

L.7.5.4 SQPSK constellation mapped data points

Figure L-12 node ①. For SQPSK modulation, each block of N_{CBPS} = 336 LDPC encoded bits is converted in the specified manner to 168 QPSK constellation point values and their complex conjugates prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 336 LDPC encoded bits, so there are 40 sets of 336 constellation points (13440 point in total) at this node.

Reference:
Samples 337 to 13776 of the file **OFDMPHY_MCS14_Constellation Mapped Data Points.txt**

L.7.5.5 Payload samples

Figure L-12 node ②. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 40 OFDM symbols in this example payload, giving a total of 40 × 640 = 25600 samples.

Reference: **OFDMPHY_MCS14_Payload Samples.txt**

L.7.6 OFDM PHY MCS17 payload modulation

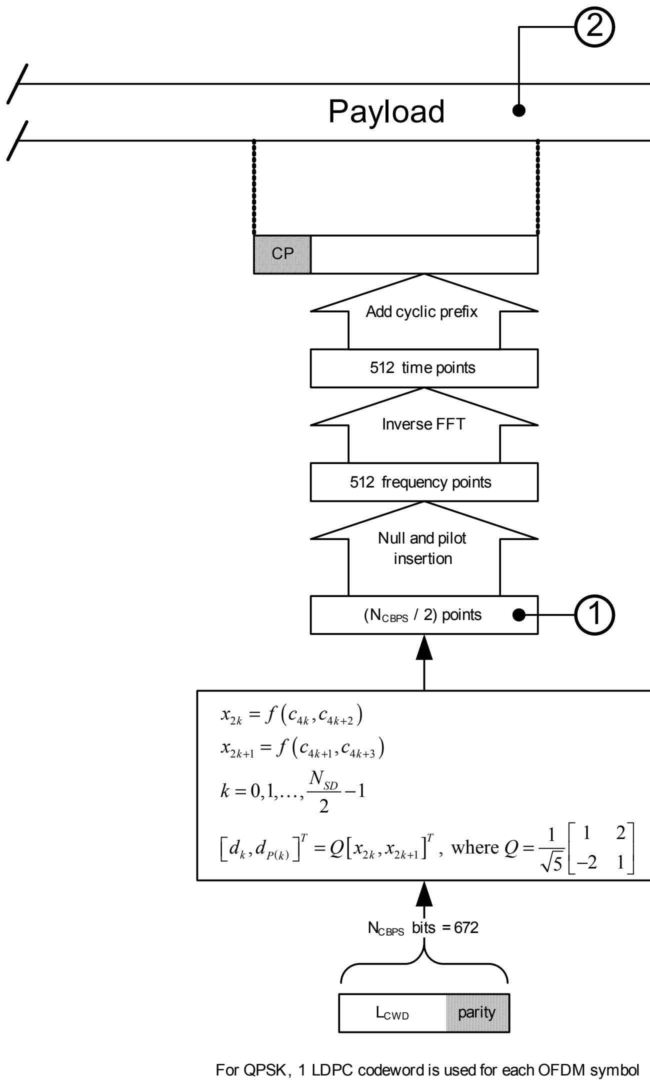


Figure L-13—OFDM PHY QPSK payload modulation

L.7.6.1 Payload bits

Figure L-11 node ①. The payload comprises 1000 × 8 bits. With N_{CBPS} = 672 and rate 3/4 LDPC coding the OFDM PHY zero padding N_{PAD} = 64, so the padded payload comprises 8064 bits.

Reference: **OFDMPHY_MCS17_ Payload bits.txt**

L.7.6.2 Scrambled payload bits

Figure L-11 node ②. All 8064 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY_MCS17_Scrambled Payload bits.txt**

L.7.6.3 LDPC encoded payload bits

Figure L-11 node ③. For this example, with N_{CBPS} = 672 and rate 3/4 LDPC coding there are 16 LDPC codewords or 16 × 672 = 10752 bits at this node.

Reference: **OFDMPHY_MCS17_LDPC Encoded Payload bits.txt**

L.7.6.4 QPSK constellation mapped data points

Figure L-13 node ①. For QPSK modulation, each block of N_{CBPS} = 672 LDPC encoded bits is converted in the specified manner to 336 QPSK constellation point values prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 672 LDPC encoded bits, so there are 16 sets of 336 constellation points (5376 point in total) at this node.

Reference:
Samples 337 to 5712 of the file **OFDMPHY_MCS17_Constellation Mapped Data Points.txt**

L.7.6.5 Payload samples

Figure L-13 node ②. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 16 OFDM symbols in this example payload giving a total of 16 × 640 = 10240 samples.

Reference: **OFDMPHY_MCS17_Payload Samples.txt**

L.7.7 OFDM PHY MCS19 payload modulation

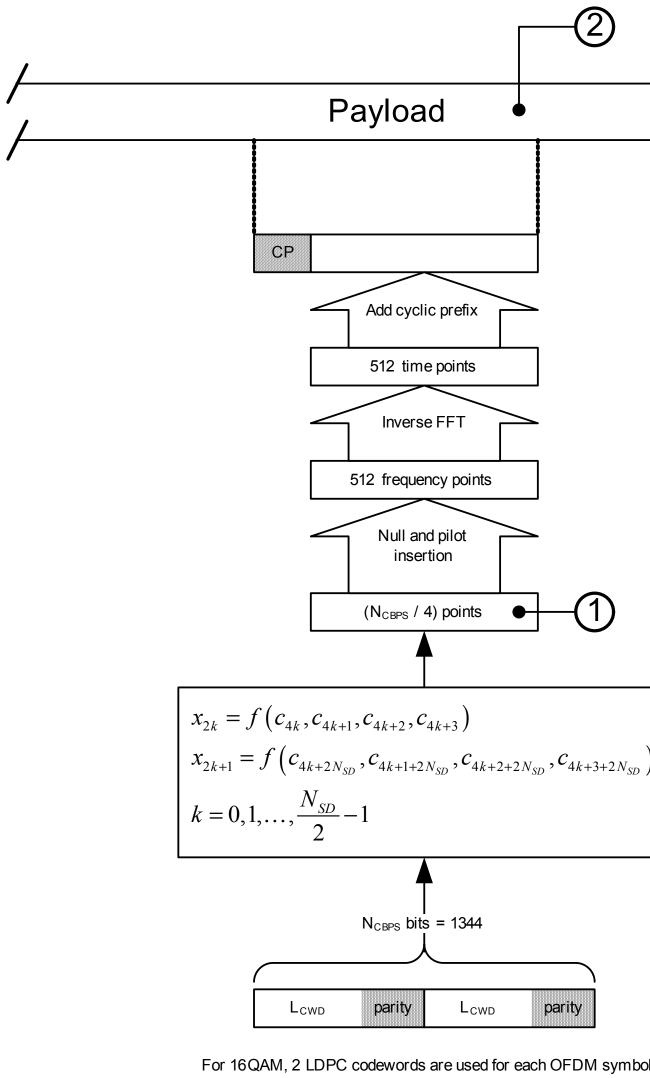


Figure L-14—OFDM PHY 16QAM payload modulation

L.7.7.1 Payload bits

Figure L-11 node ①. The payload comprises 1000 × 8 bits. With N_{CBPS} = 1344 and rate 5/8 LDPC coding the OFDM PHY zero padding N_{PAD} = 400, so the padded payload comprises 8400 bits.

Reference: **OFDMPHY_MCS19_ Payload bits.txt**

L.7.7.2 Scrambled payload bits

Figure L-11 node ②. All 8400 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY_MCS19_Scrambled Payload bits.txt**

L.7.7.3 LDPC encoded payload bits

Figure L-11 node ③. For this example, with N_{CBPS} = 1344 and rate 5/8 LDPC coding there are 20 LDPC codewords or 20 × 672 = 13440 bits at this node.

Reference: **OFDMPHY_MCS19_LDPC Encoded Payload bits.txt**

L.7.7.4 16QAM constellation mapped data points

Figure L-14 node ①. For 16QAM modulation, each block of N_{CBPS} = 1344 LDPC encoded bits is converted in the specified manner to 336 16QAM constellation point values prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 1344 LDPC encoded bits, so there are 10 sets of 336 constellation points (3360 points in total) at this node.

Reference:
Samples 337 to 3696 of the file **OFDMPHY_MCS19_Constellation Mapped Data Points.txt**

L.7.7.5 Payload samples

Figure L-14 node ②. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 10 OFDM symbols in this example payload giving a total of 10 × 640 = 6400 samples.

Reference: **OFDMPHY_MCS19_Payload Samples.txt**

L.7.8 OFDM PHY MCS23 payload modulation

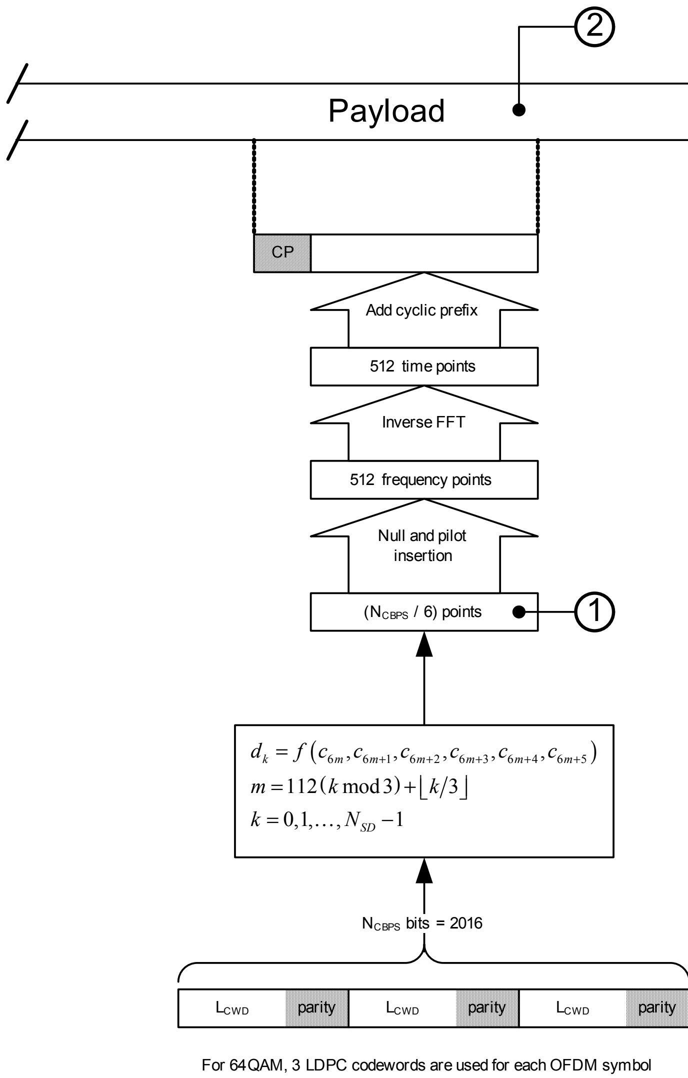


Figure L-15—OFDM PHY 64QAM payload modulation

L.7.8.1 Payload bits

Figure L-11 node ①. The payload comprises 1000 × 8 bits. With N_{CBPS} = 2016 and rate 3/4 LDPC coding the OFDM PHY zero padding N_{PAD} = 1072, so the padded payload comprises 9072 bits.

Reference: **OFDMPHY_MCS23_ Payload bits.txt**

L.7.8.2 Scrambled payload bits

Figure L-11 node ②. All 9072 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY_MCS23_Scrambled Payload bits.txt**

L.7.8.3 LDPC encoded bits

Figure L-11 node ③. For this example, with N_{CBPS} = 2016 and rate 3/4 LDPC coding there are 18 LDPC codewords or 18 × 672 = 12096 bits at this node.

Reference: **OFDMPHY_MCS23_LDPC Encoded Payload bits.txt**

L.7.8.4 64QAM constellation mapped data points

Figure L-15 node ①. For 64QAM modulation, each block of N_{CBPS} = 2016 LDPC encoded bits is converted in the specified manner to 336 64QAM constellation point values prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 2016 LDPC encoded bits, so there are 6 sets of 336 constellation points (2016 points in total) at this node.

Reference:
Samples 337 to 2352 of the file **OFDMPHY_MCS23_Constellation Mapped Data Points.txt**

L.7.8.5 Payload samples

Figure L-15 node ②. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 6 OFDM symbols in this example payload giving a total of 6 × 640 = 3840 samples.

Reference: **OFDMPHY_MCS23_Payload Samples.txt**

L.8 DMG Example 4 – LP SC PHY encoding

L.8.1 LP SC PHY preamble

The LP SC PHY preamble is identical to the SC PHY preamble.

L.8.2 LP SC PHY header

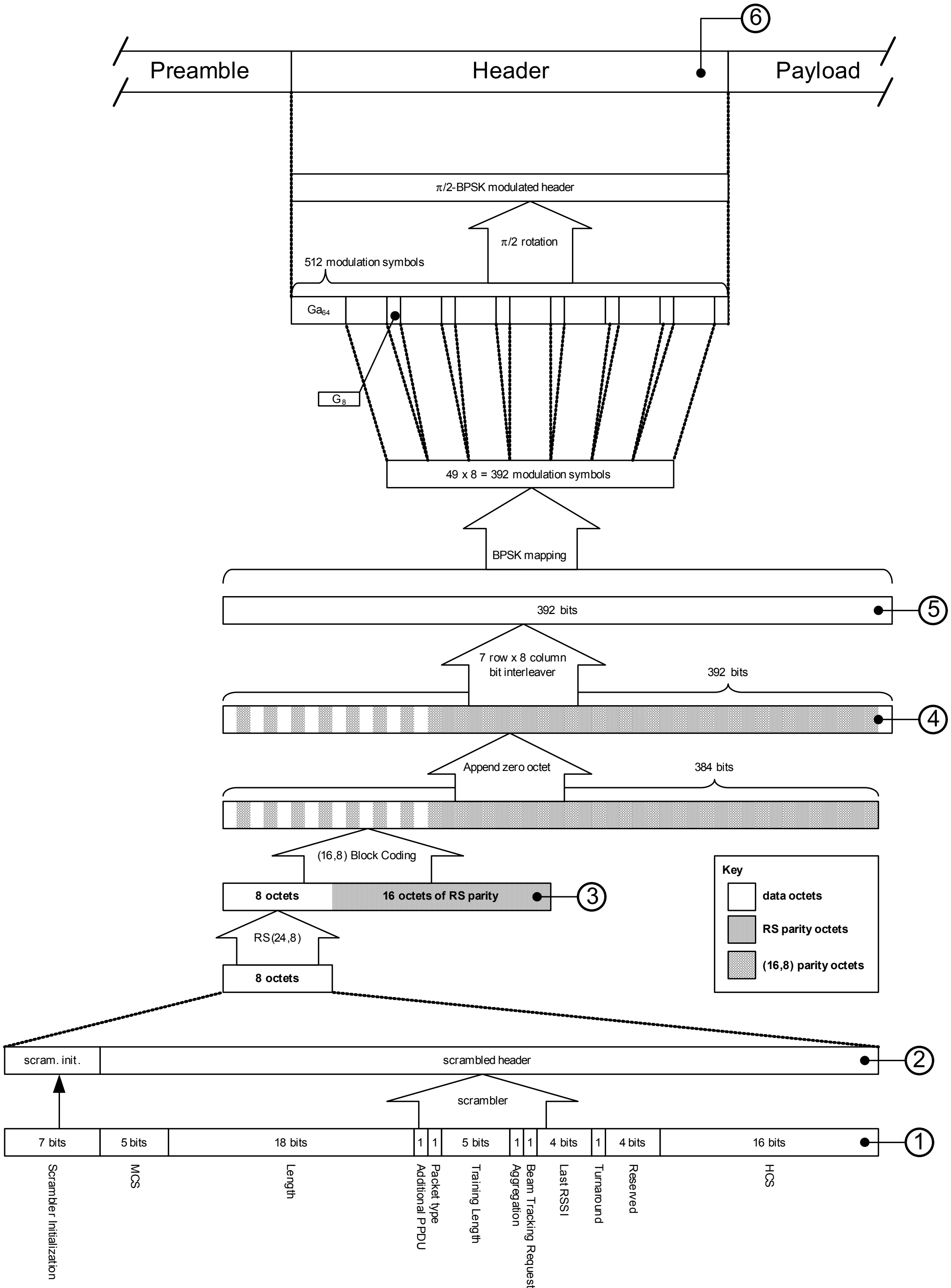


Figure L-16—LP SC PHY header coding and modulation

L.8.2.1 Header bits

Figure L-16 node ①. The 8 octets of header data.

For this example the LP SC PHY header bit fields are set as shown in Table L-46.

Table L-46—LP SC PHY header settings

Field	Value
Scrambler Initialization	66
MCS	26
Length	1000
Additional PPDU	0
Packet Type	0
Training Length	0
Aggregation	0
Beam Tracking Request	0
Last RSSI	0
Turnaround	0
Reserved bits	0

Reference: **LPSCPHY_MCS26_Header bits.txt**

L.8.2.2 Scrambled header bits

Figure L-16 node ②. The header bits after scrambling bits 8 to 64 of the header using the seed 66 (0x42).

Reference: **LPSCPHY_MCS26_Scrambled Header bits.txt**

L.8.2.3 RS(24,8) encoded header bits

Figure L-16 node ③. The 8 octets of header data are RS(24,8) encoded. The 8 message octets followed by the 16 parity octets give the complete 24 octet RS codeword.

There are 24 × 8 = 192 bits at this node.

Reference: **LPSCPHY_MCS26_RS(24,8) Encoded Header bits.txt**

L.8.2.4 (16,8) block coded header bits

Figure L-16 node ④. The (16,8) block coder doubles the effective bits from 192 to 384, then a zero padding octet is added to take the bit count up to the 392 needed to compose a modulation block.

Reference: **LPSCPHY_MCS26_(16,8) Block Coded Header bits.txt**

L.8.2.5 Header bit interleaver output

Figure L-16 node ⑤. The bit interleaver re-orders the 392 bits into a different time sequence.

Reference: **LPSCPHY_MCS26_Header Interleaver Output bits.txt**

L.8.2.6 Header samples

Figure L-16 node ⑥. The 392 bits of the header interleaver output are BPSK mapped, prepended with a Ga_{64} sequence as a Guard Interval and punctuated by G_8 (last 8 samples of Ga_{64}) Guard Intervals, then $\pi/2$ rotated; resulting in a 512 sample $\pi/2$-BPSK header modulation block.

Reference: **LPSCPHY_MCS26_Header Samples.txt**

L.8.3 LP SC PHY MCS26 payload

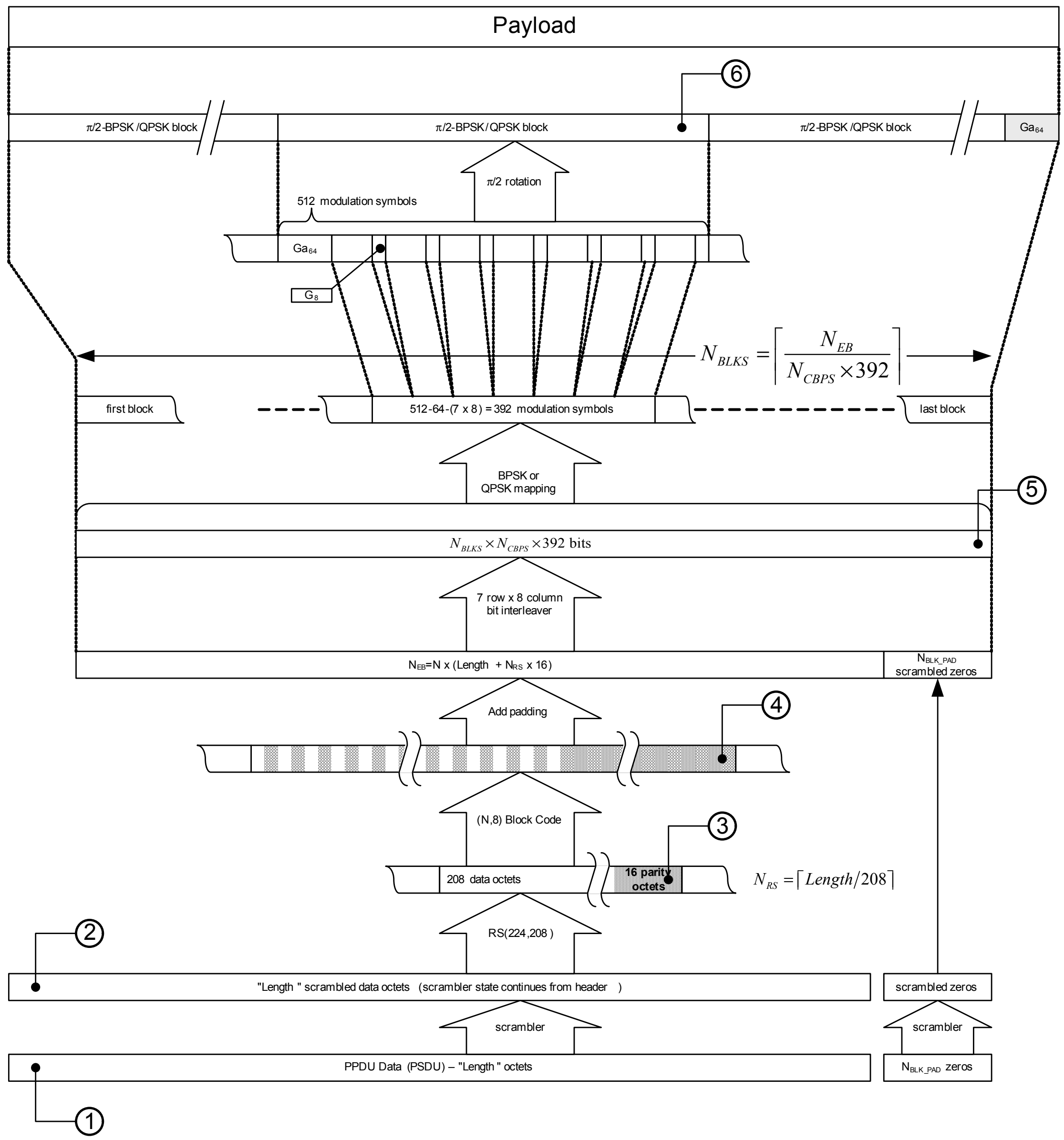


Figure L-17—LP SC PHY payload coding and modulation

L.8.3.1 Payload bits

Figure L-17 node ①. The payload at node is a count, modulo 256, starting at 0.

For MCS26, the LP SC PHY payload padding calculation gives $N_{\text{DATA\_PAD}}$ = 368; however, unlike the other PHYs, this padding data is not appended before FEC computation.

So there are just 1000 × 8 = 8000 payload bits.

Reference: **LPSCPHY_MCS26_Payload bits.txt**

L.8.3.2 Scrambled payload bits

Figure L-17 node ②. All 8000 bits are scrambled according to a scrambler initialization value of 66.

Reference: **LPSCPHY_MCS26_Scrambled Payload bits.txt**

L.8.3.3 RS(224,208) encoded payload bits

Figure L-17 node ③. In this example, there are 4 RS(224,208) codewords and one shortened RS(184,168) codeword, giving a total of $(4 \times 224 + 1 \times 184) \times 8 = 8640$ bits at this node.

Reference: **LPSCPHY_MCS26_RS(224,208) Output bits.txt**

L.8.3.4 (12,8) block coded payload bits

Figure L-17 node ④. The (12,8) block coder increases the effective bits from 8640 to 12960.

Reference: **LPSCPHY_MCS26_Block Coded Payload bits.txt**

L.8.3.5 Interleaved payload bits

Figure L-17 node ⑤. Before interleaving the block coder output is padded with $N_{DATA\_PAD} = 368$ scrambled zeros to give 13328 bits (34 x 392). The interleaver then redistributes these bits in time, as specified.

Reference: **LPSCPHY_MCS26_RS Encoded and Interleaved Payload bits.txt**

L.8.3.6 Payload samples

Figure L-17 node ⑥. Each block of 392 bits from the interleaver output is BPSK mapped to 392 modulation symbols, prepended with a Ga_{64} sequence as a Guard Interval and punctuated by G_8 (last 8 samples of Ga_{64}) Guard Intervals, then π/2 rotated, thus resulting in a 512 symbol π/2-BPSK modulation block.

In this example, there are 34 modulation blocks and, as specified, the last one is followed by a terminating Ga_{64} Guard Interval sequence, so there are $34 \times 512 + 64 = 17472$ samples at this node.

Reference: **LPSCPHY_MCS26_Payload Samples.txt**

L.8.4 LP SC PHY MCS30 payload

L.8.4.1 Payload bits

Figure L-17 node ①. The payload at node is a count, modulo 256, starting at 0.

For MCS30, the LP SC PHY payload padding calculation gives $N_{DATA\_PAD} = 472$; however, unlike the other PHYs, this padding data is not appended before FEC computation.

So there are just $1000 \times 8 = 8000$ payload bits.

Reference: **LPSCPHY_MCS30_Payload bits.txt**

L.8.4.2 Scrambled payload bits

Figure L-17 node ②. All 8000 bits are scrambled according to a scrambler initialization value of 66.

Reference: **LPSCPHY_MCS30_Scrambled Payload bits.txt**

L.8.4.3 RS(224,208) encoded payload bits

Figure L-17 node ③. In this example, there are 4 RS(224,208) codewords and one shortened RS(184,168) codeword, giving a total of $(4 \times 224 + 1 \times 184) \times 8 = 8640$ bits at this node.

Reference: **LPSCPHY_MCS30_RS(224,208) Output bits.txt**

L.8.4.4 Spc(9,8) block coded payload bits

Figure L-17 node ④. The (9,8) block coder increases the effective bits from 8640 to 9720.

Reference: **LPSCPHY_MCS30_Block Coded Payload bits.txt**

L.8.4.5 Interleaved payload bits

Figure L-17 node ⑤. Before interleaving the block coder output is padded with $N_{DATA\_PAD} = 472$ scrambled zeros to give 10192 bits (26×392). The interleaver then redistributes these bits in time, as specified.

Reference: **LPSCPHY_MCS30_RS Encoded and Interleaved Payload bits.txt**

L.8.4.6 Payload samples

Figure L-17 node ⑥. Each block of 784 bits from the interleaver output is QPSK mapped to 392 modulation symbols, prepended with a Ga_{64} sequence as a Guard Interval and punctuated by G_8 (last 8 samples of Ga_{64}) Guard Intervals, then $\pi/2$ rotated, thus resulting in a 512 symbol $\pi/2$-BPSK modulation block.

In this example, there are 13 modulation blocks and, as specified, the last one is followed by a terminating Ga_{64} Guard Interval sequence, so there are $13 \times 512 + 64 = 6720$ samples at this node.

Reference: **LPSCPHY_MCS30_Payload Samples.txt**

Annex M

(informative)

RSNA reference implementations and test vectors

Insert the following subclauses, M.11 to M.11.2, after M.10:

M.11 GCMP

M.11.1 Test vector

==== GCMP test mpdu #1 ====

Plain Text: The plain text is a sequence of 0s made up to 256 octets.

- Input data (Plain text): 256 octets
  - 1: 0x00000000000000000000000000000000
  - 2: 0x00000000000000000000000000000000
  - 3: 0x00000000000000000000000000000000
  - 4: 0x00000000000000000000000000000000
  - 5: 0x00000000000000000000000000000000
  - 6: 0x00000000000000000000000000000000
  - 7: 0x00000000000000000000000000000000
  - 8: 0x00000000000000000000000000000000
  - 9: 0x00000000000000000000000000000000
  - 10: 0x00000000000000000000000000000000
  - 11: 0x00000000000000000000000000000000
  - 12: 0x00000000000000000000000000000000
  - 13: 0x00000000000000000000000000000000
  - 14: 0x00000000000000000000000000000000
  - 15: 0x00000000000000000000000000000000
  - 16: 0x00000000000000000000000000000000
- Key: 16 octets
  - 0xAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
- AAD: 22 octets
  - 0x2002000000000000FFFFFFFFFFFFFFFFFFFFFFFF0000
    - Frame Control (FC): 2 octets, 0x0220
    - Address 1 (A1): 6 octets, 0x000000000000
    - Address 2 (A2): 6 octets, 0xFFFFFFFFFFFF
    - BSSID: 6 octets, 0xFFFFFFFFFFFF
    - Sequence Control (SC): 2 octets, 0x0000
- GCM nonce: 12 octets
  - 0xFFFFFFFFFFFF000000000001
    - A2: 6 octets, 0xFFFFFFFFFFFF
    - PN: 6 octets, 0x000000000001
- Output data (Cipher text): 256 octets
  - 1: 0x5F5578C18F137AD279BF3F2B24C7BD8F
  - 2: 0x277A1BE6770DA1D98B70C6D28AE01C55
  - 3: 0x9ECBA6A01DB067C5A27E4DB08CDADC77
  - 4: 0x52AD637EAF0A18ED13FBAA143BAFEF18
  - 5: 0xF8FBCE4C65E86BD02A87B601B7EAB93F
  - 6: 0x2BBC874C8A710580F502341A6A533931

  - 7: 0x43DE4C9EC6A286F125718378AEDC84EB
  - 8: 0xA2B30F5C28BB5D75C6B025466D0651C7
  - 9: 0x22DC71151F212D6887828A0382E9288A
  - 10: 0x7F43D52B7D25086157646954BB43B57E
  - 11: 0xA587A025F40CE74511E4DD2285B40BA3
  - 12: 0xF3B96262CBC28C6AA7BE443E7B41E1EB
  - 13: 0xFF524857A6816897750115B0231AB7C2
  - 14: 0x8472C06DD0B49BE9F369A8C39CCD0DB7
  - 15: 0x983510E1AE8F05D77545E0235CDBD612
  - 16: 0xF3150754CEE5CE6A1225D99525026F74
- MIC (Tag): 16 octets
  - 0x80CB0662EA71ABFD9F04C7F872F58090

==== GCMP test mpdu #2 (CCMP test vector format) ====

//Changed Plaintext, Key, AAD and Nonce

// MPDU Fields

Version = 0
Type = 2 SubType= 8QoS Data
ToDS = 0 FromDS = 0
MoreFrag = 0 Retry = 1
PwrMgt = 0 MoreData= 0
Encrypt = 1
Order = 0
Duration= 11 (40 Octets(MCS1) + SIFS + ACK(MCS1))
A1 = 0f-d2-e1-28-a5-7c DA
A2 = 50-30-f1-84-44-08 SA
A3 = 50-30-f1-84-44-08 BSSID
SC = 0x3380
seqNum = 824 (0x0338) fragNum = 0 (0x00)
QoSControl = 0x0003
TID = 3
Algorithm = AES_GCMP
Key ID = 0

TK = c9 7c 1f 67 ce 37 11 85 51 4a 8a 19 f2 bd d5 2f

PN = 590010592008 (0x00895F5F2B08)

802.11 Header = 88 48 0b 00 0f d2 e1 28 a5 7c 50 30 f1 84 44 08 50 30 f1 84 44 08 80 33 03 00

Muted 802.11 Header = 88 40 0f d2 e1 28 a5 7c 50 30 f1 84 44 08 50 30 f1 84 44 08 00 00 03 00

GCMP Header = 08 2b 00 20 5f 5f 89 00

GCM Nonce = 50 30 f1 84 44 08 00 89 5f 5f 2b 08

Plaintext Data = 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 10 11 12 13
14 15 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 26 27

Encrypted Data = 60 e9 70 0c c4 d4 0a c6 d2 88 b2 01 c3 8f 5b f0 8b 80 74 42
64 0a 15 96 e5 db da d4 1d 1f 36 23 f4 5d 7a 12 db 7a fb 23

GCM MIC = de f6 19 c2 a3 74 b6 df 66 ff a5 3b 6c 69 d7 9e

-- Encrypted MPDU with FCS
88 48 0b 00 0f d2 e1 28 a5 7c 50 30 f1 84 44 08 50 30 f1 84 44 08 80 33 03 00 08 2b 00 20 5f 5f 89 00 60 e9 70 0c c4 d4 0a c6 d2 88 b2 01 c3 8f 5b f0 8b 80 74 42 64 0a 15 96 e5 db da d4 1d 1f 36 23 f4 5d 7a 12 db 7a fb 23 de f6 19 c2 a3 74 b6 df 66 ff a5 3b 6c 69 d7 9e bf ee e9 53

M.11.2 Example of encryption C code

```
// GCMP code
#include <stdio.h>

#define USE_VECTOR_1                    // Use test vector #1 as GCMP input
// #define USE_VECTOR_2                 // Use test vector #2 as GCMP input

// Prototype
int tcSubWord(int x);
int tcSubByte(int x);
void tcAESfunc(int StartofRound[4], int RoundKey[44]);
void tcKeyExpansion(int x[4], int RoundKey[44]);
void tcAdjustText(int move, int data[4]);
int tcMixColumns(int x);
int tcMultEight(int x, int y);
void tcMultGF(int x[4], int y[4], int Zout[4]);

int main(void)
{
        // Function parameter
        int i, j, temp[4];
        int Nr = 16;                    // 256-octet * 8-bit / 128-bit

        // Input for main
        int ENCDEC=1;                   // Indication of Encryption and Decryption: 1 Enc 0 Dec

#ifdef USE_VECTOR_1
        // Input for GCMP test vector #1

        int Key[4]={0xaaaaaaaa, 0xaaaaaaaa, 0xaaaaaaaa, 0xaaaaaaaa};          // Key for system 128-bit
        int IV[4]={0xffffffff, 0xffff0000, 0x00000001, 0x00000001};            // Initialization Vector 96-bit + 1 (32-bit)
        int AAD[2][4]={{0x20020000, 0x00000000, 0xffffffff, 0xffffffff},      // Additional Authenticated Data
                        {0xffffffff, 0x00000000, 0x00000000, 0x00000000}};            // FC, A1=0s, A2=Fs, A3=Fs
        int LENAC[4]={0x00000000, 0x000000b0, 0x00000000, 0x00000800};  // Length of AAD and Cipher Text
#endif // USE_VECTOR_1

#ifdef USE_VECTOR_2
        // Input for GCMP test vector #2 (see also plaintext input below)
        int Key[4]={0xc97c1f67, 0xce371185, 0x514a8a19, 0xf2bdd52f};          // Key for system 128-bit
        int IV[4]={0x5030f184, 0x44080089, 0x5f5f2b08, 0x00000001};            // Initialization Vector 96-bit + 1 (32-bit)
                                        // 88 40 0f d2 e1 28 a5 7c 50 30 f1 84 44 08 50 30 f1 84 44 08 00 00 03 00
        int AAD[2][4]={{0x88400fd2, 0xe128a57c, 0x5030f184, 0x44085030},  // Additional Authenticated Data
                {0xf1844408, 0x00000300, 0x00000000, 0x00000000}}; // FC, A1=0f-d2-e1-28-a5-7c,
                                                                // A2=50-30-f1-84-44-08, A3=50-30-f1-84-44-08
        int LENAC[4]={0x00000000, 0x000000c0, 0x00000000, 0x00000140};  // Length of AAD and Cipher Text
#endif // USE_VECTOR_2

        int TextIn[16][4];

        // AES parameter
        int RoundKey[44];               // Round Keys, Generated by Input Keys and use for AES
```

```
int StartofRound[4];          // Input/output of AES function
int HASH[4];                  // HASH output, AES function with 0s input
int EKY0[4];                  // First output of AES function with Y0 input, which uses for generating Tag
int TextOut[16][4];           // Output Text, which is either Cipher/Plain text. Length should much with TextIn

// GF parameter
int MultIn[4];                // Input of Multiplication
int Tag[4] = {0, 0, 0, 0};    // Tag output

// Processing Parameter
int p_flag = 1;               // Indication of end of process
int LengthTxt[2];             // Block length of text that is Plain/Cipher Text
int TxtRemain;                // The last block of text, range is between 0 to 127
int Txt_flag = 0;             // Indication of last text is not 128-bit

// ===== Main Process =====
// Generate 1500 Bytes '0' Text
for (i=0;i<Nr;i++) {
        for (j=0;j<4;j++) {
                TextIn[i][j] = 0;
        }
}

#ifdef USE_VECTOR_1
        // Plaintext for GCMP test vector #1
        // Not necessary as data is all zeros
#endif // USE_VECTOR_1

#ifdef USE_VECTOR_2
        // Plaintext for GCMP test vector #2
        TextIn[0][0] = 0x00010203;
        TextIn[0][1] = 0x04050607;
        TextIn[0][2] = 0x08090a0b;
        TextIn[0][3] = 0x0c0d0e0f;
        TextIn[1][0] = 0x10111213;
        TextIn[1][1] = 0x14151617;
        TextIn[1][2] = 0x18191a1b;
        TextIn[1][3] = 0x1c1d1e1f;
        TextIn[2][0] = 0x20212223;
        TextIn[2][1] = 0x24252627;
#endif // USE_VECTOR_2

// Generate Round Key
tcKeyExpansion(Key, RoundKey);

// Count 128-bit Text block size
// Check input text size is multiply by 128-bit or not
// Calculate the text length of last block
LengthTxt[0] = LENAC[2] >> 7;
if ((LENAC[3] & 0x0000007f) == 0) {
        LengthTxt[1] = LENAC[3] >> 7;
}
else {
        LengthTxt[1] = (LENAC[3] >> 7) + 1;
        TxtRemain = LENAC[3] & 0x0000007F;
        Txt_flag = 1;
}
```



```
        // Generate HASH, which uses for GF(2^128) function
        // AES function with 0s input
        for (i=0;i<4;i++) {
                StartofRound[i] = 0;
        }
        tcAESfunc(StartofRound, RoundKey);
        for (i=0;i<4;i++) {
                HASH[i] = StartofRound[i];
        }
        // GF 2^128 with AAD
        for (i=0;i<2;i++) {
                for (j=0;j<4;j++) {
                        MultIn[j] = AAD[i][j] ^ Tag[j];
                }
                tcMultGF(HASH, MultIn, Tag);
        }

        // Generate Encryption Key and Tag
        // AES function with Yi input to generate Encryption Keys
        // First output for which Y0 input is used for generating Tag
        i = 0;
        while (p_flag) {
                // Set IV as a Input of AES
                for (j=0;j<4;j++) {
                        StartofRound[j] = IV[j];
                }
                // AES function
                tcAESfunc(StartofRound, RoundKey);
                printf("AES Number %02d is %08x %08x %08x %08x\n", i, StartofRound[0],
StartofRound[1], StartofRound[2], StartofRound[3]);
                // Increment IV by '1'
                IV[3] = IV[3] + 1;
                // Set EKY0 for Tag
                if (i == 0) {
                        for (j=0;j<4;j++) {
                                EKY0[j] = StartofRound[j];
                        }
                }
                // Xor Input Text and Encryption Keys
                // Check the last Block of processing
                else if (LengthTxt[1] == 0) {
                        if (LengthTxt[0] == 0) {
                                p_flag = 0;
                                for (j=0;j<4;j++) {
                                        TextOut[i-1][j] = TextIn[i-1][j] ^ StartofRound[j];
                                }
                                // Adjust the length textout
                                for (j=0;j<4;j++) {
                                        temp[j] = TextOut[i-1][j];
                                }
                                if (Txt_flag == 1) {
                                        tcAdjustText(TxtRemain, temp);
                                }
                                for (j=0;j<4;j++) {
                                        TextOut[i-1][j] = temp[j];
```

```
                        }
                        // XOR with last text and former Tag
                        for (j=0;j<4;j++) {
                                if (ENCDEC == 1) {
                                        MultIn[j] = TextOut[i-1][j] ^ Tag[j];
                                }
                                else {
                                        MultIn[j] = TextIn[i-1][j] ^ Tag[j];
                                }
                        }
                        tcMultGF(HASH, MultIn, Tag);
                }
                else {
                        LengthTxt[0]--;
                        LengthTxt[1]--;
                        for (j=0;j<4;j++) {
                                TextOut[i-1][j] = TextIn[i-1][j] ^ StartofRound[j];
                                if (ENCDEC == 1) {
                                        MultIn[j] = TextOut[i-1][j] ^ Tag[j];
                                }
                                else {
                                        MultIn[j] = TextIn[i-1][j] ^ Tag[j];
                                }
                        }
                        tcMultGF(HASH, MultIn, Tag);
                }
        }
        else {
                for (j=0;j<4;j++) {
                        TextOut[i-1][j] = TextIn[i-1][j] ^ StartofRound[j];
                        if (ENCDEC == 1) {
                                MultIn[j] = TextOut[i-1][j] ^ Tag[j];
                        }
                        else {
                                MultIn[j] = TextIn[i-1][j] ^ Tag[j];
                        }
                }
                tcMultGF(HASH, MultIn, Tag);
        }
        i++;
        LengthTxt[1]--;
}
// Generate Tag
// 1. XOR with LENAC and Tag
for (j=0;j<4;j++) {
        MultIn[j] = LENAC[j] ^ Tag[j];
}
// 2. GF(2^128)
tcMultGF(HASH, MultIn, Tag);
// 3. XOR with EKY0 and Tag
for (j=0;j<4;j++) {
        Tag[j] = EKY0[j] ^ Tag[j];
}
// Display
for (i=0;i<Nr;i++) {
        printf("Text Output %d is %08x %08x %08x %08x\n", i, TextOut[i][0], TextOut[i][1],
```

```
TextOut[i][2], TextOut[i][3]);
        }
        printf("Tag is %08x %08x %08x %08x\n", Tag[0], Tag[1], Tag[2], Tag[3]);

        return 0;
}

// AES function with 128-bit Key length
void tcAESfunc(int StartofRound[4], int RoundKey[44])
{
        int i;
        int Nr = 10;
        int AfterSubBytes[4];
        int AfterShiftRows[4];
        int AfterMixColumns[4];

        // XOR Input and Round Key
        StartofRound[0] = StartofRound[0] ^ RoundKey[0];
        StartofRound[1] = StartofRound[1] ^ RoundKey[1];
        StartofRound[2] = StartofRound[2] ^ RoundKey[2];
        StartofRound[3] = StartofRound[3] ^ RoundKey[3];

        for (i=0;i<Nr-1;i++) {
                // Sub Bytes
                AfterSubBytes[0] = tcSubWord(StartofRound[0]);
                AfterSubBytes[1] = tcSubWord(StartofRound[1]);
                AfterSubBytes[2] = tcSubWord(StartofRound[2]);
                AfterSubBytes[3] = tcSubWord(StartofRound[3]);
                // Shift Rows
                AfterShiftRows[0] = (AfterSubBytes[0] & 0xFF000000) ^ (AfterSubBytes[1] & 0x00FF0000)
^ (AfterSubBytes[2] & 0x0000FF00) ^ (AfterSubBytes[3] & 0x000000FF);
                AfterShiftRows[1] = (AfterSubBytes[1] & 0xFF000000) ^ (AfterSubBytes[2] & 0x00FF0000)
^ (AfterSubBytes[3] & 0x0000FF00) ^ (AfterSubBytes[0] & 0x000000FF);
                AfterShiftRows[2] = (AfterSubBytes[2] & 0xFF000000) ^ (AfterSubBytes[3] & 0x00FF0000)
^ (AfterSubBytes[0] & 0x0000FF00) ^ (AfterSubBytes[1] & 0x000000FF);
                AfterShiftRows[3] = (AfterSubBytes[3] & 0xFF000000) ^ (AfterSubBytes[0] & 0x00FF0000)
^ (AfterSubBytes[1] & 0x0000FF00) ^ (AfterSubBytes[2] & 0x000000FF);
                // Mix Columns
                AfterMixColumns[0] = tcMixColumns(AfterShiftRows[0]);
                AfterMixColumns[1] = tcMixColumns(AfterShiftRows[1]);
                AfterMixColumns[2] = tcMixColumns(AfterShiftRows[2]);
                AfterMixColumns[3] = tcMixColumns(AfterShiftRows[3]);
                // XOR with Round Key
                StartofRound[0] = AfterMixColumns[0] ^ RoundKey[(i*4)+4];
                StartofRound[1] = AfterMixColumns[1] ^ RoundKey[(i*4)+5];
                StartofRound[2] = AfterMixColumns[2] ^ RoundKey[(i*4)+6];
                StartofRound[3] = AfterMixColumns[3] ^ RoundKey[(i*4)+7];
        }
        // Last Round
        // Sub Bytes
        AfterSubBytes[0] = tcSubWord(StartofRound[0]);
        AfterSubBytes[1] = tcSubWord(StartofRound[1]);
        AfterSubBytes[2] = tcSubWord(StartofRound[2]);
        AfterSubBytes[3] = tcSubWord(StartofRound[3]);
        // Shift Rows
        AfterShiftRows[0] = (AfterSubBytes[0] & 0xFF000000) ^ (AfterSubBytes[1] & 0x00FF0000) ^
```

```
(AfterSubBytes[2] & 0x0000FF00) ^ (AfterSubBytes[3] & 0x000000FF);
	AfterShiftRows[1] = (AfterSubBytes[1] & 0xFF000000) ^ (AfterSubBytes[2] & 0x00FF0000) ^
(AfterSubBytes[3] & 0x0000FF00) ^ (AfterSubBytes[0] & 0x000000FF);
	AfterShiftRows[2] = (AfterSubBytes[2] & 0xFF000000) ^ (AfterSubBytes[3] & 0x00FF0000) ^
(AfterSubBytes[0] & 0x0000FF00) ^ (AfterSubBytes[1] & 0x000000FF);
	AfterShiftRows[3] = (AfterSubBytes[3] & 0xFF000000) ^ (AfterSubBytes[0] & 0x00FF0000) ^
(AfterSubBytes[1] & 0x0000FF00) ^ (AfterSubBytes[2] & 0x000000FF);
	// XOR with Round Key
	StartofRound[0] = AfterShiftRows[0] ^ RoundKey[40];
	StartofRound[1] = AfterShiftRows[1] ^ RoundKey[41];
	StartofRound[2] = AfterShiftRows[2] ^ RoundKey[42];
	StartofRound[3] = AfterShiftRows[3] ^ RoundKey[43];
}

// Key Expansion function used for AES
void tcKeyExpansion(int x[4], int RoundKey[44])
{
	int i;

	int AfterRotWord;
	int AfterSubWord;
	int AfterXorWithRcon;
	int Rcon[10] = {0x01000000, 0x02000000, 0x04000000, 0x08000000, 0x10000000, 0x20000000,
0x40000000, 0x80000000, 0x1b000000, 0x36000000};

	// Generate first Round Key from Input Key
	for (i=0;i<4;i++) {
		RoundKey[i] = x[i];
	}
	// Generate other Round Key
	for (i=4;i<44;i++) {
		if (i%4 == 0) {
			AfterRotWord = (RoundKey[i-1] << 8) ^ ((RoundKey[i-1] >>24) & 0x000000FF);
			AfterSubWord = tcSubWord(AfterRotWord);
			AfterXorWithRcon = AfterSubWord ^ Rcon[i/4-1];
			RoundKey[i] = RoundKey[i-4] ^ AfterXorWithRcon;
		}
		else {
			RoundKey[i] = RoundKey[i-4] ^ RoundKey[i-1];
		}
	}
}

// Adjust the Plain/Cipher Text Size if it is not multiply by 128-bit
void tcAdjustText(int move, int data[4])
{
	int i;
	// Move to MSB -> LSB
	i = 128 - move;
	while (i) {
		data[3] = ((data[3] >> 1) & 0x7FFFFFFF) ^ ((data[2] << 31) & 0x80000000);
		data[2] = ((data[2] >> 1) & 0x7FFFFFFF) ^ ((data[1] << 31) & 0x80000000);
		data[1] = ((data[1] >> 1) & 0x7FFFFFFF) ^ ((data[0] << 31) & 0x80000000);
		data[0] = (data[0] >> 1) & 0x7FFFFFFF;
		i--;
	}
```



```
        // Move to LSB -> MSB
        i = 128 - move;
        while (i) {
                data[0] = ((data[0] << 1) & 0xFFFFFFFE) ^ ((data[1] >> 31) & 0x00000001);
                data[1] = ((data[1] << 1) & 0xFFFFFFFE) ^ ((data[2] >> 31) & 0x00000001);
                data[2] = ((data[2] << 1) & 0xFFFFFFFE) ^ ((data[3] >> 31) & 0x00000001);
                data[3] = (data[3] << 1) & 0xFFFFFFFE;
                i--;
        }
}

// 32-bit SubByte function
int tcSubWord(int x)
{
        int r = 0;
        int i;
        int temp;
        for (i=0;i<4;i++) {
                temp = (x >> i*8) & 0xFF;
                r = r ^ tcSubByte(temp) << i*8;
        }
        return r;
}

// S-Box Lookup Table
int tcSubByte(int x)
{
        int r;
        switch(x) {
                case 0x00 : r = 0x63; break;
                case 0x01 : r = 0x7c; break;
                case 0x02 : r = 0x77; break;
                case 0x03 : r = 0x7b; break;
                case 0x04 : r = 0xf2; break;
                case 0x05 : r = 0x6b; break;
                case 0x06 : r = 0x6f; break;
                case 0x07 : r = 0xc5; break;
                case 0x08 : r = 0x30; break;
                case 0x09 : r = 0x01; break;
                case 0x0A : r = 0x67; break;
                case 0x0B : r = 0x2b; break;
                case 0x0C : r = 0xfe; break;
                case 0x0D : r = 0xd7; break;
                case 0x0E : r = 0xab; break;
                case 0x0F : r = 0x76; break;
                case 0x10 : r = 0xca; break;
                case 0x11 : r = 0x82; break;
                case 0x12 : r = 0xc9; break;
                case 0x13 : r = 0x7d; break;
                case 0x14 : r = 0xfa; break;
                case 0x15 : r = 0x59; break;
                case 0x16 : r = 0x47; break;
                case 0x17 : r = 0xf0; break;
                case 0x18 : r = 0xad; break;
                case 0x19 : r = 0xd4; break;
                case 0x1A : r = 0xa2; break;
```

```
case 0x1B : r = 0xaf; break;
case 0x1C : r = 0x9c; break;
case 0x1D : r = 0xa4; break;
case 0x1E : r = 0x72; break;
case 0x1F : r = 0xc0; break;
case 0x20 : r = 0xb7; break;
case 0x21 : r = 0xfd; break;
case 0x22 : r = 0x93; break;
case 0x23 : r = 0x26; break;
case 0x24 : r = 0x36; break;
case 0x25 : r = 0x3f; break;
case 0x26 : r = 0xf7; break;
case 0x27 : r = 0xcc; break;
case 0x28 : r = 0x34; break;
case 0x29 : r = 0xa5; break;
case 0x2A : r = 0xe5; break;
case 0x2B : r = 0xf1; break;
case 0x2C : r = 0x71; break;
case 0x2D : r = 0xd8; break;
case 0x2E : r = 0x31; break;
case 0x2F : r = 0x15; break;
case 0x30 : r = 0x04; break;
case 0x31 : r = 0xc7; break;
case 0x32 : r = 0x23; break;
case 0x33 : r = 0xc3; break;
case 0x34 : r = 0x18; break;
case 0x35 : r = 0x96; break;
case 0x36 : r = 0x05; break;
case 0x37 : r = 0x9a; break;
case 0x38 : r = 0x07; break;
case 0x39 : r = 0x12; break;
case 0x3A : r = 0x80; break;
case 0x3B : r = 0xe2; break;
case 0x3C : r = 0xeb; break;
case 0x3D : r = 0x27; break;
case 0x3E : r = 0xb2; break;
case 0x3F : r = 0x75; break;
case 0x40 : r = 0x09; break;
case 0x41 : r = 0x83; break;
case 0x42 : r = 0x2c; break;
case 0x43 : r = 0x1a; break;
case 0x44 : r = 0x1b; break;
case 0x45 : r = 0x6e; break;
case 0x46 : r = 0x5a; break;
case 0x47 : r = 0xa0; break;
case 0x48 : r = 0x52; break;
case 0x49 : r = 0x3b; break;
case 0x4A : r = 0xd6; break;
case 0x4B : r = 0xb3; break;
case 0x4C : r = 0x29; break;
case 0x4D : r = 0xe3; break;
case 0x4E : r = 0x2f; break;
case 0x4F : r = 0x84; break;
case 0x50 : r = 0x53; break;
case 0x51 : r = 0xd1; break;
case 0x52 : r = 0x00; break;
```

```
case 0x53 : r = 0xed; break;
case 0x54 : r = 0x20; break;
case 0x55 : r = 0xfc; break;
case 0x56 : r = 0xb1; break;
case 0x57 : r = 0x5b; break;
case 0x58 : r = 0x6a; break;
case 0x59 : r = 0xcb; break;
case 0x5A : r = 0xbe; break;
case 0x5B : r = 0x39; break;
case 0x5C : r = 0x4a; break;
case 0x5D : r = 0x4c; break;
case 0x5E : r = 0x58; break;
case 0x5F : r = 0xcf; break;
case 0x60 : r = 0xd0; break;
case 0x61 : r = 0xef; break;
case 0x62 : r = 0xaa; break;
case 0x63 : r = 0xfb; break;
case 0x64 : r = 0x43; break;
case 0x65 : r = 0x4d; break;
case 0x66 : r = 0x33; break;
case 0x67 : r = 0x85; break;
case 0x68 : r = 0x45; break;
case 0x69 : r = 0xf9; break;
case 0x6A : r = 0x02; break;
case 0x6B : r = 0x7f; break;
case 0x6C : r = 0x50; break;
case 0x6D : r = 0x3c; break;
case 0x6E : r = 0x9f; break;
case 0x6F : r = 0xa8; break;
case 0x70 : r = 0x51; break;
case 0x71 : r = 0xa3; break;
case 0x72 : r = 0x40; break;
case 0x73 : r = 0x8f; break;
case 0x74 : r = 0x92; break;
case 0x75 : r = 0x9d; break;
case 0x76 : r = 0x38; break;
case 0x77 : r = 0xf5; break;
case 0x78 : r = 0xbc; break;
case 0x79 : r = 0xb6; break;
case 0x7A : r = 0xda; break;
case 0x7B : r = 0x21; break;
case 0x7C : r = 0x10; break;
case 0x7D : r = 0xff; break;
case 0x7E : r = 0xf3; break;
case 0x7F : r = 0xd2; break;
case 0x80 : r = 0xcd; break;
case 0x81 : r = 0x0c; break;
case 0x82 : r = 0x13; break;
case 0x83 : r = 0xec; break;
case 0x84 : r = 0x5f; break;
case 0x85 : r = 0x97; break;
case 0x86 : r = 0x44; break;
case 0x87 : r = 0x17; break;
case 0x88 : r = 0xc4; break;
case 0x89 : r = 0xa7; break;
case 0x8A : r = 0x7e; break;
```

```
case 0x8B : r = 0x3d; break;
case 0x8C : r = 0x64; break;
case 0x8D : r = 0x5d; break;
case 0x8E : r = 0x19; break;
case 0x8F : r = 0x73; break;
case 0x90 : r = 0x60; break;
case 0x91 : r = 0x81; break;
case 0x92 : r = 0x4f; break;
case 0x93 : r = 0xdc; break;
case 0x94 : r = 0x22; break;
case 0x95 : r = 0x2a; break;
case 0x96 : r = 0x90; break;
case 0x97 : r = 0x88; break;
case 0x98 : r = 0x46; break;
case 0x99 : r = 0xee; break;
case 0x9A : r = 0xb8; break;
case 0x9B : r = 0x14; break;
case 0x9C : r = 0xde; break;
case 0x9D : r = 0x5e; break;
case 0x9E : r = 0x0b; break;
case 0x9F : r = 0xdb; break;
case 0xA0 : r = 0xe0; break;
case 0xA1 : r = 0x32; break;
case 0xA2 : r = 0x3a; break;
case 0xA3 : r = 0x0a; break;
case 0xA4 : r = 0x49; break;
case 0xA5 : r = 0x06; break;
case 0xA6 : r = 0x24; break;
case 0xA7 : r = 0x5c; break;
case 0xA8 : r = 0xc2; break;
case 0xA9 : r = 0xd3; break;
case 0xAA : r = 0xac; break;
case 0xAB : r = 0x62; break;
case 0xAC : r = 0x91; break;
case 0xAD : r = 0x95; break;
case 0xAE : r = 0xe4; break;
case 0xAF : r = 0x79; break;
case 0xB0 : r = 0xe7; break;
case 0xB1 : r = 0xc8; break;
case 0xB2 : r = 0x37; break;
case 0xB3 : r = 0x6d; break;
case 0xB4 : r = 0x8d; break;
case 0xB5 : r = 0xd5; break;
case 0xB6 : r = 0x4e; break;
case 0xB7 : r = 0xa9; break;
case 0xB8 : r = 0x6c; break;
case 0xB9 : r = 0x56; break;
case 0xBA : r = 0xf4; break;
case 0xBB : r = 0xea; break;
case 0xBC : r = 0x65; break;
case 0xBD : r = 0x7a; break;
case 0xBE : r = 0xae; break;
case 0xBF : r = 0x08; break;
case 0xC0 : r = 0xba; break;
case 0xC1 : r = 0x78; break;
case 0xC2 : r = 0x25; break;
```



```
case 0xC3 : r = 0x2e; break;
case 0xC4 : r = 0x1c; break;
case 0xC5 : r = 0xa6; break;
case 0xC6 : r = 0xb4; break;
case 0xC7 : r = 0xc6; break;
case 0xC8 : r = 0xe8; break;
case 0xC9 : r = 0xdd; break;
case 0xCA : r = 0x74; break;
case 0xCB : r = 0x1f; break;
case 0xCC : r = 0x4b; break;
case 0xCD : r = 0xbd; break;
case 0xCE : r = 0x8b; break;
case 0xCF : r = 0x8a; break;
case 0xD0 : r = 0x70; break;
case 0xD1 : r = 0x3e; break;
case 0xD2 : r = 0xb5; break;
case 0xD3 : r = 0x66; break;
case 0xD4 : r = 0x48; break;
case 0xD5 : r = 0x03; break;
case 0xD6 : r = 0xf6; break;
case 0xD7 : r = 0x0e; break;
case 0xD8 : r = 0x61; break;
case 0xD9 : r = 0x35; break;
case 0xDA : r = 0x57; break;
case 0xDB : r = 0xb9; break;
case 0xDC : r = 0x86; break;
case 0xDD : r = 0xc1; break;
case 0xDE : r = 0x1d; break;
case 0xDF : r = 0x9e; break;
case 0xE0 : r = 0xe1; break;
case 0xE1 : r = 0xf8; break;
case 0xE2 : r = 0x98; break;
case 0xE3 : r = 0x11; break;
case 0xE4 : r = 0x69; break;
case 0xE5 : r = 0xd9; break;
case 0xE6 : r = 0x8e; break;
case 0xE7 : r = 0x94; break;
case 0xE8 : r = 0x9b; break;
case 0xE9 : r = 0x1e; break;
case 0xEA : r = 0x87; break;
case 0xEB : r = 0xe9; break;
case 0xEC : r = 0xce; break;
case 0xED : r = 0x55; break;
case 0xEE : r = 0x28; break;
case 0xEF : r = 0xdf; break;
case 0xF0 : r = 0x8c; break;
case 0xF1 : r = 0xa1; break;
case 0xF2 : r = 0x89; break;
case 0xF3 : r = 0x0d; break;
case 0xF4 : r = 0xbf; break;
case 0xF5 : r = 0xe6; break;
case 0xF6 : r = 0x42; break;
case 0xF7 : r = 0x68; break;
case 0xF8 : r = 0x41; break;
case 0xF9 : r = 0x99; break;
case 0xFA : r = 0x2d; break;
```

```
			case 0xFB : r = 0x0f; break;
			case 0xFC : r = 0xb0; break;
			case 0xFD : r = 0x54; break;
			case 0xFE : r = 0xbb; break;
			case 0xFF : r = 0x16; break;
			default : r = 0x00; printf("S-BOX Error!!"); break;
		}
		return r;
}

// MixColumns function for AES
int tcMixColumns(int x)
{
		int r;
		int s0, s1, s2, s3;
		s0 = (tcMultEight(0x02,(x>>24) & 0xFF))^ (tcMultEight(0x03,(x>>16) & 0xFF))^ ((x>>8) & 0xFF)^ (x
& 0xFF);
		s1 = ((x>>24) & 0xFF)^ (tcMultEight(0x02,(x>>16) & 0xFF))^ (tcMultEight(0x03,(x>>8) & 0xFF))^ (x
& 0xFF);
		s2 = ((x>>24) & 0xFF)^ ((x>>16) & 0xFF)^ (tcMultEight(0x02,(x>>8) & 0xFF))^ (tcMultEight(0x03,x
& 0xFF));
		s3 = (tcMultEight(0x03,(x>>24) & 0xFF))^ ((x>>16) & 0xFF)^ ((x>>8) & 0xFF)^ (tcMultEight(0x02,x
& 0xFF));

		r = ((s0<<24) & 0xFF000000) ^ ((s1<<16) & 0x00FF0000) ^ ((s2<<8) & 0x0000FF00) ^ (s3 &
0x000000FF);
		return r;
}

// Multiplication in GF(2^8)
int tcMultEight(int x, int y)
{
		int r = 0x1b;
		int i, z = 0;
		int y_flag = 0;
		for (i=0;i<8;i++) {
			if (((x>>i) & 1) == 1) {
				z = z ^ y;
			}
			if (((y >> 7) & 1) == 1) {
				y_flag = 1;
			}
			y = (y << 1) & 0xFF;
			if (y_flag == 1) {
				y = y ^ r;
			}
			y_flag = 0;
		}
		return z;
}

// Multiplication in GF(2^128)
void tcMultGF(int x[4], int y[4], int Zout[4])
{
		int i,j,k=0;
		int r[4] = {0xe1000000, 0x00000000, 0x00000000, 0x00000000};
```



```
	int z[4] = {0x00000000, 0x00000000, 0x00000000, 0x00000000};
	int V[4];
	for (i=0;i<4;i++) {
		V[i] = x[i];
	}
	for (i=0;i<4;i++) {
		for (j=0;j<32;j++) {
			if (((y[i]>>(31-j)) & 1) == 1) {
				for (k=0;k<4;k++) {
					z[k] = z[k] ^ V[k];
				}
			}
			if ((V[3] & 1) == 0) {
				V[3] = ((V[3] >> 1) & 0x7fffffff) ^ ((V[2] << 31) & 0x80000000);
				V[2] = ((V[2] >> 1) & 0x7fffffff) ^ ((V[1] << 31) & 0x80000000);
				V[1] = ((V[1] >> 1) & 0x7fffffff) ^ ((V[0] << 31) & 0x80000000);
				V[0] = ((V[0] >> 1) & 0x7fffffff);
			}
			else {
				V[3] = ((V[3] >> 1) & 0x7fffffff) ^ ((V[2] << 31) & 0x80000000);
				V[2] = ((V[2] >> 1) & 0x7fffffff) ^ ((V[1] << 31) & 0x80000000);
				V[1] = ((V[1] >> 1) & 0x7fffffff) ^ ((V[0] << 31) & 0x80000000);
				V[0] = ((V[0] >> 1) & 0x7fffffff);
				for (k=0;k<4;k++) {
					V[k] = V[k] ^ r[k];
				}
			}
		}
	}
	for (i=0;i<4;i++) {
		Zout[i] = z[i];
	}
}
```

Annex N

(informative)

Admission control

N.3 Guidelines and reference design for sample scheduler and admission control unit

N.3.3 Reference design for sample scheduler and admission control unit

N.3.3.1 Sample scheduler

Change the variable list for the equation after the fifth paragraph of N.3.3.1 as follows:

where

R	is the Physical Transmission Rate
M	is the maximum possible size of MSDU~~, i.e., 2304 octets~~
O	is the Overhead in time units

Insert the following text, Annex Y and Annex Z, after Annex X:

Annex Y

(informative)

Functions of the centralized coordination service root (CCSR)

Via unspecified means over the DS, a centralized coordination service root (CCSR) performs the following functions:

— Allows APs to enroll or unenroll from the CCSS.

— Provides a directory service, wherein the CCSR responds to a Directory Service request that includes a MAC address with an indication of whether the MAC address is an S-AP within the CCSS.

— Configures the beacon interval, ClusterMaxMem, Beacon SP duration , TXSS Offset, TXSS CBAP Duration, and TXSS CBAP MaxMem (see 9.34.2.2) of each S-AP.

— Aligns the rate of increment of TSFs of S-APs within the CCSS.

— Configures the individual TSF offsets of each S-AP in order to minimize the temporal, spatial, and frequency overlap of BHIs of the BSSs in the same CCSS.

— Provides to each S-AP the Cluster Time Offset availability information from nearby co-channel S-Aps.

— Configures each S-AP with certain medium access policies for its centralized PCP/AP cluster (see 9.34.3.4). The CCSR is permitted to configure different S-APs with different medium access policies.

— Configures each S-AP with a list of one or more channels in an Operating Class that the S-AP is excluded from operating upon and that the S-AP advertises via the Channel Usage procedures (see 10.23.14). The excluded channels are available to STAs that are operating in the area covered by the ECPAC, yet are not within the ECPAC.

Annex Z

(informative)

TSPEC aggregation for DMG BSSs

Examples of TSPEC aggregation include, but are not limited to, the following:

— Traffic streams between DMG STA A and DMG STA B, having an access policy of SPCA, even if they flow in opposite directions, sharing an SP allocation created with DMG STA A as Source AID and DMG STA B as Destination AID.

— Traffic streams between DMG STA A and other DMG STAs, having an access policy of EDCA, even if they flow in opposite directions (some having DMG STA A as source and some having DMG STA A as destination), sharing a CBAP allocation created with DMG STA A as Source AID and broadcast Destination AID.

Figure Z-1 and Figure Z-2 show examples of TSPEC aggregation in a DMG BSS. Note that TSPEC 3 in Figure Z-1 (for both SPCA and EDCA cases) can flow only through an RD grant.

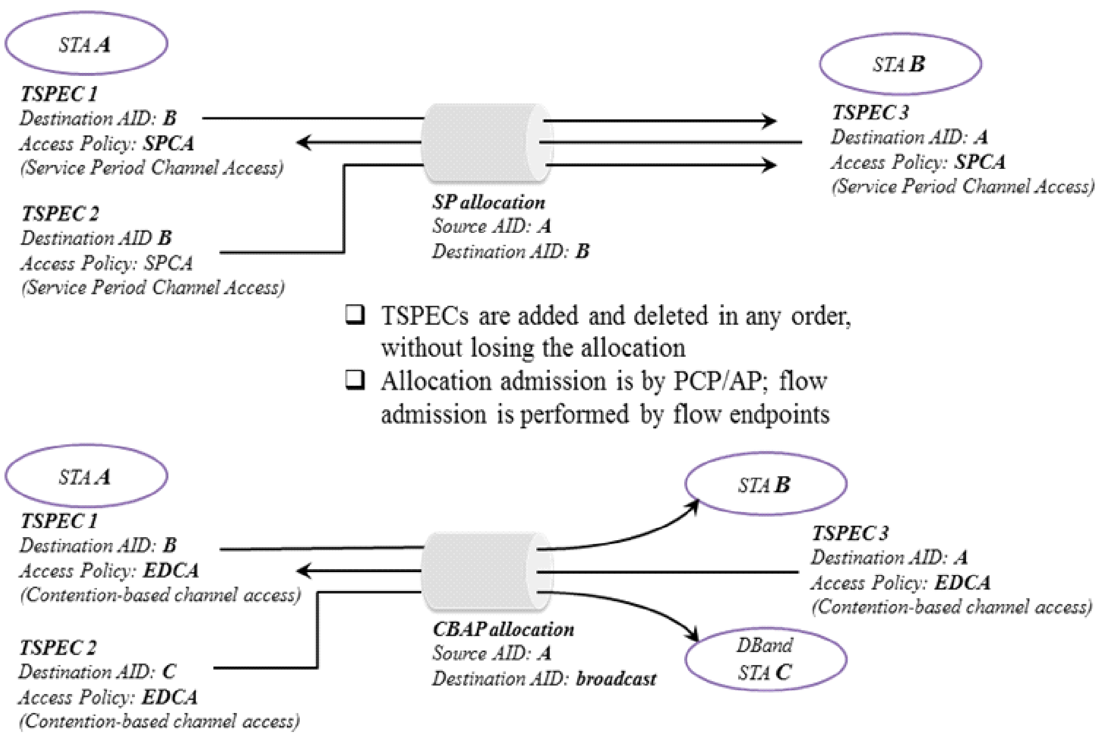


Figure Z-1—Example of TSPEC aggregation (SPCA and EDCA access policies)

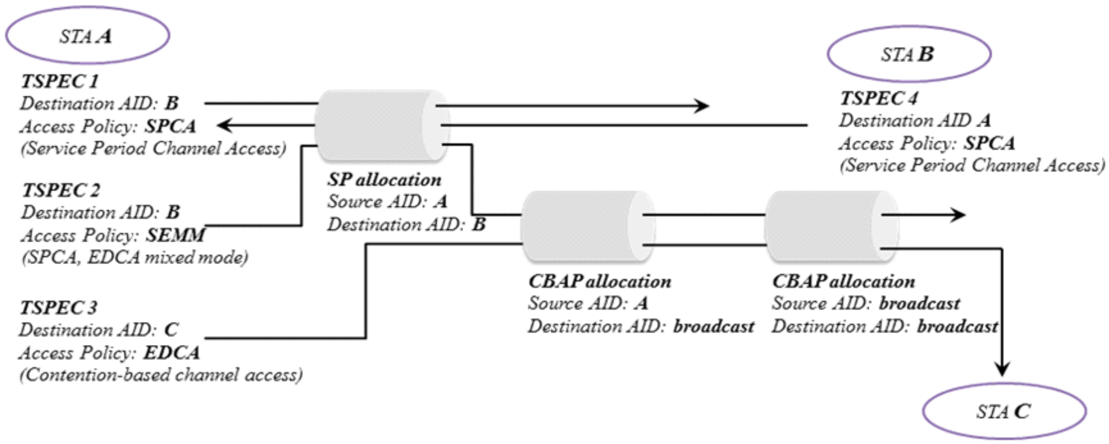


Figure Z-2—Example of TSPEC aggregation (SPCA, EDCA, and SEMM access policies)