
**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
(adoption of IEEE Std 802.11ad-2012)**

*Technologies de l'information — Télécommunications et échange
d'information entre systèmes — Réseaux locaux et métropolitains —
Exigences spécifiques —*

*Partie 11: Spécifications du contrôle d'accès du milieu sans fil (MAC) et
de la couche physique (PHY)*

*AMENDEMENT 3: Améliorations pour un très haut débit de traitement
dans la bande de fréquence 60 GHz (adoption de la norme IEEE Std
802.11ad-2012)*



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

Sponsor

**LAN/MAN Standards Committee
of the
IEEE Computer Society**

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

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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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**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**

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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 ~~strike through~~ (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

¹Notes 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).

²ITU publications are available from the International Telecommunications Union (<http://www.itu.int/>).

³NIST 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 (ANIP): 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
ANIP	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
BRPFS	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.

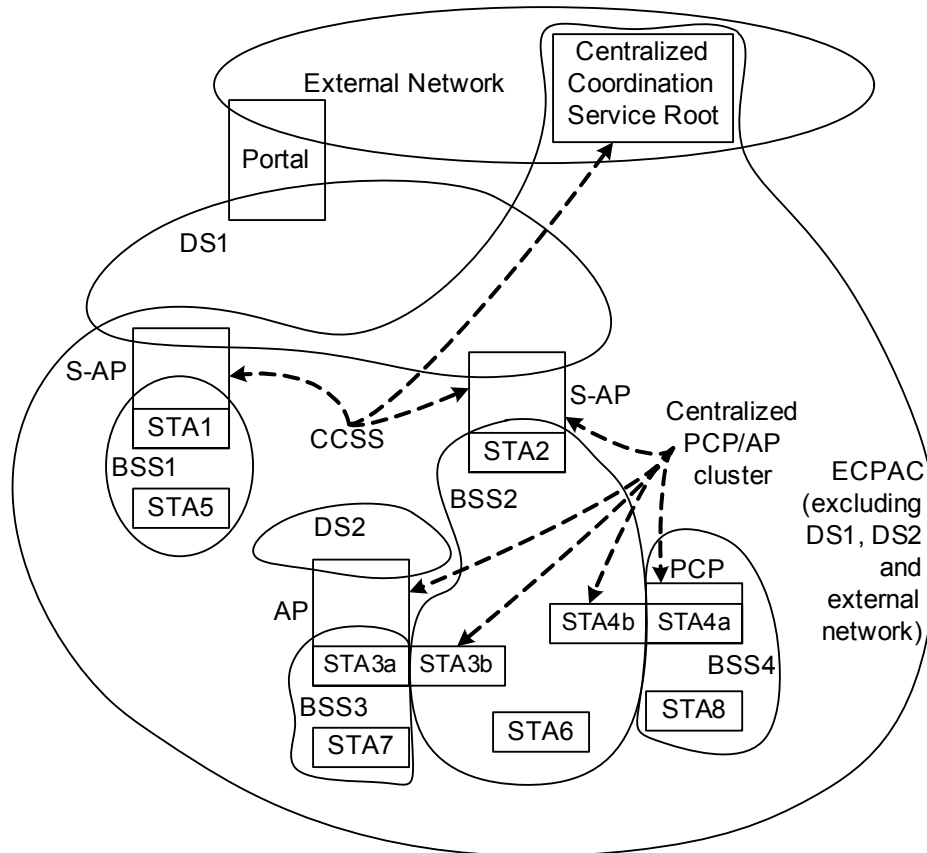


Figure 4-3a—CCSS and ECPAC

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, because a 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 PPDU 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.

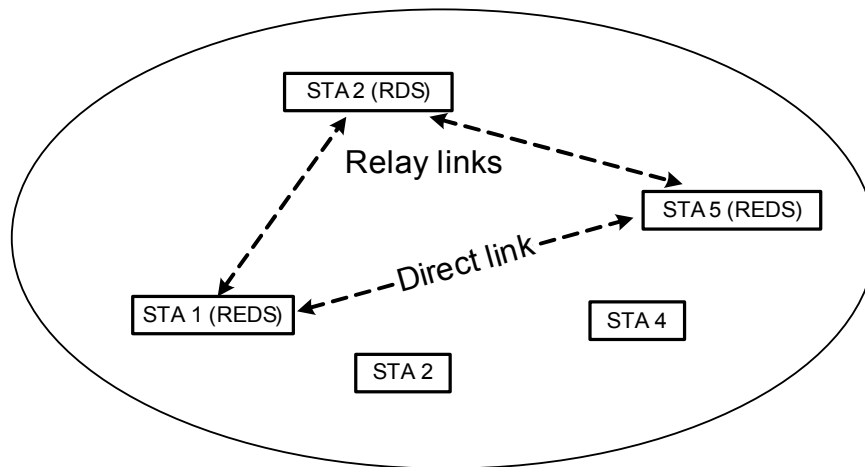


Figure 4-10a—DMG relay in a DMG BSS

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~~ both the three types of services to show the complete IEEE 802.11 architecture.

Replace Figure 4-11 with the following figure:

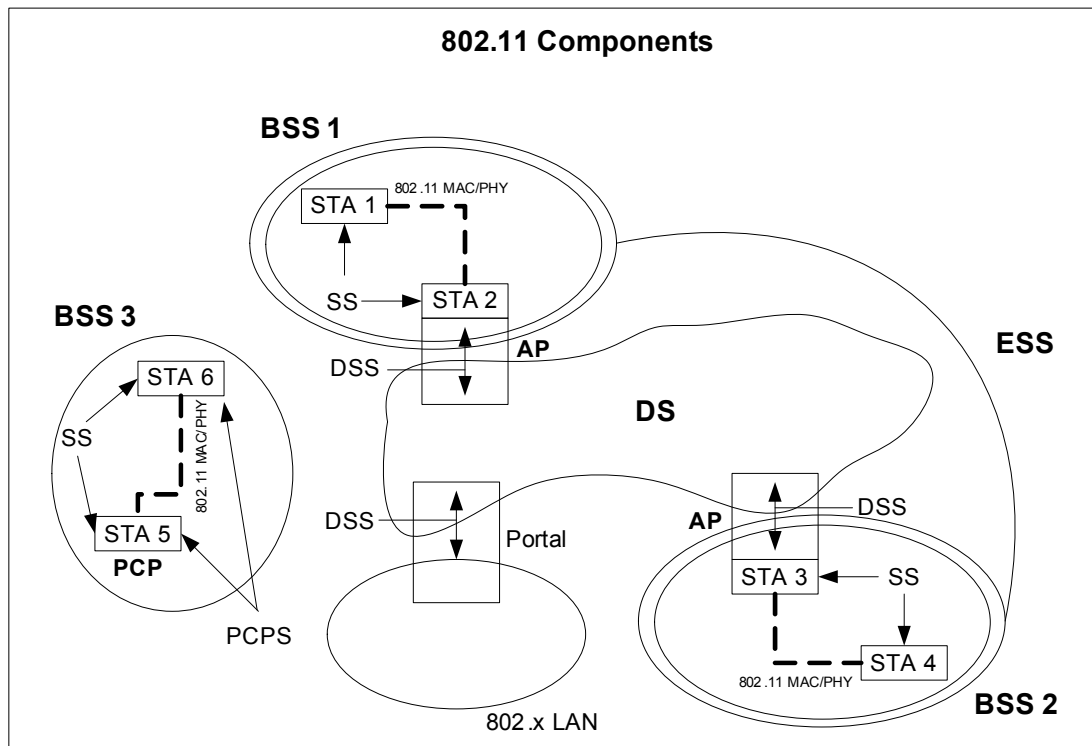


Figure 4-11—Complete IEEE 802.11 architecture

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 ARC4¹⁹ 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.