



**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 8: Medium Access Control
(MAC) Quality of Service Enhancements**

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

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

Amendment 8: Medium Access Control (MAC) Quality of Service Enhancements

Sponsor
LAN/MAN Committee
of the
IEEE Computer Society

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Abstract: This amendment defines the medium access control (MAC) procedures to support local area network (LAN) applications with quality of service (QoS) requirements. The procedures include the transport of voice, audio, and video over IEEE 802.11 wireless LANs (WLANs).

Keywords: BA, block acknowledgement, carrier sense multiple access/collision avoidance, CSMA/CA, priority, polling, power save, QoS, quality of service, traffic stream

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This introduction is not part of IEEE Std 802.11e-2005, 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 8: Medium Access Control (MAC) Quality of Service (QoS) Enhancements).

This amendment defines the medium access control (MAC) procedures to support local area network (LAN) applications with quality of service (QoS) requirements, including the transport of voice, audio, and video over IEEE 802.11 wireless LANs (WLANs).

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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 8: Medium Access Control
(MAC) Quality of Service Enhancements**

[This amendment is based on IEEE Std 802.11™, 1999 Edition (Reaff 2003), as amended by IEEE Std 802.11a™-1999, IEEE Std 802.11b™-1999, IEEE Std 802.11b-1999/Cor 1-2001, IEEE Std 802.11d™-2001, IEEE Std 802.11g™-2003, IEEE Std 802.11h™-2003, IEEE Std 802.11i™-2004, and IEEE Std 802.11j™-2004.]

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

The editing instructions are shown in ***bold italic***. Three editing instructions are used: change, delete, and insert. ***Change*** is used to make small corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed either by using ~~strike through~~ (to remove old material) or underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instructions. Editorial notes will not be carried over into future editions.

1. Overview

1.2 Purpose

Insert the following text at the end of 1.2, as part of the dashed list:

- Defines the medium access control (MAC) procedures to support local area network (LAN) applications with quality of service (QoS) requirements, including the transport of voice, audio, and video over IEEE 802.11 wireless LANs (WLANs).

End of changes to Clause 1.

2. Normative references

Insert the following citation in alpha-numerical order in Clause 2:

ISO/IEC 15802-3, Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 3: Media Access Control (MAC) Bridges.

End of changes to Clause 2.

3. Definitions

Change the definition of “coordination function” in 3.13 as follows:

3.13 coordination function: The logical function that determines when a station (STA) operating within a basic service set (BSS) is permitted to transmit and may be able to receive protocol data units (PDUs) via the wireless medium (WM). The coordination function within a BSS may have one hybrid coordination function (HCF), or it may have one HCF and one point coordination function (PCF) and will have one distributed coordination function (DCF). A quality of service (QoS) basic service set (QBSS) will have one DCF and one HCF.

Change the term “coordination function pollable” to “contention-free pollable” and change its definition in 3.14 as follows:

3.14 ~~coordination function~~ contention-free (CF) pollable: A station (STA) ~~that is able to (1) respond to a coordination function CF poll with a data frame, if such a frame is queued and able to be generated, and (2) interpret acknowledgments in frames sent to or from a point coordinator.~~

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

3.123 access category (AC): A label for the common set of enhanced distributed channel access (EDCA) parameters that are used by a quality of service (QoS) station (QSTA) to contend for the channel in order to transmit medium access control (MAC) service data units (MSDUs) with certain priorities.

3.124 admission control: An algorithm to ensure that admittance of a new flow into a resource constrained network does not violate parameterized service commitments made by the network to admitted flows.

3.125 aggregated schedule: The aggregation of delivery and/or poll schedules by the quality of service (QoS) access point (QAP) for a particular non-access point (non-AP) QoS station (QSTA) into a single service period (SP).

3.126 contention-free period (CFP): The time period during operation of a point coordination function (PCF) when the right to transmit is assigned to stations (STAs) solely by a point coordinator (PC), allowing frame exchanges to occur between members of the basic service set (BSS) without contention for the wireless medium (WM).

3.127 contention period (CP): The time period outside of the contention-free period (CFP) in a point-coordinated basic service set (BSS). In a BSS where there is no point coordinator (PC), this corresponds to the entire time of operation of the BSS.

3.128 controlled access phase (CAP): A time period when the hybrid coordinator (HC) maintains control of the medium, after gaining medium access by sensing the channel to be idle for a point coordination

function (PCF) interframe space (PIFS) duration. It may span multiple consecutive transmission opportunities (TXOPs) and can contain polled TXOPs.

3.129 delivery-enabled access category (AC): A quality of service (QoS) access point (QAP) AC where the QAP is allowed to use enhanced distributed channel access (EDCA) to deliver traffic from the AC to a non-access point (non-AP) QoS station (QSTA) in an unscheduled service period (SP) triggered by the station (STA).

3.130 direct link: A unidirectional link from one non-access point (non-AP) quality of service (QoS) station (QSTA) to another non-AP QSTA operating in the same infrastructure QoS basic service set (QBSS) that does not pass through a QoS access point (QAP). Once a direct link has been set up, all frames between the two non-AP QSTAs are exchanged directly.

3.131 downlink: A unidirectional link from an access point (AP) to one or more non-AP stations (STAs).

3.132 enhanced distributed channel access (EDCA): The prioritized carrier sense multiple access with collision avoidance (CSMA/CA) access mechanism used by quality of service (QoS) stations (QSTAs) in a QoS basic service set (QBSS). This access mechanism is also used by the QoS access point (QAP) and operates concurrently with hybrid coordination function (HCF) controlled channel access (HCCA).

3.133 enhanced distributed channel access function (EDCAF): A logical function in a quality of service (QoS) station (QSTA) that determines, using enhanced distributed channel access (EDCA), when a frame in the transmit queue with the associated access category (AC) is permitted to be transmitted via the wireless medium (WM). There is one EDCAF per AC.

3.134 fragmentation: The process of partitioning a medium access control (MAC) service data unit (MSDU) or MAC management protocol data unit (MMPDU) into a sequence of smaller MAC protocol data units (MPDUs) prior to transmission. The process of recombining a set of fragment MPDUs into an MSDU or MMPDU is known as defragmentation.

3.135 hidden station (STA): A STA whose transmissions cannot be detected using carrier sense (CS) by a second STA, but whose transmissions interfere with transmissions from the second STA to a third STA

3.136 hybrid coordination function (HCF): A coordination function that combines and enhances aspects of the contention-based and contention-free access methods to provide quality of service (QoS) stations (QSTAs) with prioritized and parameterized QoS access to the wireless medium (WM), while continuing to support non-QSTAs (nQSTAs) for best-effort transfer. The HCF includes the functionality provided by both enhanced distributed channel access (EDCA) and HCF controlled channel access (HCCA). The HCF is compatible with the distributed coordination function (DCF) and the point coordination function (PCF). It supports a uniform set of frame formats and exchange sequences that QSTAs may use during both the contention period (CP) and the contention-free period (CFP).

3.137 hybrid coordinator (HC): A type of coordinator, defined as part of the quality of service (QoS) facility, that implements the frame exchange sequences and medium access control (MAC) service data unit (MSDU) handling rules defined by the hybrid coordination function (HCF). The HC operates during both the contention period (CP) and contention-free period (CFP). The HC performs bandwidth management including the allocation of transmission opportunities (TXOPs) to QoS stations (QSTAs). The HC is collocated with a QoS access point (QAP).

3.138 hybrid coordination function (HCF) controlled channel access (HCCA): The channel access mechanism utilized by the hybrid coordinator (HC) to coordinate contention-free media use by quality of service (QoS) stations (QSTAs) for downlink unicast, uplink, and direct-link transmissions.

3.139 link: In the context of an IEEE 802.11 medium access control (MAC) entity, a physical path consisting of exactly one traversal of the wireless medium (WM) that is used to transfer an MAC service data unit (MSDU) between two stations (STAs).

3.140 non-access point (non-AP) quality of service (QoS) station (QSTA): A station (STA) that supports the QoS facility, but is not an access point (AP). A non-AP QSTA does not have an hybrid coordinator (HC) and uses the QoS AP (QAP) for the distribution system services (DSSs).

3.141 non-quality of service (non-QoS) access point (nQAP): An access point (AP) that does not support the quality of service (QoS) facility.

3.142 non-quality of service (non-QoS) basic service set (nQBSS): A basic service set (BSS) that does not support the quality of service (QoS) facility.

3.143 non-quality of service (non-QoS) station (nQSTA): A station (STA) that does not support the quality of service (QoS) facility.

3.144 parameterized quality of service (QoS): The treatment of the medium access control (MAC) protocol data units (MPDUs) depends on the parameters associated with the MPDU. Parameterized QoS is primarily provided through the hybrid coordination function (HCF) controlled channel access (HCCA) mechanism, but may also be provided by the enhanced distributed channel access (EDCA) mechanism when used with a traffic specification (TSPEC) for admission control.

3.145 piggyback: The overloading of a data frame with an acknowledgment of a previously received medium access control (MAC) protocol data unit (MPDU) and/or a poll to the station (STA) to which the frame is directed.

3.146 prioritized quality of service (QoS): The provisioning of service in which the medium access control (MAC) protocol data units (MPDUs) with higher priority are given a preferential treatment over MPDUs with a lower priority. Prioritized QoS is provided through the enhanced distributed channel access (EDCA) mechanism.

3.147 quality of service (QoS) access point (QAP): An access point (AP) that supports the QoS facility specified in this amendment. The functions of a QAP are a superset of the functions of a non-QAP (nQAP), and thus a QAP is able to function as an nQAP to non-QoS stations (nQSTAs).

3.148 quality of service (QoS) basic service set (QBSS): A basic service set (BSS) that provides the QoS facility. An infrastructure QBSS contains a QoS access point (QAP).

3.149 quality of service (QoS) facility: The set of enhanced functions, channel access rules, frame formats, frame exchange sequences and managed objects used to provide parameterized and prioritized QoS.

3.150 quality of service (QoS) independent basic service set (QIBSS): An independent basic service set (IBSS) in which one or more of its stations (STAs) support the QoS facility.

3.151 quality of service (QoS) station (QSTA): A station (STA) that implements the QoS facility. A QSTA acts as a non-QSTA (nQSTA) when associated in a non-QoS basic service set (nQBSS).

3.152 scheduled service period (SP): The SP that is scheduled by the quality of service (QoS) access point (QAP). Scheduled SPs start at fixed intervals of time.

3.153 service period (SP): A contiguous time during which one or more downlink unicast frames are transmitted to a quality of service (QoS) station (QSTA) and/or one or more transmission opportunities (TXOPs).

are granted to the same QSTA. SPs can be scheduled or unscheduled. For a non-access point (non-AP) QSTA, there can be at most one SP active at any time.

3.154 service interval (SI): The interval between the start of two successive scheduled service periods (SPs).

3.155 traffic category (TC): A label for medium access control (MAC) service data units (MSDUs) that have a distinct user priority (UP), as viewed by higher layer entities, relative to other MSDUs provided for delivery over the same link. Traffic categories are meaningful only to MAC entities that support quality of service (QoS) within the MAC data service. These MAC entities determine the UP for MSDUs belonging to a particular traffic category using the priority value provided with those MSDUs at the MAC service access point (MAC_SAP).

3.156 traffic classification (TCLAS): The specification of certain parameter values to identify the medium access control (MAC) service data units (MSDUs) belonging to a particular traffic stream (TS). The classification process, performed above the MAC service access point (MAC_SAP) at a quality of service (QoS) access point (QAP), uses the parameter values for a given TS to examine each incoming MSDU and determine whether this MSDU belongs to that TS. TCLAS may also occur at non-access point (non-AP) QoS station (QSTA) with multiple streams. However, such classification is beyond the scope of this amendment.

3.157 traffic identifier (TID): Any of the identifiers usable by higher layer entities to distinguish medium access control (MAC) service data units (MSDUs) to MAC entities that support quality of service (QoS) within the MAC data service. There are 16 possible TID values; 8 identify TCs, and the other 8 identify parameterized TSs. The TID is assigned to an MSDU in the layers above the MAC.

3.158 traffic specification (TSPEC): The quality of service (QoS) characteristics of a data flow to and from a non-access point (non-AP) QoS station (QSTA).

3.159 traffic stream (TS): A set of medium access control (MAC) service data units (MSDUs) to be delivered subject to the quality of service (QoS) parameter values provided to the MAC in a particular traffic specification (TSPEC). TSs are meaningful only to MAC entities that support QoS within the MAC data service. These MAC entities determine the TSPEC applicable for delivery of MSDUs belonging to a particular TS using the TS identifier (TSID) value provided with those MSDUs at the MAC service access point (MAC_SAP).

3.160 traffic stream identifier (TSID): Any of the identifiers usable by higher layer entities to distinguish medium access control (MAC) service data units (MSDUs) to MAC entities for parameterized quality of service (QoS) [i.e., the traffic stream (TS) with a particular traffic specification (TSPEC)] within the MAC data service. The TSID is assigned to an MSDU in the layers above the MAC.

3.161 transmission opportunity (TXOP): An interval of time when a particular quality of service (QoS) station (QSTA) has the right to initiate frame exchange sequences onto the wireless medium (WM). A TXOP is defined by a starting time and a maximum duration. The TXOP is either obtained by the QSTA by successfully contending for the channel or assigned by the hybrid coordinator (HC).

3.162 trigger-enabled access category (AC): A non-access point (non-AP) quality of service (QoS) station (QSTA) AC where frames of subtype QoS Data and QoS Null from the non-AP QSTA that map to the AC trigger an unscheduled service period (SP) if one is not in progress.

3.163 transmission opportunity (TXOP) holder: A quality of service (QoS) station (QSTA) that has either been granted a TXOP by the hybrid coordinator (HC) or successfully contended for a TXOP.

3.164 uplink: A unidirectional link from a non-access point (non-AP) station (STA) to an access point (AP).

3.165 unscheduled service period (SP): The period that is started when a non-access point (non-AP) quality of service (QoS) station (QSTA) transmits a trigger frame to the QoS access point (QAP).

3.166 user priority (UP): A value associated with an medium access control (MAC) service data unit (MSDU) that indicates how the MSDU is to be handled. The UP is assigned to an MSDU in the layers above the MAC.

End of changes to Clause 3.

4. Abbreviations and acronyms

Delete the acronym CID from Clause 4 as follows:

~~CID~~ ~~connection identifier~~

Insert the following acronyms in alphabetical order in Clause 4:

AC	access category
ACI	access category index
ACM	admission control mandatory
ACU	admission control unit
ADDBA	add Block Acknowledgment
ADDTS	add traffic stream
AIFS	arbitration interframe space
AIFSN	arbitration interframe space number
APSD	automatic power-save delivery
APSD QSTAs	non-AP QoS stations that use automatic power-save delivery
BA	Block Acknowledgment
BAR	Block Acknowledgment request
CAP	controlled access phase
DELBA	delete Block Acknowledgment
DELTS	delete traffic stream
DLS	direct-link setup
DSCP	differentiated services code point
EDCA	enhanced distributed channel access
EDCAF	enhanced distributed channel access function
EOSP	end of service period
HCCA	HCF controlled channel access
HC	hybrid coordinator
HCF	hybrid coordination function
HEMM	HCCA, EDCA mixed mode
nQAP	non-QoS access point
nQBSS	non-QoS basic service set
nQSTA	non-QoS station
QAP	QoS access point
QBSS	QoS basic service set

QIBSS	QoS independent basic service set
QoS	quality of service
QLRC	QoS long retry counter
QSRC	QoS short retry counter
QSTA	QoS station
S-APSD	scheduled automatic power-save delivery
SI	service interval
SP	service period
TC	traffic category
TCLAS	traffic classification
TID	traffic identifier
TS	traffic stream
TSID	traffic stream identifier
TSPEC	traffic specification
TXOP	transmission opportunity
U-APSD	unscheduled automatic power-save delivery
UP	user priority

End of changes to Clause 4.

5. General description

5.1 General description of the architecture

5.1.1 How wireless LAN systems are different

Change the heading of 5.1.1.2 as shown:

5.1.1.2 The medium impact on design and performance

Change item b) of 5.1.1.2 as follows:

- b) Are potentially unprotected from ~~outside other signals that may be sharing the medium.~~

Insert the following text at the end of the lettered list in 5.1.1.2:

- g) May experience interference from logically disjoint IEEE 802.11 networks operating in overlapping areas.

Insert the following text at the end of the final paragraph in 5.1.1.2:

When providing QoS services it should be understood that the MAC endeavors to provide QoS “service guarantees” within the limitations of the medium properties identified above. In other words, particularly in unlicensed spectrum, true guarantees are often not possible. However, gradations of service are always possible; and in sufficiently controlled environments, QoS guarantees can truly be made.

5.1.1.4 Interaction with other IEEE 802[®] layers

Insert the following paragraph at the end of 5.1.1.4:

When used to support applications with QoS requirements, each IEEE 802.11 LAN provides a link within an end-to-end QoS environment that may be established between, and managed by, higher layer entities. To handle QoS traffic in a manner comparable to other IEEE 802 LANs, the IEEE 802.11 QoS facility requires the IEEE 802.11 MAC sublayers to incorporate functionality that is not traditional for MAC sublayers. In addition, it may be necessary for certain higher layer management entities to be “WLAN aware” at least to the extent of understanding that the available bandwidth and other QoS characteristics of a WLAN are subject to frequent, and sometimes substantial, dynamic changes due to causes other than traffic load and are outside the direct control of network management entities.

5.2 Components of the IEEE 802.11 architecture

Insert after 5.2.4 the following subclause (5.2.5):

5.2.5 QoS basic service set (QBSS): The QoS network

The IEEE 802.11 QoS facility provides MAC enhancements to support LAN applications with QoS requirements. The QoS enhancements are available to QoS stations (QSTAs) associated with a QoS access point (QAP) in a QBSS. A subset of the QoS enhancements is available for use between QSTAs that are members of the same QoS independent basic service set (IBSS) (QIBSS). Because a QSTA implements a superset of station (STA) functionality, as defined in this standard, the QSTA may associate with a non-QoS access point (nQAP) in a non-QoS basic service set (BSS) (nQBSS), to provide non-QoS MAC data service when there is no QBSS with which to associate.

The enhancements that distinguish QSTAs from non-QoS STAs (nQSTAs) and QAPs from nQAPs are collectively termed the *QoS facility*. The quantity of certain, QoS-specific, mechanisms may vary among QoS implementations, as well as between QSTAs and QAPs, 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 QSTA or QAP must implement those core QoS facilities necessary for its QoS functions to interoperate with other QSTAs in the QBSS. 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 QSTAs separately from the core QoS facilities. A comprehensive statement on mandatory and optional functionalities is available in Annex A.

This amendment provides 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. Details of this mechanism are provided in 9.9.1.

The second mechanism, designated the *hybrid coordination function* (HCF) *controlled channel access* (HCCA), allows for the reservation of transmission opportunities (TXOPs) with the hybrid coordinator

(HC). A non-access point (non-AP) QSTA based on its requirements requests the HC for TXOPs, both for its own transmissions as well as for transmissions from the QAP to itself.¹ The request is initiated by the station management entity (SME) of the non-AP QSTA. The HC, which is collocated at the QAP, either accepts or rejects the request based on an admission control policy. If the request is accepted, the HC schedules TXOPs for both the QAP and the non-AP QSTA. For transmissions from the non-AP QSTA, the HC polls the non-AP QSTA based on the parameters supplied by the non-AP QSTA at the time of its request. For transmissions to the non-AP QSTA, the QAP directly obtains TXOPs from the collocated HC and delivers the queued frames to the non-AP QSTA, again based on the parameters supplied by the non-AP QSTA. Details of the mechanism are provided in 9.9.2 and 11.4. 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.

nQSTAs may associate in a QBSS, if allowed to associate by the QAP. All directed frames that are sent to nQSTAs by a QAP shall not use the frame formats associated with the QoS facility.

A QSTA associated in an nQBSS shall act as an nQSTA.

5.3 Logical service interfaces

Insert the following items at the end of the lettered list in 5.3:

- l) Higher layer timer synchronization (QoS facility only)
- m) QoS traffic scheduling (QoS facility only)

5.3.1 Station service (SS)

Insert the following items at the end of the lettered list in 5.3.1:

- g) Higher layer timer synchronization (QoS facility only)
- h) QoS traffic scheduling (QoS facility only)

5.3.2 Distribution system service (DSS)

Insert the following item at the end of the lettered list in 5.3.2:

- f) QoS traffic scheduling (QoS facility only)

5.4 Overview of the services

Change the first paragraph in 5.4 as follows:

There are ~~several~~many services specified by IEEE 802.11. Six of the services are used to support medium access control (MAC) service data unit (MSDU) delivery between STAs. Three of the services are used to control IEEE 802.11 LAN access and confidentiality. Two of the services are used to provide spectrum management. One of the services provides support for LAN applications with QoS requirements. Another of the services provides support for higher layer timer synchronization.

¹ In the case of downlink traffic streams (TSs).

5.4.1 Distribution of messages within a DS

Insert after 5.4.1.2 the following subclause (5.4.1.3):

5.4.1.3 QoS traffic scheduling

QoS traffic scheduling provides intra-QBSS QoS frame transfers under the HCF, using either contention-based or controlled channel access. At each TXOP, a traffic scheduling entity at the QSTA selects a frame for transmission, from the set of frames at the heads of a plurality of traffic queues, based on requested UP and/or parameter values in the traffic specification (TSPEC) for the requested MSDU. Additional information is available in 9.9.

5.4.2 Services that support the distribution service

5.4.2.2 Association

Change the last paragraph of 5.4.2.2 as follows:

A STA learns what access points (APs) are present and what operational capabilities are available from each of those APs and then requests ~~to the establishment of~~ an association with an AP of appropriate capabilities by invoking the association service. For details of how a STA learns about what APs are present, see 11.1.3.

Insert after 5.4.4.2 the following subclauses (5.4.5 and 5.4.6):

5.4.5 Traffic differentiation and QoS support

IEEE 802.11 uses a shared medium and provides differentiated control of access to the medium to handle data transfers with QoS requirements. The QoS facility (per MSDU traffic class and TSPEC negotiation) allows an IEEE 802.11 LAN to become part of a larger network providing end-to-end QoS delivery or to function as an independent network providing transport on a per-link basis with specified QoS commitments. The specifications regarding the integration and operability of the QoS facility in IEEE 802.11 specification with any other end-to-end QoS delivery mechanism like Resource Reservation Protocol (RSVP) are beyond the scope of this amendment.

5.4.6 Support for higher layer timer synchronization

Some applications, e.g., the transport and rendering of audio or video streams, require synchronized timers shared among different STAs. Greater accuracy (in terms of jitter bounds) or finer timer granularity than that provided by a BSS timing synchronization function (TSF) may be an additional requirement. In support of such applications, this amendment defines a MAC service that enables layers above the MAC to accurately synchronize application-dependent timers shared among QSTAs. The service is usable by more than one application at a time.

Although the timer synchronization methods and accuracy requirements are application-dependent and are beyond the scope of this amendment, they rely on an indication from each QSTA's MAC that is provided essentially simultaneously, via multicast, to the QSTAs. The MAC accomplishes this by indicating the occurrence of the end of the last symbol of particular data frames; the data frames of interest are identified by their MAC header Address 1 field when it contains a group address previously registered with the MAC. The last symbol is observed² on the air by QSTAs within a BSS while the delay between the observation and the delivery of the indication is known within a MAC by design (and communicated to the application by implementation-dependent means). The common reference point in time provided by the end of last symbol indication is the essential building block upon which a variety of application-dependent timer synchronization methods may be based.

²The synchronization indication (observed time) within the BSS will vary slightly due to propagation.

5.5 Relationships between services

Change item vi) of Class 1 management frames in 5.5 as follows:

- 2) Management frames
 - vi) Spectrum Management Action.

Change item i) of Class 1 data frames in 5.5 as follows:

- 3) Data frames
 - i) Data: Data frames between STAs in an IBSS with frame control (FC) bits “To DS” and “From DS” both false.

Change item c) (Class 3 frames) in 5.5 as follows:

- c) Class 3 frames (if and only if associated; allowed only from within State 3):
 - 1) Data frames
 - i) Data subtypes: Data frames allowed. That is, the “To DS” and/or “From DS” FC bits may be set to true to utilize DSSs.
 - ii) QoS data subtypes allowed to/from non-AP QSTA(s) that are associated with QAP(s).
 - iii) Data frames between QSTAs in a QBSS with FC bits “To DS” and “From DS” both false.
 - 2) Management frames
 - i) Deauthentication: Deauthentication notification when in State 3 implies disassociation as well, changing the STA’s state from 3 to 1. The STA shall become authenticated again prior to another association.
 - ii) QoS, DLS, and Block Ack Action
 - 3) Control frames
 - i) Power save (PS)-Poll
 - ii) Block Ack (BlockAck)
 - iii) Block Ack Request (BlockAckReq)

5.6 Differences between ESS and IBSS LANs

Change the final paragraph in 5.6 as follows:

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

5.7 Message information contents that support the services

5.7.1 Data

Change the text of 5.7.1 as shown:

For a STA to send data to another STA, it sends one of the following data messages, as shown below:

Data messages

- Message type: Data
- Message subtype: Data
- Information items:
 - IEEE source address (SA) of message
 - IEEE destination address (DA) of message
 - BSS identification (BSSID)
- Direction of message: From QSTA or nQSTA to nQSTA

QoS data messages

- Message type: Data
- Message subtype: QoS Data
- Information items:
 - IEEE SA of message
 - IEEE DA of message
 - BSSID
 - Traffic identifier (TID)
- Direction of message: From QSTA to QSTA

5.7.2 Association

Insert in 5.7.2 under “Association request” the following “Information items” text just after “ESSID”:

- Requester’s capabilities

Insert in 5.7.2 under “Association response” the following “Information items” text just after the entry beginning “If the association...”:

- Responder’s capabilities

5.7.3 Reassociation

Insert in 5.7.3 under “Reassociation request” the following “Information items” text just after “ESSID”:

- Requester’s capabilities

Insert in 5.7.3 under “Reassociation response” the following “Information items” text just after the entry beginning “If the reassociation...”:

- Responder’s capabilities

End of changes to Clause 5.

6. MAC service definition

6.1 Overview of MAC services

Change the heading and text of 6.1.1 as follows:

6.1.1 ~~Asynchronous~~ Data service

This service provides peer LLC entities with the ability to exchange MSDUs. To support this service, the local MAC uses the underlying PHY-level services to transport an MSDU to a peer MAC entity, where it will be delivered to the peer LLC. Such asynchronous MSDU transport is performed on a ~~best-effort~~ connectionless basis. By default, MSDU transport is on a best-effort basis. However, the QoS facility uses a traffic identifier (TID) to specify differentiated services on a per-MSDU basis. The QoS facility also permits more synchronous behavior to be supported on a connection-oriented basis using TSPECs. There are no guarantees that the submitted MSDU will be delivered successfully. Broadcast and multicast transport is part of the ~~asynchronous~~ data service provided by the MAC. Due to the characteristics of the wireless medium (WM), broadcast and multicast MSDUs may experience a lower QoS, compared to that of unicast MSDUs. All STAs will support the ~~asynchronous~~ data service, but only QSTAs in a QBSS differentiate their MSDU delivery according to the designated traffic category or traffic stream (TS) of individual MSDUs.

Because operation of certain functions of the MAC may cause reordering of some MSDUs, as discussed in more detail below, in nQSTAs, there are two service classes within the ~~asynchronous~~ data service. By selecting the desired service class, each LLC entity initiating the transfer of MSDUs is able to control whether MAC entities are or are not allowed to reorder those MSDUs.

There are two service classes available in a QSTA: QoSAck and QoSNoAck. The service classes are used to signal if the MSDU is to be transmitted with or without using the MAC-level acknowledgment.

In QSTAs either associated in a QBSS or having membership in a QIBSS, the MAC uses a set of rules that tends to cause higher UP MSDUs in a BSS to be sent before lower UP MSDUs in the BSS. The MAC sublayer entities determine the UPs for MSDUs based on the TID values provided with those MSDUs. If a TSPEC has been provided for a TS, via the MAC sublayer management entity, the MAC attempts to deliver MSDUs belonging to that TS in accordance with the QoS parameter values contained in the TSPEC. In a QBSS with some QSTAs supporting the QoS facility and others not supporting the QoS facility, in delivering an MSDU to an nQSTA, the QSTA uses the access category (AC) corresponding to the UP of the MSDU.

Insert after 6.1.1 the following subclauses (6.1.1.1 through 6.1.1.3):

6.1.1.1 Determination of UP

The QoS facility supports eight priority values, referred to as *UPs*. The values a UP may take are the integer values from 0 to 7 and are identical to the IEEE 802.1D priority tags. An MSDU with a particular UP is said to belong to a traffic category (TC) with that UP. The UP is provided with each MSDU at the medium access control service access point (MAC_SAP) either directly, in the UP parameter, or indirectly, in a TSPEC designated by the UP parameter.

6.1.1.1.1 Determination of UP of received frames at the QAP sent by other STAs in the BSS

The received unicast frames at the QAP may be as follows:

- a) Non-QoS subtypes, in which case the QAP shall assign to them a priority of Contention, if they are received during the contention period (CP), or ContentionFree, if they are received during the contention-free period (CFP).

- b) QoS subtypes, in which case the QAP shall infer the UP value from the TID in the QoS Control field directly for TID values between 0 and 7. For TID values between 8 and 15, the QAP shall extract the UP value in the UP subfield of the TS Info field in the associated TSPEC or from the UP field in the associated TCLAS (traffic classification) element, as applicable.

QAPs deliver the UP with the received MSDUs to the DS.

6.1.1.2 Interpretation of priority parameter in MAC service primitives

The value of the priority parameter in the MAC service primitives (see 6.2) may be a non-integer value of either Contention or ContentionFree or may be any integer value in the range 0 through 15.

When the priority parameter has an integer value, it is used in the TID subfields that appear in certain frames that are used to deliver and to control the delivery of QoS data across the WM.

Priority parameter and TID subfield values 0 through 7 are interpreted as UPs for the MSDUs. Outgoing MSDUs with UP values 0 through 7 are handled by MAC entities at QSTAs in accordance with the UP.

Priority parameter and TID subfield values 8 through 15 specify TIDs that are also TS identifiers (TSIDs) and select the TSPEC for the TS designated by the TID. Outgoing MSDUs with priority parameter values 8 through 15 are handled by MAC entities at QSTAs in accordance with the UP value determined from the UP subfield as well as other parameter values in the selected TSPEC. When an MSDU arrives with a priority value between 8 and 15 and for which there is no TSPEC defined, then the MSDU will be sent with priority parameter set to 0.

The non-integer values of the priority parameter are allowed at all nQSTAs. The use of priority value of ContentionFree is deprecated at QSTAs. The integer values of the priority parameter (i.e., TID) are supported only at QSTAs that are either associated in a QBSS or members of a QIBSS. A range of 0 through 15 is supported by QSTAs associated in a QBSS; whereas a range of 0 through 7 is supported by QSTAs that are members of a QIBSS. If a QSTA is associated in an nQBSS, the QSTA is functioning as an nQSTA, so the priority value is always Contention or ContentionFree.

At QSTAs associated in a QBSS, MSDUs with a priority of Contention are considered equivalent to MSDUs with TID 0, and those with a priority of ContentionFree are delivered using the contention-free delivery if a point coordinator (PC) is present in the QAP. If a PC is not present, MSDUs with a priority of ContentionFree shall be delivered using an UP of 0. At QSTAs associated in an nQBSS, all MSDUs with an integer priority are considered equivalent to MSDUs with a priority of Contention.

If a QSTA is associated in a QBSS, the MSDUs it receives in QoS data frames are reported with the TID value contained in the MAC header of that frame. The MSDUs such a QSTA receives in non-QoS data frames are reported to LLC with a priority of Contention, if they are received during the CP, or Contention-Free, if they are received during the CFP.

6.1.1.3 Interpretation of service class parameter in MAC service primitives in a QSTA

In QSTAs, the value of the service class parameter in the MAC service primitive (see 6.2) may be a non-integer value of QoSAck or QoSNoAck.

When an MSDU is received from the MAC_SAP and the recipient STA is a QSTA with the service class set to

- QoSAck, the MSDU is transmitted using a QoS data frame with the Ack Policy subfield in the QoS Control field set to either Normal Acknowledgment (Normal Ack) or Block Ack.

- QoSNoAck, the MSDU is transmitted using a QoS data frame with the Ack Policy subfield in the QoS Control field set to No Acknowledgment (No Ack). If the sender QSTA is a QAP and the frame has a multicast/broadcast DA, then the MSDU is buffered for transmission and is also sent to the DS.

When an MSDU is received from the MAC_SAP and the recipient STA is not a QSTA, the MSDU is transmitted using a non-QoS data frame.

When a QoS data frame is received from another QSTA, the service class parameter in MA-UNIT-DATA.indication primitive is set to

- QoSAck, if the frame is a QoS data frame with the Ack Policy subfield in the QoS Control field set to either Normal Ack or Block Ack.
- QoSNoAck, if the frame is a QoS data frame with the Ack Policy subfield in the QoS Control field set to No Ack. This service class is also used where the DA parameter is a broadcast/multicast address.

When a non-QoS data frame is received from an nQSTA, the service class parameter in MA-UNIT-DATA.indication primitive is set to

- QoSAck, if the frame is a unicast frame and is acknowledged by the QSTA.
- QoSNoAck, if the frame is a broadcast/multicast frame and is not acknowledged by the QSTA.

Note that the broadcast/multicast frames sent by nQSTA are not acknowledged regardless of the service class parameter in MA-UNITDATA.indication primitive.

6.1.3 MSDU ordering

Change the text of 6.1.3 as follows:

The services provided by the MAC sublayer permit, and may in certain cases require, the reordering of MSDUs.

In an nQSTA, the MAC does not intentionally reorder MSDUs except as may be necessary to improve the likelihood of successful delivery based on the current operational (power management) mode of the designated recipient STA(s). The sole effect of this reordering (if any), for the set of MSDUs received at the MAC service interface of any single STA, is a change in the delivery order of broadcast and multicast MSDUs, relative to directed MSDUs, originating from a single source STA address. If a higher layer protocol using the asynchronous data service cannot tolerate this possible reordering, the optional StrictlyOrdered service class should be used. MSDUs transferred between any pair of STAs using the StrictlyOrdered service class are not subject to the relative reordering that is possible when the ReorderableMulticast service class is used. However, the desire to receive MSDUs sent using the StrictlyOrdered service class at a STA precludes simultaneous use of the MAC power management facilities at that STA.

In QSTAs operating in a OBSS, there are two service classes, designated as QoSAck and QoSNoAck (see 6.1.1.3 for more information). The MSDUs are reordered, not only to improve the likelihood of successful delivery based on the current operational mode of the designated recipient STA(s), but also to honor the priority parameters, specified in the MA-UNITDATA.request primitive, of the individual MSDUs. The effects of this reordering (if any), for the set of MSDUs received at the MAC service interface of any single STA, are

- A change in the delivery order of broadcast and multicast MSDUs, relative to unicast MSDUs,
- The reordering of MSDUs with different TID values, originating from a single source STA address, and
- The reordering of broadcast and multicast MSDUs with the same TID but different service classes.

There shall be no reordering of unicast MSDUs with the same TID value and addressed to the same destination.

QSTAs operating in an nQBSS shall follow the reordering rules as defined for an nQSTA.

In order for the MAC to operate properly, the DS must meet the requirements of ISO/IEC 15802-1:1995.

Operational restrictions that ensure the appropriate ordering of MSDUs are specified in 9.8.

6.1.4 MAC data service architecture

Change the text in 6.1.4, including Figure 11g, as shown:

The MAC data plane architecture (i.e., processes that involve transport of all or part of an MSDU) is shown in Figure 11g. During transmission, an MSDU goes through some or all of the following processes: frame delivery deferral during power save (PS) mode, sequence number assignment, fragmentation, encryption, integrity protection, and frame formatting. IEEE 802.1X 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. This queuing may be at any of the three points indicated in Figure 11g.

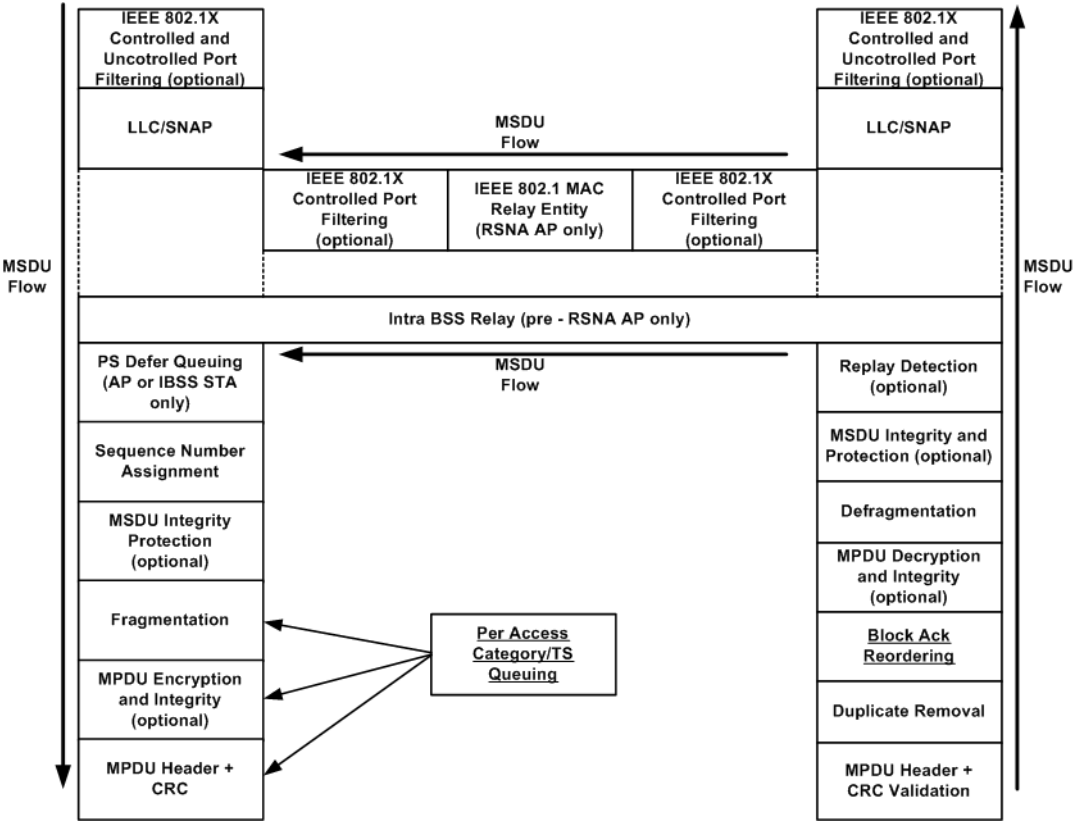


Figure 11g—MAC data plane architecture

During reception, a received data frame goes through processes of MAC protocol data unit (MPDU) header + cyclic redundancy code (CRC) validation, duplicate removal, possible reordering if the Block Ack mechanism is used, decryption, defragmentation, integrity checking, and replay detection. After replay detection (or defragmentation if security is used), the MSDU is delivered to the MAC SAP or to the DS. The IEEE 802.1X Controlled/Uncontrolled Ports discard the MSDU if the Controlled Port is not enabled or if the MSDU does not represent an IEEE 802.1X frame. Temporal Key Integrity Protocol (TKIP) and Counter

Mode (CTR) with Cipher-Block Chaining with Message Authentication Code (CBC-MAC) Protocol (CCMP) MPDU frame order enforcement occurs after decryption, but prior to MSDU defragmentation; therefore, defragmentation will fail if MPDUs arrive out of order.

6.2 Detailed service specification

6.2.1 MAC data services

6.2.1.1 MA-UNITDATA.request

6.2.1.1.2 Semantics of the service primitive

Change the final two paragraphs of 6.2.1.1.2 as follows:

The priority parameter specifies the priority desired for the data unit transfer. ~~IEEE 802.11 allows two values: Contention or ContentionFree.~~ The allowed values of priority are described in 6.1.1.2.

The service class parameter specifies the service class desired for the data unit transfer. ~~IEEE 802.11 allows two values: ReorderableMulticast or StrictlyOrdered.~~ The allowed values of service class are described in 6.1.1.3 and 6.1.3.

6.2.1.1.4 Effect of receipt

Change the text of 6.2.1.1.4 as follows:

~~On the receipt of this primitive, causes the MAC sublayer entity determines whether the request can be fulfilled according to the requested parameters. A request that cannot be fulfilled according to the requested parameters is discarded, and this action is indicated to the LLC sublayer entity using an MA-UNITDATA-STATUS.indication primitive that describes why the MAC was unable to fulfill the request. If the request can be fulfilled according to the requested parameters, the MAC sublayer entity to appends all MAC specified fields; (including DA, SA, FCS, and all fields that are unique to IEEE 802.11), and passes the properly formatted frame to the lower layers for transfer to a peer MAC sublayer entity or entities (see 6.1.4), and indicates this action to the LLC sublayer entity using an MA-UNITDATA-STATUS.indication primitive with transmission status set to Successful.~~

6.2.1.2 MA-UNITDATA.indication

6.2.1.2.2 Semantics of the service primitive

Change the final three paragraphs of 6.2.1.2.2 as follows:

The reception status parameter indicates the success or failure of the received frame for those frames that IEEE 802.11 reports via a MA-UNITDATA.indication primitive. This MAC only reports “success” ~~when because~~ all failures of reception are discarded without generating MA-UNITDATA.indication primitive.

The priority parameter specifies the receive processing priority that was used for the data unit transfer. ~~IEEE 802.11 allows two values: Contention or ContentionFree.~~ The allowed values of priority are described in 6.1.1.2.

The service class parameter specifies the receive service class that was used for the data unit transfer. ~~IEEE 802.11 allows two values: ReorderableMulticast or StrictlyOrdered.~~ The allowed values of service class are described in 6.1.1.3 and 6.1.3.

6.2.1.3 MA-UNITDATA-STATUS.indication

6.2.1.3.2 Semantics of the service primitive

Change the final three paragraphs, including the lettered list, in 6.2.1.3.2 as follows:

The transmission status parameter ~~will be~~ is used to pass status information back to the local requesting LLC sublayer entity. IEEE 802.11 specifies the following values for transmission status:

- a) Successful;
- b) Undeliverable (for unacknowledged directed MSDUs when the ~~adot11ShortRetryLimitMax~~ or ~~adot11LongRetryLimitMax~~ retry limit would otherwise be exceeded);
- c) Undeliverable (excessive data length);
- d) Undeliverable (non-null source routing);
- e) Undeliverable: unsupported priority (for priorities other than Contention or ContentionFree at an nQSTA; or for priorities other than Contention, ContentionFree, or an integer between and including 0 and 15 at a QSTA);
- f) Undeliverable: unsupported service class (for service classes other than ReorderableMulticast or StrictlyOrdered) for nQSTAs and service classes other than QoSACK or QoSNoAck for QSTAs);
- g) Unavailable priority (for ContentionFree when no PC or HC is available, or an integer between and including 1 and 15 at a QSTA that is associated in an nQBSS, or an integer between and including 8 and 15 at a QSTA that is a member of an IBSS, in which case the MSDU is transmitted with a provided priority of Contention);
- h) Undeliverable: unavailable service class (for StrictlyOrdered service when the STA's power management mode is other than "active" for nQSTAs; QSTAs do not return this value as they do not provide the StrictlyOrdered service);
- i) Undeliverable (TransmitMSDUTimer reached ~~adot11~~MaxTransmitMSDULifetime before successful delivery);
- j) Undeliverable (no BSS available);
- k) Undeliverable (cannot encrypt with a null key);
- l) Undeliverable (MSDU transmit timer reached the value in dot11EDCATableMSDULifetime or dot11QAPEDCATableMSDULifetime prior to a successful delivery or the TransmitMSDUTimer reached the delay bound prior to successful delivery);
- m) Undeliverable (Block Ack timeout value has been exceeded).

The provided priority parameter specifies the priority that was used for the associated data unit transfer (Contention, ~~or ContentionFree, or an integer between and including 0 and 15~~).

The provided service class parameter specifies the class of service used for the associated data unit transfer. In nQSTAs, the value of this parameter is {ReorderableMulticast or StrictlyOrdered}. In QSTAs, it is QoSACK or QoSNoAck.

End of changes to Clause 6.

7. Frame formats

Change the introductory text of Clause 7 as follows:

The format of the MAC frames is specified in this clause. ~~All stations~~ A STA shall be able to properly construct a subset of the frames specified in this subclause for transmission and to decode a (potentially

different) subset of the frames specified in this subclause upon validation following reception, as specified in this clause. The particular subset of these frames that a STA constructs and decodes is determined by the functions supported by that particular STA, as specified in 7.5. All STAs shall be able to validate every received frame using the frame check sequence (FCS) and to interpret certain fields from the MAC headers of all frames.

7.1 MAC frame formats

Change the text of 7.1 as follows:

Each frame consists of the following basic components:

- a) A *MAC header*, which comprises frame control, duration, address, ~~and~~ sequence control information, and, for QoS data frames, QoS control information;
- b) A variable length *frame body*, which contains information specific to the frame *type* and subtype;
- c) A *frame check sequence* (FCS), which contains an IEEE 32-bit CRC.

7.1.1 Conventions

Insert in 7.1.1 the following text before the final paragraph:

Reception, in references to frames or fields within frames (e.g., received beacon frames or a received Duration/ID field), applies to MPDUs or MAC management protocol data units (MMPDUs) indicated from the PHY layer without error and validated by FCS within the MAC sublayer. Without further qualification, *reception* by the MAC sublayer implies that the frame contents are valid, and that the protocol version is supported (see 7.1.3.1.1), with no implication regarding frame addressing or regarding whether the frame type or other fields in the MAC header are meaningful to the MAC entity that has received the frame.

Parentheses enclosing portions of names or acronyms are used to designate a set of related names that vary based on the inclusion of the parenthesized portion. For example,

- *QoS +CF-Poll frame* refers to the three QoS data subtypes that include “+CF-Poll”: the QoS Data+CF-Poll frame, subtype 1010; QoS Data+CF-Ack+CF-Poll frame, subtype 1011; and QoS CF-Ack+CF-Poll frame, subtype 1111.
- *QoS CF-Poll frame* refers specifically to the QoS CF-Poll frame, subtype 1110.
- *QoS (+)CF-Poll frame* refers to all four QoS data subtypes with CF-Poll: the QoS CF-Poll frame, subtype 1110; the QoS CF-Ack+CF-Poll frame, subtype 1111; the QoS Data+CF-Poll frame, subtype 1010; and the QoS Data+CF-Ack+CF-Poll frame, subtype 1011.
- *QoS (+)Null frame* refers to all three QoS data subtypes with “no data”: the QoS Null (no data) frame, subtype 1100; the QoS CF-Poll (no data) frame, subtype 1110; and the QoS CF-Ack+CF-Poll frame, subtype 1111.
- *QoS +CF-Ack frame* refers to the three QoS data subtypes that include “+CF-Ack”: the QoS Data+CF-Ack frame, subtype 1001; QoS Data+CF-Ack+CF-Poll frame, subtype 1011; and QoS CF-Ack+CF-Poll frame, subtype 1111.
- Whereas (*QoS*) *CF-Poll frame* refers to the QoS CF-Poll frame, subtype 1110, and the CF-Poll frame, subtype 0110.

7.1.2 General frame format

Change the text in 7.1.2, including Figure 12, as follows:

The MAC frame format comprises a set of fields that occur in a fixed order in all frames. Figure 12 depicts the general MAC frame format. The first three fields (Frame Control, Duration/ID, and Address 1) and the last field (FCS) in Figure 12 constitute the minimal frame format and are present in all frames, including reserved types and subtypes. The fields Address 2, Address 3, Sequence Control, Address 4, QoS Control, and Frame Body are present only in certain frame types and subtypes. Each field is defined in 7.1.3. The format of each of the individual subtypes of each frame types is defined in 7.2. The components of management frame bodies are defined in 7.3. The formats of management frames of subtype Action are defined in 7.4

The Frame Body field is of variable size. The maximum frame body size is determined by the maximum MSDU size (2304 octets) plus any overhead from security encapsulation.

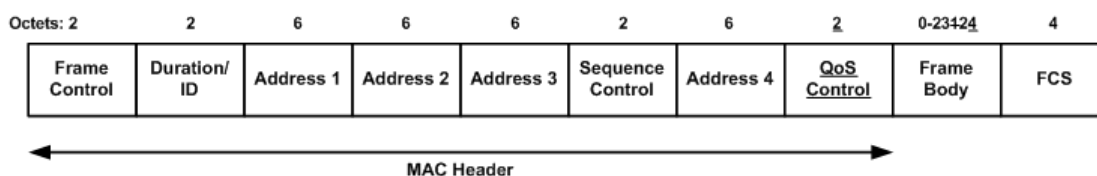


Figure 12—MAC frame format

7.1.3 Frame fields

7.1.3.1 Frame Control field

7.1.3.1.2 Type and Subtype fields

Change the text of 7.1.3.1.2, including Table 1, as shown:

The Type field is 2 bits in length, and the Subtype field is 4 bits in length. The Type and Subtype fields together identify the function of the frame. There are three frame types: control, data, and management. Each of the frame types have several defined subtypes. In data frames, the most significant bit (MSB) of the Subtype field, b7, is defined as the QoS subfield. Table 1 defines the valid combinations of type and subtype. (The numeric values in Table 1 are shown in binary.)

Table 1—Valid type and subtype combinations

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
00	Management	0000	Association request
00	Management	0001	Association response
00	Management	0010	Reassociation request
00	Management	0011	Reassociation response
00	Management	0100	Probe request
00	Management	0101	Probe response
00	Management	0110–0111	Reserved
00	Management	1000	Beacon

Table 1—Valid type and subtype combinations (*continued*)

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
00	Management	1001	Announcement traffic indication message (ATIM)
00	Management	1010	Disassociation
00	Management	1011	Authentication
00	Management	1100	Deauthentication
00	Management	1101	Action
00	Management	1110–1111	Reserved
01	Control	~~0000–1001~~ 11	Reserved
<u>01</u>	<u>Control</u>	<u>1000</u>	<u>Block Ack Request (BlockAckReq)</u>
<u>01</u>	<u>Control</u>	<u>1001</u>	<u>Block Ack (BlockAck)</u>
01	Control	1010	Power Save Poll (PS-Poll)
01	Control	1011	Request To Send (RTS)
01	Control	1100	Clear To Send (CTS)
01	Control	1101	Acknowledgment (ACK)
01	Control	1110	Contention-Free (CF)-End
01	Control	1111	CF-End + CF-Ack
10	Data	0000	Data
10	Data	0001	Data + CF-Ack
10	Data	0010	Data + CF-Poll
10	Data	0011	Data + CF-Ack + CF-Poll
10	Data	0100	Null function (no data)
10	Data	0101	CF-Ack (no data)
10	Data	0110	CF-Poll (no data)
10	Data	0111	CF-Ack + CF-Poll (no data)
10	Data	~~1000–1111~~	~~QoS DataReserved~~
<u>10</u>	<u>Data</u>	<u>1001</u>	<u>QoS Data + CF-Ack</u>
<u>10</u>	<u>Data</u>	<u>1010</u>	<u>QoS Data + CF-Poll</u>
<u>10</u>	<u>Data</u>	<u>1011</u>	<u>QoS Data + CF-Ack + CF-Poll</u>
<u>10</u>	<u>Data</u>	<u>1100</u>	<u>QoS Null (no data)</u>
<u>10</u>	<u>Data</u>	<u>1101</u>	<u>Reserved</u>
<u>10</u>	<u>Data</u>	<u>1110</u>	<u>QoS CF-Poll (no data)</u>
<u>10</u>	<u>Data</u>	<u>1111</u>	<u>QoS CF-Ack + CF-Poll (no data)</u>
11	Reserved	0000–1111	Reserved

Each Subtype field bit position is used to indicate a specific modification of the basic data frame (subtype 0). Frame Control bit 4 is set to 1 in data subtypes that include +CF-Ack, bit 5 is set to 1 in data subtypes which include +CF-Poll, bit 6 is set to 1 in data subtypes that contain no Frame Body field, and bit 7 is set to 1 in the QoS data subtypes, which have QoS Control fields in their MAC headers.

7.1.3.1.3 To DS field

Change the text in 7.1.3.1.3 as follows:

The To DS field is one bit in length and is set to 1 in data ~~type~~ frames destined for the DS. This includes all data ~~type~~ frames sent to an AP, including all data frames sent by nQSTAs associated with an AP and all data frames being sent between APs using the WM as a wireless distribution system (WDS). The To DS field is set to 0 in all other frames. For additional details, see Table 2.

7.1.3.1.4 From DS field

Change the text in 7.1.3.1.4, including Table 2, as follows:

The From DS field is 1 bit in length and is set to 1 in data ~~type~~ frames exiting the DS. This includes all data frames sent by APs, including frames sent using the WM as a WDS. ~~The From DS field is set to 0 in all other frames.~~

The permitted To/From DS bit combinations and their meanings are given in Table 2.

Table 2—To/From DS combinations in data ~~type~~ frames

To/From DS values	Meaning
To DS = 0 From DS = 0	A data frame direct from one STA to another STA within the same IBSS, <u>or a data frame direct from one non-AP QSTA to another non-AP QSTA within the same QBSS</u> , as well as all management and control ~~type~~ frames.
To DS = 1 From DS = 0	~~Data frame destined for the DS.~~ <u>A data frame from a STA to the DS via an AP.</u>
To DS = 0 From DS = 1	~~Data frame exiting the DS.~~ <u>A data frame from the DS to a STA via an AP.</u>
To DS = 1 From DS = 1	WDS <u>data</u> frame being distributed from one AP to another AP <u>via the WM.</u>

7.1.3.1.8 More Data field

Insert the following paragraph at the end of 7.1.3.1.8:

For a non-AP QSTA that has the More Data Ack subfield set in its QoS Capability information element and also has APSD enabled, a QAP may set the More Data field to 1 in ACK frames to this non-AP QSTA to indicate that the QAP has a pending transmission for the non-AP QSTA.

7.1.3.1.10 Order field

Change the text of 7.1.3.1.10 as shown:

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

7.1.3.2 Duration/ID field

Change the text of 7.1.3.2, including Table 3 (note that the order of the left three columns has been reversed), as follows:

The Duration/ID field is 16 bits in length. The contents of this field are vary with frame type and subtype, with whether the frame is transmitted during the CFP, and with the QoS capabilities of the sending STA. The contents of the field are defined as follows:

- In control ~~type~~ frames of subtype Power Save (PS)-Poll the Duration/ID field carries the association identity (AID) of the STA that transmitted the frame in the 14 least significant bits (LSB), ~~with~~ and the 2 most significant bits (MSB) both set to 1. The value of the AID is in the range 1–2007.
- In frames transmitted by the PC and nQSTAs, during the CFP, the Duration/ID field is set to a fixed value of 32 768.
- In all other frames sent by nQSTAs and control frames sent by QSTAs, the Duration/ID field contains a duration value as defined for each frame type in 7.2.
- In data and management frames sent by QSTAs, the Duration/ID field contains a duration value as defined for each frame type in 7.1.4. ~~For frames transmitted during the contention-free period (CFP), the duration field is set to 32768.~~

~~Whenever~~ 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 ~~Clause 9.2.5.4 or 9.9.2.2.1, as appropriate.~~

When the contents of a received Duration/ID field, treated as an unsigned integer, are greater than 32 768, the contents are interpreted as appropriate for the frame type and subtype or ignored if the receiving MAC entity does not have a defined interpretation for that type and subtype.

The encoding of the Duration/ID field is given in Table 3.

Table 3—Duration/ID field encoding

Bit 0–13	Bit 14	Bits 15	Usage
0–32767		0	<u>Duration value (in microseconds) within all frames other than PS-Poll frames transmitted during the CP, and under HCF for frames transmitted during the CFP.</u>
0	0	1	Fixed value <u>under point coordination function (PCF)</u> within frames transmitted during the CFP
1–16 383	0	1	Reserved
0	1	1	Reserved
1–2 007	1	1	AID in PS-Poll frames
2 008–16 383	1	1	Reserved

7.1.3.4 Sequence Control field

Insert the following sentence at the end of the text in 7.1.3.4:

Sequence Control field is not present in control frames.

7.1.3.4.1 Sequence Number field

Change the text of 7.1.3.4.1 as shown:

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

Sequence numbers are assigned to QSTAs, as well as QSTAs operating as nQSTAs because they are in an nQBSS or nQIBSS, assigned sequence numbers, to management frames and data frames (QoS subfield is set to 0), from a single modulo-4096 counter, starting at 0 and incrementing by 1 for each MSDU or MMPDU.

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

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

Insert after 7.1.3.4.2 the following new subclauses as 7.1.3.5 through 7.1.3.5.7, including the new figures in those subclauses (instructions for renumbering the existing 7.1.3.5 are given after this new text):

7.1.3.5 QoS Control field

The QoS Control field is a 16-bit field that identifies the TC or TS to which the frame belongs and various other QoS-related information about the frame that varies by frame type and subtype. The QoS Control field is present in all data frames in which the QoS subfield is set to 1 (see 7.1.3.1.2). Each QoS Control field comprises five subfields, as defined for the particular sender (HC or non-AP QSTA) and frame type and subtype. The usage of these subfields and the various possible layouts of the QoS Control field are described 7.1.3.5.1 through 7.1.3.5.7 and illustrated in Table 3a.

Table 3a—QoS Control field

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

7.1.3.5.1 TID subfield

The TID subfield identifies the TC or TS to which the corresponding MSDU, or fragment thereof, in the Frame Body field belongs. The TID subfield also identifies the TC or TS of traffic for which a TXOP is

being requested, through the setting of TXOP duration requested or queue size. The encoding of the TID subfield depends on the access policy (see 7.3.2.28) and is shown in Table 3b. Additional information on the interpretation of the contents of this field appears in 6.1.1.2.³

Table 3b—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	TSID	8–15
HEMM	TSID, regardless of the access mechanism used	8–15

For QoS Data+CF-Poll, the TID subfield in the QoS Control field indicates the TID of the data. For all QoS (+)CF-Poll frames of subtype Null, the TID subfield in the QoS Control field indicates the TID for which the poll is intended. The requirement to respond to that TID is nonbinding, and a QSTA may respond with any frame.

7.1.3.5.2 EOSP (end of service period) subfield

The EOSP subfield is 1 bit in length and is used by the HC to indicate the end of the current service period (SP). 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.

7.1.3.5.3 Ack Policy subfield

The Ack Policy subfield is 2 bits in length and identifies the acknowledgement policy that is followed upon the delivery of the MPDU. The interpretation of these 2 bits is given in Table 3c.

Table 3c—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. The addressed recipient returns an ACK or QoS +CF-Ack frame after a short inter-frame space (SIFS) period, according to the procedures defined in 9.2.8, 9.3.3 and 9.9.2.3. The Ack Policy subfield is set to this value in all directed frames in which the sender requires acknowledgment. For QoS Null (no data) frames, this is the only permissible value for the Ack Policy subfield.
1	0	No Ack The addressed recipient takes no action upon receipt of the frame. More details are provided in 9.11. The Ack Policy subfield is set to this value in all directed frames in which the sender does not require acknowledgment. This combination is also used for broadcast and multicast frames that use the QoS frame format.

³The presence of the TID subfield allows an IEEE 802.11 QBSS to function as a LAN that is able to signal the priority.

Table 3c—Ack Policy subfield in QoS Control field of QoS data frames (continued)

Bits in QoS Control field		Meaning
Bit 5	Bit 6	
0	1	No explicit acknowledgment. There may be a response frame to the frame that is received, but it is neither the ACK nor any data frame of subtype +CF-Ack. For QoS CF-Poll and QoS CF-Ack+CF-Poll data frames, this is the only permissible value for the Ack Policy subfield.
1	1	Block Ack The addressed recipient takes no action upon the receipt of the frame except for recording the state. The recipient can expect a BlockAckReq frame in the future to which it responds using the procedure described in 9.10.

An MSDU is sent using an acknowledgment policy of Normal Ack or Block Ack if the service class parameter in MA-UNITDATA.request primitive is set to QoSAck and of No Ack if the service class parameter in MA-UNITDATA.request primitive is set to QoSNoAck.

7.1.3.5.4 TXOP Limit subfield

The TXOP Limit subfield is an 8-bit field that is present in QoS data frames of subtypes that include CF-Poll and specifies the time limit on a TXOP granted by a QoS (+)CF-Poll frame from an HC in a QBSS. In QoS data frames with subtypes that include CF-Poll, the addressed QSTA is granted a TXOP that begins a SIFS period after this frame and lasts no longer than the number of 32 μ s periods specified by the TXOP limit value. The range of time values is 32 μ s to 8160 μ s. A TXOP limit value of 0 implies that one MPDU or one QoS Null frame is to be transmitted immediately following the QoS (+)CF-Poll frame. The TXOP limit is inclusive of the PHY and IFS overhead, and a QAP should account for the overhead when granting TXOPs.

7.1.3.5.5 Queue Size subfield

The Queue Size subfield is an 8-bit field that indicates the amount of buffered traffic for a given TC or TS at the non-AP QSTA sending this frame. The Queue Size subfield is present in QoS data frames sent by STAs associated in a QBSS with bit 4 of the QoS Control field set to 1. The QAP may use information contained in the Queue Size subfield to determine the TXOP duration assigned to non-AP QSTA.

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

7.1.3.5.6 TXOP Duration Requested subfield

The TXOP Duration Requested subfield is an 8-bit field that indicates the duration, in units of 32 μ s, that the sending STA desires for its next TXOP for the specified TID. The range of time values is 32 μ s to 8160 μ s. If the calculated TXOP duration requested is not a factor of 32 μ s, that value is rounded up to the next higher integer that is a factor of 32 μ s. The TXOP Duration Requested subfield is present in QoS data frames sent by non-AP QSTAs associated in a QBSS with bit 4 of the QoS Control field set to 0. The QAP may choose

to assign a TXOP duration shorter than that requested in the TXOP Duration Requested subfield. A value of 0 in the TXOP Duration Requested subfield indicates that no TXOP is requested for the MSDUs for the specified TID in the current SP.

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

7.1.3.5.7 QAP PS Buffer State subfield

The QAP PS Buffer State subfield, defined in Figure 14a, is an 8-bit field that indicates the PS buffer state at the QAP for a non-AP QSTA. The QAP PS Buffer State subfield is further subdivided into three subfields: Buffer State Indicated, Highest-Priority Buffered AC, and QAP Buffered Load.

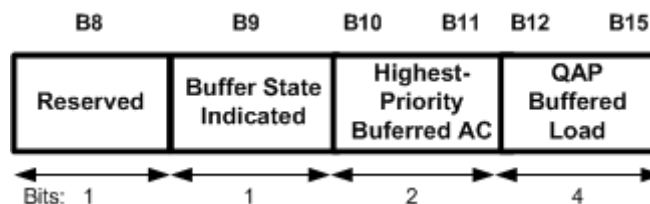


Figure 14a—QAP PS Buffer State subfield

The Buffered State Indicated subfield is 1 bit in length and is used to indicate whether the QAP PS buffer state is specified. A value of 1 indicates that the QAP PS buffer state is specified.

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

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

When the Buffered State Indicated subfield is set to 0, the Highest-Priority Buffered AC subfield and the QAP Buffered Load subfield are reserved; and the values of these subfields are either unspecified or unknown.

Change the following subclause numbers due to the insertion above of the new subclause, 7.1.3.5:

7.1.3.6 ~~7.1.3.5~~ Frame Body field

7.1.3.7 ~~7.1.3.6~~ FCS field

Insert after 7.1.3.7 the following new subclause (7.1.4):

7.1.4 Duration/ID field in data and management frames

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

- One SIFS duration plus the TXOP limit, if the TXOP limit is nonzero, or
- The time required for the transmission of one MPDU of nominal MSDU size and the associated ACK frame plus two SIFS intervals, if the TXOP limit is zero.

Within all data or management frames sent in a CP by the QSTAs outside of a controlled access phase (CAP), following a contention access of the channel, the Duration/ID field is set to one of the following values:

- a) For management frames, frames with QoS Data subfield set to 0, and unicast data frames with Ack Policy subfield set to Normal Ack,
 - 1) The time required for the transmission of one ACK frame (including appropriate IFS values), if the frame is the final fragment of the TXOP, or
 - 2) The time required for the transmission of one ACK frame plus the time required for the transmission of the following MPDU and its response if required (including appropriate IFS values).
- b) For unicast data frames with the Ack Policy subfield set to No Ack or Block Ack and for multicast/broadcast frames,
 - 1) Zero, if the frame is the final fragment of the TXOP, or
 - 2) The time required for the transmission of the following MPDU and its response frame, if required (including appropriate IFS values).
- c) The minimum of
 - 1) The time required for the transmission the pending MPDUs of the AC and the associated ACKs, if any, and applicable SIFS durations, and
 - 2) The time limit imposed by the MIB attribute dot11EDCATableTXOPLimit (dot11EDCAQAP-TableTXOPLimit for the QAP) for that AC minus the already used time within the TXOP.

Within all data or management frames sent under HCCA, to ensure NAV protection for the entire CAP, the Duration/ID field is set to one of the following values:

- The remaining duration of the TXOP, if the frame is a nonfinal frame in a TXOP with multiple frame exchanges.
- The actual remaining time needed for this frame exchange sequence, if the frame is the sole or final frame in the TXOP.