Draft Supplement to STANDARD FOR Telecommunications and Information Exchange Between Systems - LAN/MAN Specific Requirements -

Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications:

Medium Access Control (MAC) Enhancements for Quality of Service (QoS)

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IEEE 802 Committee
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Introduction

(This introduction is not part of IEEE P802.11d, Draft Supplement to STANDARD FOR Telecommunications and Information Exchange Between Systems -LAN/MAN Specific Requirements - Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications: Medium Access Control (MAC) Enhancements for Quality of Service (QoS))

At the time this standard was submitted to Sponsor Ballot, the working group had the following membership:

Current Chair, Chair

The following persons were on the balloting committee:
(To be provided by IEEE editor at time of publication.)

Contents

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Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications:

Medium Access Control (MAC) Enhancements for Quality of Service (QoS)

[This supplement is based on the current edition of IEEE Std 802.11, 1999 Edition and the 802.11a, 802.11b and 802.11d supplements]

NOTE—The editing instructions contained in this supplement define how to merge the material contained herein into the existing base standard to form the new comprehensive standard as created by the addition of IEEE Std 802.11-1999.

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 strikethrough (to remove old material) or underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material with-out disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. Editorial notes will not be carried over into future editions.

1.2 Purpose

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

- Defines the MAC procedures to support LAN applications with Quality of Service (QoS) requirements, including the transport of voice, audio and video over IEEE 802.11 wireless LANs.

2. Normative references

Insert the following two citations at the appropriate locations in clause 2:

ISO/IEC 15802-3: 1998, Information Technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Common specifications – Part 3: Media Access Control (MAC) Bridges.

IEEE Std 802.1Q-1998, IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks.

3. Definitions

Change the definition of coordination function in 3.13 as follows:

3.13 coordination function

The logical function which determines when a station operating within a Basic Service Set is permitted to transmit and may be able to receive PDUs via the wireless medium. The coordination function within a BSS may have one PCF and will have one DCF. The coordination within a QBSS will have one HCF.

Change the definition of distribution system in 3.20, and insert the informative note, as follows:

3.20 distribution system (DS)

A system used to interconnect a set of basic service sets (BSSs) and portals to create an extended service set (ESS).

NOTE: This correction, and the correction of ESS below, are needed because of a conflict in IEEE Std 802.11-1999 between these definitions and the text clause 5.4.1.2, which states "Messages which are distributed to a portal cause the DS to invoke the integration function (conceptually after the distribution service). The Integration function is responsible for accomplishing whatever is needed to deliver a message from the DSM to the integrated LAN media (including any required media or address space translations)." Clause 5.4.1.2 is correct; whereas the existing definitions, which place the integrated LAN within the DS/ESS, are incorrect. If an integrated IEEE 802.3 LAN (or any other LAN that does not signal user priority) were connected directly to the DS/ESS, then QoS traffic from a device on the integrated LAN to an 802.11 station associated in the ESS would not transit a portal, hence there would be no opportunity to regenerate the priority value needed to identify the 802.11 QoS traffic category.

Change the definition of extended service set in 3.25 as follows:

3.25 extended service set (ESS)

A set of one or more interconnected basic service sets (BSSs) and portals that appears as a single BSS to the logical link control sublayer at any station associated with one of those BSSs.

Change the definition of station in 3.42 as follows:

3.42 station (STA)

Any device that contains an 802.11 conformant medium access control (MAC) and physical layer (PHY) interface to the wireless medium (WM). As used in this standard, "STA" generally will apply to stations that do not support the full QoS facilities of a QSTA.

Insert the following new definitions at the appropriate locations in clause 3, renumbering as necessary:

3.52 access category (AC)

An enhanced variant of the DCF that contends for TXOPs using one set of EDCF channel access parameters from the QoS Parameter Set element in the beacon and Probe Response. Each QSTA shall have up to 8 ACs to support 8 user priorities.

3.53 contention free burst (CFB)

A set of frame exchange sequences, separated by SIFS, all initiated by a single WSTA, during a CP. A CFB is initiated by a WSTA after either receiving a QoS (+)CF-Poll frame, i.e., within a CAP in a CP, or upon winning an EDCF contention. A CFB exists during a TXOP. The use of CFB transfers may increase the aggregate data throughput within a given basic service area (BSA), but may also cause an increase of latency and/or latency variation (jitter) for all traffic being transferred within the same BSA.

3.54 contention free period (CFP)

A time period during operation of a basic service set (BSS) when a point coordination function (PCF) or hybrid coordination function (HCF) is active, and the right to transmit is assigned to stations by a point coordinator (PC) or hybrid coordinator (HC), allowing frame exchanges to occur without intra-BSS contention for the wireless medium (WM).

3.55 contention period (CP)

A time period during operation of a basic service set (BSS) when a distributed coordination function (DCF) or hybrid coordination function (HCF) is active, and the right to transmit is either determined locally as stations with pending transfers contend for the WM using a carrier sense multiple access algorithm with collision avoidance (CSMA/CA), or is assigned to QoS enhanced stations (QSTAs) by the hybrid coordinator (HC).

3.56 controlled access period (CAP)

A time period during which a set of frame exchange sequences, starting with a transmission by the HC. This time period could potentially include one or more CCIs allocated by the HC via the CC frames and CFBs, initiated by WSTAs that receive QoS (+)CF-Polls from the HC.

3.57 controlled contention

A contention-based multiple access scheme that may be used by QoS enhanced stations (QSTAs) to request transmission opportunities (TXOPs) from the hybrid coordinator (HC) without incurring the overhead of periodic polling nor the highly variable delays of DCF-based contention in a busy QBSS. Each instance of controlled contention occurs solely among a subset of QSTAs that need to send reservation requests and which meet criteria defined by the HC. Controlled contention takes place during a controlled contention interval (CCI) whose starting time and duration are determined by the HC.

3.58 differentiation of priorities, or differing priorities

Differentiation, or differing priorities, for the purposes of this standard, refers to a relative difference in the endeavor of a STA to gain access to the medium.

3.59 downlink

Refers to transmission from a QAP to a WSTA.

3.60 fragmentation

The process of partitioning a 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 in order to increase the probability of successful transfer across the WM and/or in order to use available TXOP duration limits efficiently in cases where the remaining TXOP duration is shorter than the time required to transmit the entire pending MSDU. The process of recombining a set of fragment MPDUs into an MSDU or MMPDU is known as defragmentation.

3.61 hybrid coordination function (HCF)

A coordination function that combines, and enhances, aspects of the contention-based and polling-based access methods to provide QoS stations (QoS STAs) with prioritized and parameterized QoS access to the wireless medium (WM), while continuing to support non-QoS (STAs) for best-effort transfer. The HCF is upward compatible with the distributed coordination function (DCF) and may optionally contain the point coordination function (PCF), it supports a uniform set of frame formats and exchange sequences that QoS stations (QSTAs) may use during both the contention period (CP) and the contention free period (CFP).

NOTE: For historical reasons, the contention-based channel access mechanism of the HCF is referred to as the "EDCF." Despite the presence of "CF" in its name, the EDCF is part of the HCF and is not a separate coordination function.

3.62 hybrid coordinator (HC)

A type of point coordinator, defined as part of the QoS facility, that implements the frame exchange sequences and MSDU handling rules defined by the hybrid coordination function. The HC operates during both the CP and CFP. The HC performs bandwidth management including the allocation of TXOPs to QSTAs and the initiation of controlled contention intervals. An HC is collocated with a QAP.

3.63 link

In relation to any IEEE 802.11 MAC entity, a logical, unidirectional path used to exchange MSDUs with a peer entity, including one or more traversals of the wireless medium.

3.64 QAP-capable STA (QAPC-STA)

A QAP-capable QSTA is able to operate either as a QAP or a WSTA.

A QAPC-STA can be *enabled* or *disabled* depending on the parameters of the MLME-START.request primitive. A *disabled* QAPC-STA operates only as a WSTA. An enabled QAPC-STA can be *active* or *inactive*. An active QAPC-STA provides all the functionality of a QAP. An inactive QAPC-STA operates as a WSTA.

NOTE: an active QAPC-STA is a QAP. An inactive QAPC-STA is a WSTA.

The transition between operating as a QAP and operating as a WSTA is defined in 11.4. A QAPC-STA is backwardly compatible with an AP, and thus is able to function as an AP for legacy STAs.

3.65 QoS access point (QAP)

An access point (AP) that implements the access point functionality specified for the QoS facility in this standard. A QAP differentiates among frames with different traffic identifiers within the traffic to/from each associated QSTA, provides at least 4 transmit queues for differing priorities of QoS traffic, and supports the hybrid coordination function (HCF). The functions of a QAP are a superset of the functions of an AP, and thus a QAP is able to function as an AP in a non-QoS BSS if so desired.

3.66 QoS basic service set (QBSS)

A basic service set (BSS) that supports LAN applications with quality of service (QoS) requirements by providing a QoS facility for communication via the wireless medium (WM).

3.67 QoS facility

The set of enhanced functions, formats, frame exchange sequences and managed objects to support the selective handling of 8 traffic categories or streams per direction per bilateral wireless link. The handling of MSDUs belonging to different traffic categories may vary based on the relative priority indicated for that MSDU, as well as the values of other parameters that may be provided by an external management entity in a traffic specification for the particular traffic category, link and direction.

3.68 QoS station (QSTA)

An IEEE 802.11 station (STA) that implements the QoS facility and hybrid coordination function (HCF) as specified herein, and includes an IEEE 802.11-conformant physical (PHY) interface to the wireless medium (WM). A QSTA acts as a STA when associated in BSS.

3.69 superframe

A contention-free repetition interval in a QBSS, consisting of a single DTIM interval (CFP Period=1) and a single beacon interval (DTIM Period=1).

NOTE: The term superframe was used in the initial P802.11 drafts in 1994 to mean a beacon interval that included a CFP and a CP, but was superseded by "contention free repetition interval" in 1995. While superframe is occasionally used informally in material pertaining to IEEE Std 802.11-1999, the term does not appear in the normative text of that standard.

3.70 sidelink

Refers to transmission from an infrastructure WSTA to an infrastructure WSTA operating in the same QBSS without passing through a (Q)AP.

3.71 traffic category (TC)

A traffic category is a set of MSDUs with a distinct user priority, as viewed by higher-layer entities, relative to other MSDUs provided for delivery over the same link. Traffic categories are only meaningful to MAC entities that support quality of serivce (QoS) within the MAC data service. These MAC entities determine the user priority for MSDUs belonging to a particular traffic category using the traffic category identifier (TCID) value provided with those MSDUs at the MAC SAP.

3.72 traffic identifier (TID)

Any of the identifiers usable for higher-layer entities to distinguish MSDUs to MAC entities that support quality of service (QoS) within the MAC data service. There are 16 possible TID values, 8 of which identify traffic categories (TCIDs) and the other 8 of which identify a traffic streams (TSIDs).

3.73 traffic specification (TSPEC)

A traffic specification describes the QoS characteristics of a traffic stream created by negotiation between a WSTA and an HC.

A traffic specification shall include a priority value, and may include quantitative objectives for, or limits on, traffic attributes such as MSDU sizes and arrival rates, traffic characteristics such as constant vs. variable data rate, maximum delivery delay, maximum delay variance (jitter), etc. and/or handling modalities such as acknowledgement policy. The MAC sublayer provides selective handling of MSDUs in a manner which attempts to honor the applicable traffic specifications. However, parameter values in traffic specifications are objectives, not guarantees, and it may be impossible, or may become impossible, for the MAC sublayer to provide the requested bandwidth and/or service quality, even in cases where the requested bandwidth had been indicated as being available and/or the requested service quality has previously been provided.

3.74 traffic stream (TS)

A traffic stream is a set of MSDUs to be delivered subject to the QoS parameter values provided to the MAC in a particular traffic specification (TSPEC). Traffic streams are only meaningful to MAC entities that support quality of serivce (QoS) within the MAC data service. These MAC entities determine the TSPEC applicable for delivery of MSDUs belonging to a particular traffic stream using the traffic stream identifier (TSID) value provided with those MSDUs at the MAC SAP.

A WSTA may simultaneously support up to 8 downlink and up to 8 uplink/sidelink traffic streams. The actual number it can support may be less than this due to implementation restrictions.

An HC may simultaneously support up to 8 downlink and up to 8 uplink/sidelink traffic streams per associated WSTA. The actual number it can support may be less than this due to implementation restrictions.

3.75 transmission opportunity (TXOP)

An interval of time when a particular QoS enhanced station (QSTA) has the right to initiate transmissions onto the wireless medium (WM). A TXOP is defined by a starting time and a maximum duration. During the contention period (CP), each TXOP begins either when the medium is determined to be available under the EDCF rules or when the QSTA receives a QoS (+)CF-Poll from the HC. The duration of an EDCF TXOP is limited by a QBSS-wide TXOP limit distributed in beacon frames, while the duration of a polled TXOP is specified in the frame header that includes the QoS (+)CF-Poll function. During the contention free period

(CFP), the starting time and maximum duration of each TXOP is specified by the HC, using the QoS (+)CF-Poll function. Within the limits of each TXOP, decisions regarding what to transmit are made locally by the MAC entity at the QSTA.

3.76 uplink

Refers to transmission from a WSTA to a QAP.

3.77 wireless station (WSTA)

A QoS enhanced station (QSTA) that is not located within a QoS enhanced access point (QAP).

4. Abbreviations and acronyms

Delete the acronym "CID" from clause 4

~~CID connection identifier~~

Insert the following new acronyms at appropriate locations in clause 4:

AC	access category
AIFS	arbitration inter frame spacing
CA	collision avoidance
CAM	continuously active mode
CAP	controlled access period
CCI	controlled contention interval
CCOP	controlled contention opportunity
CFB	contention free burst
CSMA	carrier sense multiple access
EDCF	enhanced distributed coordination function
FEC	forward error correction
HC	hybrid coordinator
HCF	hybrid coordination function
PSDU	physical (layer) service data unit
PSP	PS-Poll
QAP	QoS access point
QAPC-STA	QAP-capable QSTA
QBSS	quality of service basic service set
QoS	quality of service
QSTA	QoS station
RS	Reed-Solomon
TC	traffic category
TAID	traffic category and association (identifier)
TCID	traffic category identifier
TID	traffic identifier
TS	traffic stream
TSID	traffic stream identifier
TSPEC	traffic specification
TXOP	transmission opportunity
WSTA	wireless (QoS) stationnon-QAP QSTA

5.1.1.2 The media impact the design

Insert the following text at the end of the indented list:

g) May experience interference from logically disjoint 802.11 networks operating in adjacent or overlapping areas.

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 quality of service requirements, each IEEE 802.11 LAN is a single 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, despite the enormous differences in characteristics of the underlying media, the IEEE 802.11 QoS facility incorporates functionality that is untraditional for QoS support by 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 outside the direct control of network management entities.

Insert the following subclause after 5.2.2.1:

5.2.2.2 QBSS: The quality of service network

The IEEE 802.11 QoS facility provides MAC enhancements to support LAN applications with quality of service (QoS) requirements. The QoS enhancements are available to QoS enhanced stations (QSTAs) associated with a QoS enhanced access point (QAP) in a QoS BSS (QBSS). A subset of the QoS enhancements may be available for use between QSTAs that are members of the same IBSS. Because a QSTA implements a superset of STA functionality, the QSTA may associate with an AP in a BSS, to provide non-QoS MAC data service in cases where there is no QBSS with which to associate.

The enhancements which distinguish QSTAs from STAs and QAPs from APs comprise an integrated set of QoS-related formats and functions that are collectively termed the QoS facility. The quantity of certain, QoS-specific resources, such as independent traffic queues, are permitted to vary among QoS implementations, as well as between QSTAs and QAPs, over ranges specified in subsequent clauses. However, all service primitives, frame formats, coordination function and frame exchange rules, and management interface functions defined as part of the QoS facility are mandatory, with the exception of the MAC-level forward error correction (FEC) function, defined in 7.5, which is an option, and the presence of which is indicated by QSTAs separately from the QoS capability.

5.2.4 Integration with wired LANs

5.3 Logical service interfaces

Insert the following item at the end of the list:

j) QoS traffic scheduling (QoS facility only)

5.3.1 Station service (SS)

Insert the following item at the end of the list:

e) QoS traffic scheduling (QoS facility only)

5.3.2 Distribution system service (DSS)

Change the third paragraph as follows:

The DSSs are provided by the DS. They are accessed via a STA that also provides DSSs. A STA in a BSS that is providing access to DSS is an AP. In a QBSS, the QSTA that is providing access to DSS is a QAP.

Insert the following item at the end of the list:

f) QoS traffic scheduling (QoS facility only)

5.4 Overview of the services

Change the first paragraph as follows:

There are ten services specified by IEEE 802.11. Six of the services are used to support MSDU delivery between STAs. Three of the services are used to control IEEE 802.11 LAN access and confidentiality. One of the services is used to support LAN applications with QoS requirements.

5.4.2.1 Mobility types

Insert the following item at the end of the list:

d) *QBSS-transition:* This type is defined as a QSTA movement from one QoS Basic Service Set in one Extended Service Set to another QoS Basic Service Set within the same Extended Service Set. End-to-end QoS connections are maintained, although user-detectable, temporary disruption may occur during handover.

5.4.2.2 Association

Change the fifth paragraph of 5.4.2.2 as follows:

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

Insert the following subclause after the end of 5.4.3.3:

5.4.4 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 features (per MSDU traffic class and TSPEC negotiation) allow 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 within its own boundary with specified QoS commitments..

5.5 Relationships between services

Change the definition of class 1 frames as follows:

a) Class 1 frames (permitted from within States 1, 2, and 3):

1) Control frames

   i) Request to send (RTS)
   ii) Clear to send (CTS)
   iii) Acknowledgment (ACK)
   iv) Contention-Free (CF)-End+ACK
   v) CF-End

2) Management frames

   i) Probe request/response
   ii) Beacon
   iii) Authentication: Successful authentication enables a station to exchange Class 2 frames. Unsuccessful authentication leaves the STA in State 1.
   iv) Deauthentication: Deauthentication notification when in State 2 or State 3 changes the STA's state to State 1. The STA shall become authenticated again prior to sending Class 2 frames.
   v) Announcement traffic indication message (ATIM)
   vi) QAPC-STA assertion action frames

3) Data frames

   i) Data: Data frames in an IBSS with frame control bits "To DS" and "From DS" both false.

Change the definition of class 3 frames 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 WSTA(s) that are associated with QAP(s).
   iii) Data frames between QSTAs in a QBSS with frame control (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 station shall become authenticated again prior to another association.
   ii) Action

3) Control frames

   i) PS-Poll
   ii) Reservation Request (RR)
   iii) Burst Ack (BurstAck)
   iv) Burst Ack Request (BurstAckReq)
   v) Controlled Contention (CC)

5.6 Differences between ESS and IBSS LANs

Change the final paragraph in this clause as follows:

The services that apply to an IBSS are the SSs. A QIBSS supports EDCF operation. The parameters that control separation of traffic classes in EDCF are fixed. A QIBSS does not support setting up TSPECS, has no HC and cannot support HCF operation.

Operation as a QIBSS can be avoided if one or more of its QSTAs support the QAPC-STA feature described in section 5.9.

5.7.1 Data

Insert the QoS Data message at the end of 5.7.1 (with appropriate leader characters):

QoS Data Messages

type: Data
Message sub-type: QoS Data
Information items:
  IEEE source address of message
  IEEE destination address of message
  BSS ID
  Traffic Identifier
Direction of message: From STA to STA

5.7.2 Association

Insert the following text under "Association request" just after entry for "ESSID" (with appropriate leader character):

Requester's capabilities

Insert the following text under "Association response" just after entry beginning "If the association..."(with appropriate leader character):

Responder's capabilities

5.7.3 Reassociation

Insert the following text under "Reassociation request" just after entry for "ESSID" (with appropriate leader character):

Requester's capabilities

Insert the following text under "Reassociation response" just after entry beginning "If the reassociation..."(with appropriate leader character):

Responder's capabilities

Insert the following subclause, including tables and figures included therein, after 5.7, renumbering 5.8 as 5.10 and renumbering tables and figures as necessary:

5.8 AP Mobility

In 802.11, there is nothing to preclude the concept of a mobile AP, as well as mobile STAs. This document defines, in addition, the concept of a "QoS AP-capable station" (QAPC-STA). Such a STA has the ability to become an AP (regardless of whether it is physically mobile). It can continue (with reassociations) the operation of a particular SSID if an AP goes out of range or becomes unavailable. "AP mobility" relates to the movement of the AP function between QAPC-STA devices, not physical movement of these devices.

NOTE: AP mobility also implictly enables HC mobility between QAPC-STA devices that are also capable of operating as an HC when an active QAPC-STA.

A group of stations containing at least one QAPC-STA operates as an infrastructure network. A QAPC-STA acts as an AP in accordance with the following rules:

- A group of stations including QAPC-STA and non-QAPC-STA (Q) AP (legacy AP or QAPC-STA-disabled QAP) uses the non-QAPC-STA (Q)AP.
- At any time the most capable QAPC-STA is active as the AP. The "most capable" QAPC-STA is the one that has the highest ranking based on whether it is line powered or not, its Supported Rates of data transmission, and the bandwidth connection to the infrastructure.
- A QAPC-STA can inhibit transfer to another QAPC-STA while it has an active TSPEC.
- If the most capable QAPC-STA or legacy AP becomes inactive, the next most capable QAPC-STA takes over as the AP.
- If a more capable QAPC-STA arrives in a network with an active QAPC-STA, the more capable QAPC-STA takes over as the active AP.

There is no additional protection against hidden node problems. It is assumed that all QAPC-STA stations in the network (identified by its SSID) are in range.

Transfer of AP responsibility using this mechanism does not preserve:

- Any security associations (i.e. protocols for key derivation have to be performed with the new AP).
- Power management
- QoS commitments (i.e. any TSPECs that have been negotiated have to be re-negotiated after a re-association)

Following a transfer, the BSS identity is not preserved. The choice of the configuration parameters for the new BSS is the responsibility of the newly active QAPC-STA, and it may change some or all of the previous settings, with the exception of the SSID, which must be maintained.

Transfer of AP responsibility should be an infrequent event. It occurs in response to QAPC-STA or (Q)AP devices starting or stopping operation.

For the STAs using the SSID, a transfer of AP responsibility between devices triggers an association or reassociation.

5.8.1 Effect of AP Mobility on higher layers

A QAPC-STA shall inform its SME whether it is the active QAPC-STA by means of the MLME-QAPC-STATUS.indication primitive. The SME may make use of this information for purposes not limited to connecting or disconnecting from the DS.

When an active QAPC-STA becomes inactive, it shall emit MLME-DEASSOCIATION.indications for all STAs that were associated with the QAPC-STA before emiting the MLME-QAPC-STATUS.indication.

Note: the disassociation indication from the old QAPC-STA may arrive before or after an associate indication from the new QAPC-STA.5.9 Wireless Address Resolution Protocol (Informative)

5.9.1 Overview

Direct data frames are those sent from one non-AP STA to another directly in an infrastructure BSS, without using the DS. The wireless address resolution protocol (WARP) must be used by stations wishing to use this facility in order to determine whether it is possible and desirable to transmit frames in this manner. This protocol does not apply in an IBSS, since in that case frames are always sent directly from one STA to another.

The protocol is described here in outline, and the specific procedures at STAs and APs to implement each of the steps described here is contained in clause 9.

Determination of when a particular frame is to be sent directly always lies entirely with the transmitting STA, in that a transmitting STA may choose to always use the DS. However, support functions are provided by both the AP and the receiving STA, which indicates its willingness to participate in direct communication to the AP.

The setup of direct communication is illustrated in outline in Figure 10.1 and consists of several steps:

1. Registration. STA 2 indicates to the AP its willingness and capability to participate in direct communication.

2. Location discovery procedure, which consists of an exchange of management action frames with the AP:

    a. A transmitting STA, STA 1, which has traffic to send to STA 2, sends an inquiry MMPDU to the AP to determine whether the STA with that specific MAC address is likely to be available for direct communication.

    b. The AP sends a response MMPDU, indicating that the STA with that MAC address is in its BSS and has indicated willingness to participate in direct communication.

3. Direct negotiation procedure, which occurs following a successful location discovery procedure, and consists of an exchange of management action frames between the two STAs:

    a. STA 1 sends a direct communication setup request MMPDU to STA 2, choosing a data rate and power level that it wishes to use.

    b. STA 2 sends a direct communication setup reply MMPDU to STA 1, using the same rate at which it received the response, and containing the same transaction token.

Any of these steps may fail and cause the setup attempt to be abandoned; if, for instance, the receiving station had not registered with the AP its willingness to receive directed traffic, and may not in fact be in the same BSS, the AP will return a location discovery response action frame indicating a failure. The transmitting STA would not then proceed to the direct negotiation procedure.

Following a successful location discovery procedure, transmission of the direct communication setup request may fail, in which case the transmitting station should retry using a lowered data rate.

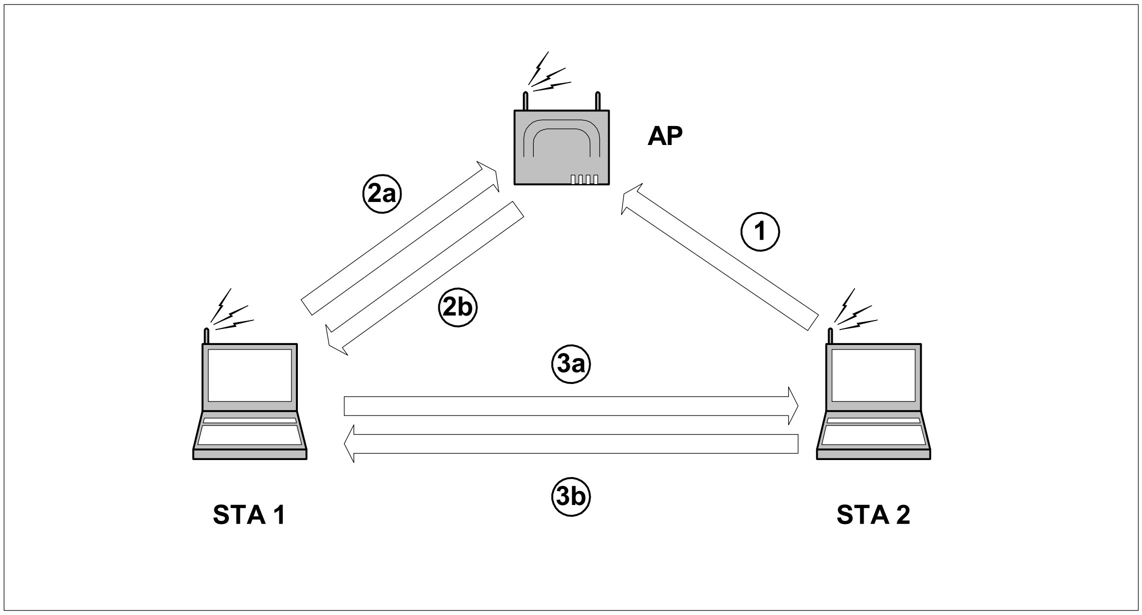

Figure 10.1 - Direct Communication Setup

A STA wishing to transmit direct frames, having completed the location discovery procedure (and possibly, but not necessarily, a direct negotiation procedure), may indicate to the AP that it wants to be informed if the AP learns of a change in status of the receiving STA. An example instance of this procedure is shown in Figure 10.2. The steps shown consist of:

1. The transmitting STA sends a status change notify request MMPDU to the AP, which updates its state table for the receiving STA.

2. The receiving STA subsequently sends a direct disable MMPDU to the AP.

3. The AP sends a status change notify response MMPDU to the STA that had previously requested notification.

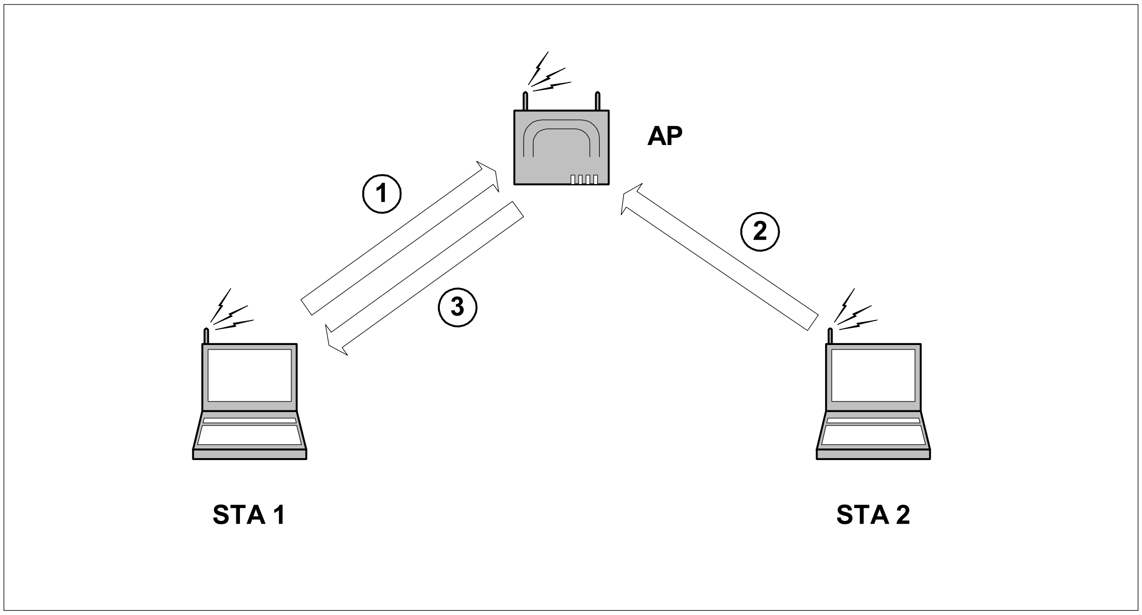

Figure 10.2 - Status Change Notification

It is also possible that the receiving STA is operating in PSP mode, and therefore may be in the doze state at certain times. The transmitting station has the responsibility of learning when the receiving station may be in that state.

In order to determine when a PSP STA is awake, the transmitting STA uses the wake notify procedure. This is illustrated in Figure 10.3.

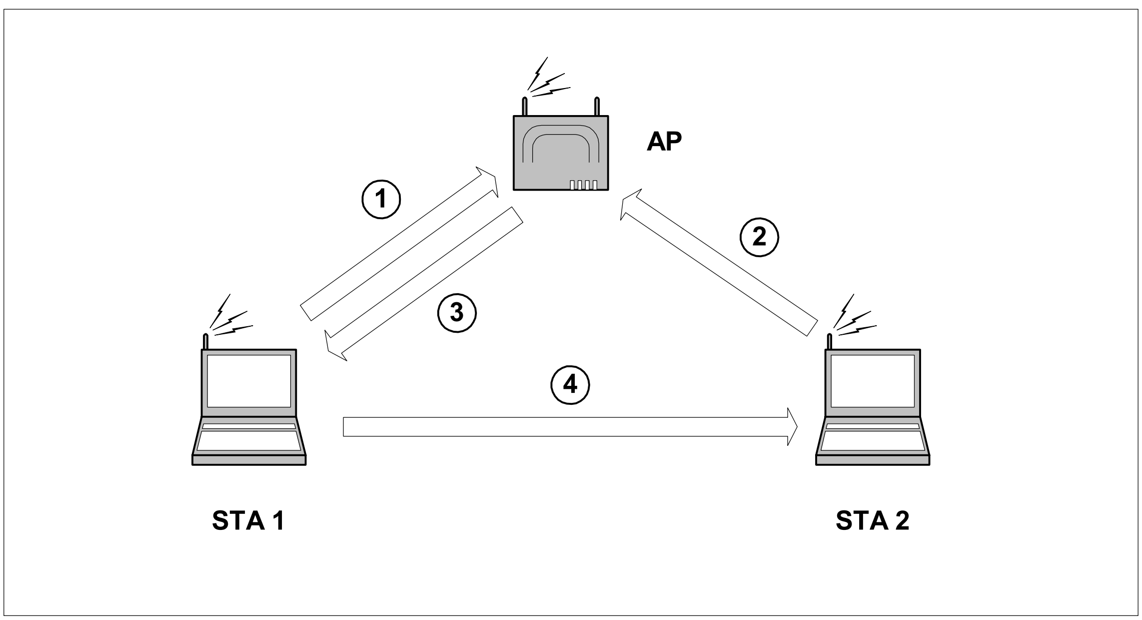

Figure 10.3 - Wake Notify Procedure

The process shown has four steps:

1. The transmitting STA sends a wakeup notify request MMPDU to the AP, containing the MAC address of the receiving STA. The Transmitting STA must previously have performed a location discovery procedure.

2. If the requested receiving STA is associated with the BSS, and is in the doze state, the AP sets the buffered traffic flag in successive beacon TIM elements for that STA. When the receiving STA detects the buffered traffic indication, it will enter the wake state and indicate this to the AP by sending it a PS-Poll frame.

3. The AP, on receipt of the PS-Poll, sends a wakeup notify response MMPDU back to the requesting STA with status “awake”.

4. The transmitting STA can now send frames to the receiving STA directly, indicating completion by setting the “More Data” bit in the frame control field of the final frame to zero.

The transmitting STA (STA1) should note in its WARP cache that the receiving STA (STA2) is in the doze state if STA2 is in PSP mode and STA1 sends STA2 a direct MPDU with the More Data bit in Frame Control set to zero.

STA1 is always permitted to redundantly send a wake notify request MMPDU to the AP; if such a request is received by the AP and the receiving STA is already in the wake state, the AP immediately responds with a wake notify response MMPDU with status “awake”.

If the AP receives a wake notify request MMPDU for a receiving STA which is not in this BSS or not currently able to receive direct frames, the AP sends a wake notify response MMPDU with status “not available”.

5.9.2 WARP Cache

STAs which wish to send frames using direct mode are required to maintain a WARP cache, which contains a list of known destination MAC addresses and associated data required to send direct mode frames. Completion of the direct communication setup procedure results in an entry being added to the WARP cache. An entry in the WARP cache may indicate that the associated MAC address is not reachable directly.

	DA	RA	PM	PS
1	00:6c:31:7b:a4:31	Direct	CAM	
2	00:6c:31:7b:a4:46	Direct	PSP	Awake
3	00:6c:31:7b:a4:05	DS		
4	00:6c:31:7b:a4:47	Direct	PSP	Doze
0	Default	DS		

Figure 10.4 - WARP Cache Example

A transmitting STA may only send frames in direct mode if it has a WARP cache entry indicating that it can at that time; by default all frames must be sent via the DS. STAs may arbitrarily discard WARP cache entries, but can only add them on successful completion of the above procedure.

An example set of cache entries is shown in Figure 10., omitting some of the supporting state information which will be required in a real implementation. In this case, the station knows of four destination addresses. If it has a frame to send to a station not on the list, it may either:

1. Send the frames using the “default” entry, that is, via the DS or
2. Perform a location discovery procedure to add a new entry. It may also discard an old cache entry to make space in its table, if the table is of limited size.

For entry 3 in the example cache, it is not possible, for some reason, to send direct frames to the indicated DA. This may be for a number of reasons - the particular DA may not be a STA in the same BSS. It might not even be a wireless LAN STA.

Entries 1, 2 and 4 are all indicated as reachable and willing to receive direct traffic. In the case of entry 1, the STA is known to be operating in CAM mode, and so may be sent direct frames at any time.

In the case of entry 2, the receiving STA is currently in the wake state, and may be sent direct frames while it remains so. If this STA does not successfully send a frame to this receiving STA in direct mode with the More Data bit set for an interval of aWakeTimeout, it will be assumed to have reverted to the doze state.

5.9.3 Willingness to Participate at a Receiver

In step 1 of the direct communication setup, the receiving STA indicates its willingness to receive frames directly. It can also revoke this indication at any time. Reasons for not participating in direct station to station transfers include but are not limited to:

a) Legacy station (unable to receive direct traffic)

b) Receiving direct traffic contrary to security policy

c) Receiving direct traffic contrary to power management policy

d) Roaming to another BSS imminent

APs are required to implement WARP support functions, which include maintaining additional state for each associated station. This state consists of an indication of the current willingness of the STA to receive direct frames, and, if the state is set to “enabled” a list of STAs which have requested notification if that state changes.

In adding entries to its WARP cache, a transmitting STA carries out a location discovery procedure. This allows the STA to determine whether it is worthwhile to initiate a direct communication setup procedure with a particular receiving STA. Possible cases for the status of a specific destination MAC address are:

a) Directly reachable from this station and capable of receiving direct traffic

b) In this BSS, but

    a. Not reachable directly from this station

    b. Capable but not currently willing to receive direct traffic

    c. Not capable of receiving direct traffic

c) Not in this BSS and

a. Capable of receiving direct traffic

b. Not capable of receiving direct traffic

d) Direct traffic prohibited in this BSS due to security policy

Note that security policy may be applied per station or imposed globally per BSS. In any case, the AP will return a status indication in the location discovery response MMPDU stating the reason in the case that directed traffic is not permitted.

6. MAC service definition

6.1.1 Asynchronous data service

Change the existing paragraph in 6.1.1 as follows:

This service provides peer LLC entities with the ability to exchange MAC service data units (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 connectionless basis. By default, MSDU transport is on a best effort basis. However, the QoS facility allows a traffric identifier to be communicated through the MAC SAP on a per-MSDU basis. 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 WM, broadcast and multicast MSDUs may experience a lower quality of service, especially with regard to loss rate, compared to that of unicast MSDUs. All STAs support the asynchronous data service, but only QSTAs in a QBSS differentiate their MSDU delivery according to the designated traffic categoryor traffic stream of individual MSDUs.

Insert the following paragraph at the end of 6.1.1:

If the MAC sublayer entity and its association in a QBSS support the QoS facility, the MAC will endeavor to deliver MSDUs with higher user priority in preference to other MSDUs with lower user priority that may be queued for delivery throughout the BSS. These MAC sublayer entities determine the user priorities for MSDUs based on the TID values provided with those MSDUs. If a TSPEC has been provided for a traffic stream, via the MAC sublayer management entity, the MAC will endeavor to deliver MSDUs belonging to that traffic stream in accordance with the QoS parameter values contained in the TSPEC. In a QBSS with some QSTAs, which support the QoS facility, and some STAs, which do not, the STA MSDU delivery corresponds to QSTA delivery of MSDUs with a user priority zero.

Insert the following two subclauses between 6.1.1 and 6.1.2:

6.1.1.1. Determination of user priority

The QoS facility supports 8 "user priority" values designated 7 (highest) through 0 (lowest). The user priority is provided with each MSDU at the medium access control service access point (MAC SAP), either directly, in the priority parameter, or indirectly, in a traffic specification (TSPEC) designated by the priority parameter.

6.1.1.2. Interpretation of TID

The value of the priority parameter in the MAC service primitives may be any integer value in the range 0 through 15. This same range of values is used in the traffic identifier (TID) fields that appear in certain frames used to deliver, and to control the delivery of, QoS data across the WM.

Priority parameter and TID field values 0 through 7 are interpreted as traffic category identifiers (TCIDs). Outgoing MSDUs with priority values 0 through 7 are handled by MAC entities at QSTAs in accordance with the local significance of the user priority determined from the specified TCID, and use the current, local default values for all other QoS parameters.

Priority parameter and TID field values 8 through 15 are interpreted as traffic stream identifiers (TSIDs), and select the TSPEC for the TS designated by the TID value minus 8 (i.e., TID 8 selects TSPEC 0, TID 9 selects TSPEC 1, ..., TID 15 selects TSPEC 7). Outgoing MSDUs with priority parameter values 8 through 15 are handled by MAC entities at QSTAs in accordance with the local significance of the user priority value determined from the priority parameter in the selected TSPEC, and using any non-null values in the selected TSPEC in lieu of the default values for the corresponding QoS parameters. Selection of a TSPEC for which the MLME has not provided (non-null) QoS parameter values is equivalent to using a TSPEC with a priority parameter equal to the TID value minus 8 and the current, local default values for all other QoS parameters.

6.1.3 MSDU ordering

Change the first paragraph of 6.1.3 as follows:

The services provided by the MAC sublayer permit, and may in certain cases require, the reordering of MSDUs. The MAC does not intentionally reorder MSDUs except as may be necessary either to improve the likelihood of successful delivery based on the current operational ("power management") mode of the designated recipient station(s), or to honor the user priorities of individual MSDUs. The sole effect of this reordering (if any), for the set of MSDUs received at the MAC service interface of any single station, is a change in the delivery order of broadcast and multicast MSDUs, relative to unicast MSDUs, and the reordering of MSDUs with different TID values, originating from a single source station address. There is no reordering of unicast MSDUs with the same TID value and addressed to the same destination.

6.2.1.1.2 Semantics of the service primitive

Change the final 3 paragraphs as follows:

The data parameter specifies the MSDU to be transmitted by the MAC sublayer entity. For IEEE 802.11, the length of the MSDU shall be less than or equal to 2304 octets. The MAC sublayer entity will generate an MPDU which is longer than this MSDU. The increase in length varies due to the operation of several MAC facilities, as specified in subsequent clauses, including 7 and 8. In some cases the MAC will transfer unicast MPDUs longer than a specified threshold using a plurality of shorter MPDUs, performing fragmentation (see 9.4) before transmission and defragmentation (see 9.5) after reception.

NOTE 1: Several enhancements to the IEEE 802.11 MAC, including but not limited to the QoS facility and MAC-level FEC, generate MPDUs with more MAC-specific information, hence a greater maximum MPDU length, than the earlier revisions of this standard.

The priority parameter specifies the TID value for the data unit transfer. IEEE 802.11 allows two values that are supported at all STAs: Contention or ContentionFree, and sixteen additional values that are supported only at QSTAs, and only available if the QSTA is associated in a QBSS: the integers between and including 0 and 15. At QSTAs associated in a QBSS, MSDUs with priority of Contention are considered equivalent to MSDUs with TID 0, and those with priority of ContentionFree are considered equivalent to those with TID 6. At QSTAs associated in a BSS, MSDUs with any integer priority are considered equivalent to MSDUs with priority Contention.

The service class parameter specifies the service class desired for the data unit transfer. IEEE 802.11provides a single class of service, so this parameter value has no normative effect and may be null.

6.2.1.1.4 Effect of receipt

Change the existing paragraph as follows:

On receipt of this primitive 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 which describes the reason that the MAC was unable to fulfill the request. If the request can be fulfilled according to the requested parameters, the MAC sublayer entity appends all MAC specified fields, including DA, SA, and all fields that are unique to 802.11, and passes the properly formatted frame to the lower layers for transfer to the peer MAC sublayer entity or entities, and indicates this action to the LLC sublayer entity using an MA-UNITDATA-STATUS.indication primitive with transmission status set to "Successful."

6.2.1.2.2 Semantics of the service primitive

Change the final 3 paragraphs 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. This MAC only reports "success" or "success with correction" because all failures of reception are discarded without generating MA-UNITDATA.indication.

The priority parameter specifies the TID value that was used for the data unit transfer. IEEE 802.11 allows two values that are supported at all STAs: Contention or ContentionFree, and sixteen additional values that are supported only at QSTAs, and only available if the QSTA is associated in a QBSS: the integers between and including 0 and 15. If a QSTAs associated in a QBSS, MSDUs it receives in QoS data frames are reported with the TID value contained in the MAC header of that frame, and MSDUs it receives in non-QoS data frames are reported with priority of Contention if they are received during the CP, or ContentionFree, if they are received during the CFP. If a QSTA is associated in a BSS, the QSTA is functioning as a STA, so the priority value is always Contention or ContentionFree.

The service class parameter specifies the receive service class that was used for the data unit transfer. Because IEEE 802.11 provides a single class of service, the value of this parameter is null.

6.2.1.2.3 When generated

Change the existing paragraph as follows:

The MA-UNITDATA.indication primitive is passed from the MAC sublayer entity to the LLC sublayer entity or entities to indicate the arrival of an MSDU at the local MAC sublayer entity. MSDUs are reported only when complete (e.g. after defragmentation, if received in fragments), and only if the received data frame(s) are validly formatted at the MAC sublayer, received without (uncorrectable) error, received with valid (or null) WEP encryption or enhanced security properties according to the security policy at the local MAC sublayer entity, and their destination address designates the local MAC sublayer entity.

6.2.1.3.2 Semantics of the service primitive

Change the final 3 regular paragraphs, including the indented list, as follows:

The transmission status parameter 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 dot11ShortRetryMax or dot11LongRetryMax retry limit would otherwise be exceeded) [no longer used, listed because this status may be returned by MAC entities conformant to IEEE Std 802.11-1999, see NOTE 2];
c) Excessive data length;

d) Non-null source routing;
e) Unsupported priority (for priorities other than Contention or ContentionFree at an STA; or for priorities other than Contention, ContentionFree or an integer between and including 0 and 15 at a QSTA);
f) Unavailable priority (for ContentionFree when no point coordinator is available, in which case the MSDU is transmitted with, and the provided priority parameter value is set to, Contention; or for an integer between and including 1 and 15 at a QSTA which is not associated in a QBSS, in which case the MSDU is transmitted with, and the provided priority parameter value is set to, Contention);
g) Undeliverable (TransmitMSDUTimer reached dot11MaxTransmitMSDULifetime before successful delivery)
   [no longer used, listed because this status may be returned by MAC entities conformant to IEEE Std IEEE Std 802.11-1999, see NOTE 2];
h) Undeliverable (no BSS available);
i) Undeliverable (the STA MAC sublayer entity cannot encrypt with a null key, or the QSTA MAC sublayer entity does not have the required credentials or other security data to transmit the frame).

In all cases where delivery of the MSDU is attempted, the transmission status parameter returned by the MAC sublayer entity is either (a) or (f). In all cases where no MSDU delivery attempt can be made, the transmission status parameter returned by the MAC sublayer entity is one of (c), (d), (e), (h) or (i).

NOTE 2: Transmission status (b) and (g) should not be returned by implementations conformant to the present standard. Transmission status (b) and (g) are listed for completeness, since they were defined in IEEE Std 802.11-1999, but are not likely ever to be returned. It is not possible to determine the occurrence of either of these two cases of an MSDU delivery attempt being abandoned (due to excessive retries for status (b) or due to exceeding the limit on transmit lifetime for status (g)) from local state available within the MAC sublayer entity at the time the MA-UNITDATA.request is received from LLC. Because all MAC data service provided within IEEE Std 802.11 is connectionless, return of transmission status (b) or (g) is incompatible with the semantics of the MA-UNITDATA-STATUS.indication primitive. Implementers are advised that the existence of transmission status (b) and (g) should not be interpreted as a requirement that conformant implementations be able to return these status values, and are directed to the absence of any reference to this clause in Annex A.4 of IEEE Std 802.11-1999.

The provided priority parameter specifies the TID that was used for the associated data unit transfer (Contention, 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. Because IEEE 802.11 provides a single class of service, the value of this parameter is null.

7. Frame formats

Change the text of the paragraph in 7 as follows:

The format of the MAC frames is specified in this clause. All stations shall be able to properly construct frames for transmission and decode frames upon reception, as specified in this clause. All stations shall be able to validate every received frame using the frame check sequence (FCS), and, for frames received without errors, as well as for the corrected contents of frames received with correctable errors, to decode certain fields from the MAC headers of all frames. In addition, every station shall be able to construct a subset of these frame formats for transmission, and to decode a (potentially different) subset of these frame formats upon validation following reception. The particular subsets of these formats that a station needs to construct and decode are determined by the functional capabilities supported by that particular station, as specified in 7.7.

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, sequence control information, and, for QoS 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 cyclic redundancy code (CRC).

7.1.1 Conventions

Insert the following text at the end of 7.1.1:

Reception, in references to frames or fields within frames (e.g. "... beacon frames received by a (Q)STA ..." or "... the value of a received Duration/ID field ...") applies to MPDUs or MMPDUs indicated from the PHY layer without error and validated by FCS (after correction of correctable errors, when applicable) 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), but implies nothing about frame addressing, nor whether the frame type or other fields in the MAC header are meaningful to the MAC entity that has received the frame.

Reserved values in non-reserved fields and subfields are not transmitted by conformant stations. However, a station conformant to an older revision of this standard may receive frames with what it considers to be reserved values in non-reserved fields and subfields. These fields, along with other fields in the same frame whose interpretation is directly dependent thereon, are ignored on reception.

NOTE: Ignoring reserved values encountered in non-reserved fields is a strict requirement of IEEE 802.11e and subsequent versions of this standard. However, in the case of many fields, this behavior was either explicitly or implicitly required since the release of IEEE Std 802.11-1997. It is strongly encouraged that all future implementations, independent of conformance level, adhere to this convention.

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, "QSTA" refers to a QoS-capable station, whereas "(Q)STA" refers to both STAs and QSTAs. Another example:

- "QoS +CF-Poll frame" refers to the 3 QoS data subtypes that include "+CF-Poll," the QoS Data+CF-Poll, subtype 1010, QoS Data+CF-Ack+CF-Poll, subtype 1011, and QoS CF-Ack+CF-Poll, subtype 1111;
- "QoS CF-Poll frame" refers specifically to the QoS CF-Poll frame, subtype 1110;
- "QoS (+)CF-Poll frame" refers to all 4 QoS data subtypes with CF-Poll mentioned above;
- "QoS CF-Ack(+CF-Poll) frame" refers to the QoS CF-Ack frame, subtype 1101, and the 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 and 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 fields Address 2, Address 3, Sequence Control, Address 4, QoS Control, and Frame Body are only present 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 type is defined in 7.2. The components which comprise the frame bodies of management type frames are defined in 7.3.

The Frame Body is of variable size. The maximum Frame Body size is determined by the maximum MSDU size (2304 octets) plus any overhead from encryption encapsulation plus any overhead from FEC.

octets: 2	2	6	6	6	2	6	2	n	4
Frame Control	**Duration / ID**	**Address 1**	**Address 2**	**Address 3**	**Sequence Control**	**Address 4**	**QoS Control**	**Frame Body**	**FCS**
MAC Header									

Figure 12 – MAC frame format

7.1.3.1 Frame Control field

Change the text in 7.1.3.1 and Figure 13 as follows:

The Frame Control field consists of the following subfields: Protocol Version, Type, Subtype, To DS, From DS, More Fragments, Retry, Power Management, More Data, Wired Equivalent Privacy (WEP) and Forward Error Correction (FEC). The format of the Frame Control field is illustrated in Figure 13. The frame control field shall always be taken as the first and second octets of any received frame.

B0 B1	B2 B3	B4 B7	B8	B9	B10	B11	B12	B13	B14	B15
Protocol Version	**Type**	**Subtype**	**To DS**	**From DS**	**More Frag**	**Retry**	**Pwr Mgt**	**More Data**	**WEP**	**FEC**
bits: 2	2	4	1	1	1	1	1	1	1	1

Figure 13 – Frame Control field

7.1.3.1.2 Type and Subtype fields

Change the contents of Table 1 and insert the note below Table 1 as follows:

Table 1 - Valid type and subtype combinations
(numeric values in Table 1 are shown in binary)

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

Type value b3 b2	**Type description**	**Subtype value** b7 b6 b5 b4	**Subtype description**
00	Management	0100	Probe request
00	Management	0101	Probe response
00	Management	0110-0111	Reserved
00	Management	1000	Beacon
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	Reserved
00	Management	1111	Reserved
01	Control	0000-0011	Reserved
01	Control	0100	Reservation Request (RR)
01	Control	0101	Reserved
01	Control	0110	Contention Control (CC)
01	Control	0111	Reserved
01	Control	1000	Burst Acknowledgement Request (BurstAckReq)
01	Control	1001	Burst Acknowledgement (BurstAck)
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	Acknowledgement (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 (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	QoS Data
10	Data	1001	QoS Data + CF-Ack
10	Data	1010	QoS Data + CF-Poll
10	Data	1011	QoS Data + CF-Ack + CF-Poll

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
10	Data	1100	QoS Null (no data)
10	Data	1101	QoS CF-Ack (no data)
10	Data	1110	QoS CF-Poll (no data)
10	Data	1111	QoS CF-Ack + CF-Poll (no data)
11	Reserved	0000-1111	Reserved

NOTE: Decoding the subtypes of data type frames can take advantage of the fact that 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 which 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 {MSDU} data, 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 by STAs associated with an AP, all data type frames sent to the QAP, and all frames being sent between APs or QAPs, 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 and 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 type frames sent by APs, or QAPs, 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 type frame direct from one STA to another STA within the same IBSS, a data type frame direct from one QSTA to another QSTA within the same QBSS, as well as all control type frames and all management type frames.
To DS = 1 From DS = 0	A data frame from a (Q)STA to the DS via a (Q)AP.
To DS = 0 From DS = 1	A data frame from the DS to a (Q)STA via a (Q)AP.
To DS = 1 From DS = 1	Wireless distribution system (WDS) data frame being distributed from one AP or QAP to another AP or QAP via the WM.

7.1.3.1.7 Power Management field

Change the text in 7.1.3.1.7 as follows:

The Power Management field is 1 bit in length and is used to indicate the power management mode of the (Q)STA. The value of this field remains constant in each frame from a particular (Q)STA within a frame exchange sequence defined in 9.7. The value in the MAC headers of frames transmitted by the STA that initiates a frame exchange indicates the mode the station is in after successful completion of the frame exchange sequence.

A value of 1 indicates that the (Q)STA that initiated the frame exchange sequence is in power-save mode. A value of 0 indicates that the (Q)STA is in active mode. This field is always set to 0 in frames transmitted by an AP or QAP. This field is reserved in frames sent in response to the initiating (Q)STA.

The use of power save mode precludes the use of direct QSTA to QSTA communications and Burst Ack.

7.1.3.1.8 More Data field

Change the text in 7.1.3.1.8 as follows:

The More Data field is 1 bit in length and is used to indicate to a STA in power-save mode that more MSDUs or MMPDUs are buffered for that STA at the AP. The More Data field is valid in unicast data or management type frames transmitted by an AP to an STA in power-save mode. A value of 1 indicates that at least one additional buffered MSDU, or MMPDU is present for the same STA.

NOTE: The More Data field may be set to 1 in unicast data type frames transmitted by a contention-free (CF)-Pollable STA to the Point Coordinator (PC) in response to a CF-Poll to indicate that the STA has at least one additional buffered MSDU available for transmission in response to a subsequent CF-Poll.

The More Data field is set to 0 in all other unicast frames, including all QoS data type frames.

The More Data field is set to 1 in broadcast/multicast frames transmitted by the (Q)AP, when additional broadcast/multicast MSDUs, or MMPDUs, remain to be transmitted by the (Q)AP during this beacon interval. The More Data field is set to 0 in broadcast/multicast frames transmitted by the (Q)AP when no more broadcast/multicast MSDUs, or MMPDUs, remain to be transmitted by the (Q)AP during this beacon interval and in all broadcast/multicast frames transmitted by non-(Q)AP stations.

Change subclause 7.1.3.1.10 as follows:

7.1.3.1.10 FEC field

The FEC field is 1 bit in length. It is set to 1 if the frame is expanded by an FEC code at the MAC sublayer as defined in 7.6. The FEC field is set to 0 in all other frames.

NOTE: This field is always be set to the same value signaled in the QoS Control Field in 7.1.3.5.

7.1.3.2 Duration/ID field

Change the contents of 7.1.3.2 as follows:

The Duration/ID field is 16 bits in length. The contents of this field vary with frame type and subtype, superframe period (i.e. CP vs. CFP), and QoS capabilities of the sending station, as follows:

a) In control type frames of subtype PS-Poll the Duration/ID field carries the association identity (AID) of the station that transmitted the frame in the 11 least-significant bits (lsb), with the 2 most-significant bits (msb) both set to 1, and the 3 intermediate bits set to 0. The value of the AID is in the range 1-2007.

b) In frames transmitted by the PC and STAs during the contention free period (CFP), the Duration field is set to a fixed value of 32768 (msb set to 1 and the 15 lsb set to 0) for transmission and ignored on reception.

c) In all other frames, the Duration/ID field carries the Duration as specified in 9.2.5, 9.10.2.1,9.10.2.2, 7.2 and 7.3 or a value of zero, as defined for each frame type and subtype in 7.2.

Whenever the contents of a received Duration/ID field, treated as an unsigned integer and without regard for address values, type and subtype are less than 32768, the duration value is used to update the network allocation vector (NAV) according to the procedures defined in 9.2.5.4 or 9.10.2.1, as appropriate.

Whenever the contents of a received Duration/ID field, treated as an unsigned integer, are greater than 32768, 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

Bits 0-13	Bit 14	Bit 15	Usage
0 – 32767		0	Duration value (in units of microseconds) that shall be used within all frames, other than PS-Poll frames, transmitted during the CP, and may be used under HCF for frames transmitted during the CFP.
0	0	1	Fixed value that shall be used under PCF and may be used under HCF, within frames transmitted during the CFP.
1 - 16383	0	1	Reserved
0	1	1	Reserved
1-2007	1	1	AID in PS-Poll frames
2008 - 16383	1	1	Reserved

7.1.3.3.3 BSSID field

Change the first paragraph of 7.1.3.3.3 as shown:

The BSSID field is a 48-bit field of the same format as an IEEE 802 MAC address. This field uniquely identifies each BSS. The value of this field, in an infrastructure BSS, is the MAC address currently in use by the (Q)STA in the (Q)AP of the BSS.

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 or QSTA is assigned a sequence number. STAs (as well as QSTAs operating as STAs because they are in a BSS or IBSS), assign sequence numbers for management type frames, and data type frames from a single modulo-4096 counter, starting at 0 and incrementing by 1 for each MSDU or MMPDU that is assigned a sequence number using this counter. QAPs and QSTAs associated in a QBSS maintain one additional modulo-4096 counter for each TID that they source to a unique destination. Sequence numbers for QoS data type 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 assigned a sequence number for that TID. Sequence numbers for management type frames sent by QSTAs and QAPs are assigned as specified in 7.2.3. Each frame containing a fragment of a single MSDU or MMPDU contains the same 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 subclauses 7.1.3.5 and 7.1.3.6, as well as the new figures contained therein, and renumber subsequent 7.1.x-subclauses and figures as necessary:

7.1.3.5 QoS Control field

The QoS Control field is 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 the last field in the MAC header in QoS data type frames and in control type frames of subtype RR. Each QoS Control field comprises 5 subfields, as defined for the particular sender (HC or QSTA) and frame type and subtype, from a set of 7 kinds of subfields. The usage of these subfields and the various possible layouts of the QoS Control field are described below and illustrated in Table 3.5.

Table 3.5 – QoS Control field

Bits 0-3	Bit 4	Bits 5-6	Bit 7	Bits 8-15	Usage
TID	FEC	Ack Policy	reserved(0)	TXOP limit, units of 32 microseconds	QoS data type frames that include CF-Poll sent by the HC
TID	FEC	Ack Policy	reserved(0)	reserved (0)	QoS data type frames without CF-Poll sent by the HC
TID	FEC	Ack Policy	reserved(0)	Queue size, units of 256 octets	QoS data (non-null) frames sent by WSTAs
TID	0	Ack Policy	reserved(0)	TXOP duration requested, units of 32 microseconds	QoS null frames sent by WSTAs
TID	1	Ack Policy	reserved(0)	Queue size, units of 256 octets	
TID	0	Reserved (00)	reserved(0)	TXOP duration requested, units of 32 microseconds	RR frames
TID	1	Reserved (00)	reserved(0)	Queue size, units of 256 octets	

7.1.3.5.1 TID field

The TID field identifies the TC or TS to which the corresponding MSDU, or fragment thereof, in the frame body field of the present MPDU belongs; or, in the case of QoS null and RR frames, the TC or TS of traffic for which a TXOP is being requested. The TID field contains the value of the priority parameter from the MA-UNITDATA.request primitive that provided the MSDU to which the QoS control field applies. The format of the TID field is shown in Figure 14.5. Additional information on the interpretation of the contents of this field appears in 6.1.1.2.

Bit in QoS Control field:	0	1	2	3
TCID for prioritized QoS:	**User priority**			**0**
TSID for parameterized QoS:	**TSPEC selector**			**1**

Figure 14.5 – TID field

NOTE: The presence of the TID field allows an 802.11 QBSS to function as a LAN that is "able to signal the user priority" as this phrase is used in IEEE 802.1D and IEEE 802.1Q.

7.1.3.5.2 Ack Policy Field

The Ack policy is two bits in length and identifies the Ack policy that shall be followed upon the delivery of the MPDU. The interpreation of these two bits is given in Table 3.6.

Table 3.6 - Ack/Burst Ack combination in QoS data frames

Bit in QoS Control field:

Bit 5	Bit 6	Meaning
0	0	Normal IEEE 802.11 acknowledgement. The addressed recipient returns an ACK or QoS (+) CF-ACK frame after a SIFS period, according to the procedures defined in 9.2.8, 9.3.3 and 9.10.3
0	1	Reserved
1	0	No Acknowledgement The addressed recipient takes no action upon receipt of the frame. The transmitter shall assume that the frame has been received successfully without regard of the actual result.
1	1	Burst Acknowledgement The addressed recipient shall take no action upon the receipt of the frame except for recording the state. The recipient can expect a Burst Ack Request frame in the future to which it shall respond with the procedure described in 9.10.5.

7.1.3.5.3 FEC field

The FEC field is one bit in length and is set to 1 in those QoS data type frames that are FEC-encoded as specified in 7.5.

NOTE: This field is a duplicate of the FEC field defined in 7.1.3.1.10. This deliberate redundancy can be used by an implementation to improve the reliability of detecting FEC-encoded frames.

7.1.3.5.4 TXOP limit field

The TXOP limit field is an 8-bit field that is present in QoS data type frames of subtypes that include CF-Poll and specifies the time limit on a TXOP granted by a QoS (+)CF-Poll from an HC in a QBSS. In QoS data type frames with subtypes that include CF-Poll, the addressed QSTA has a TXOP that begins a SIFS period after this frame and lasts no longer than the number of 32-microsecond periods specified by the TXOP limit value. The range of time values is 32 to 8160 microseconds. A TXOP limit value of 0 is used for TXOPs without an individually specified temporal extent. Any QSTA receiving a QoS (+)CF-Poll with TXOP limit =0 shall obey the rules pertaining to the temporal extent of EDCF TXOPs under HCF, specified in the HCF TXOP usage rules in 9.10.3. In QoS control fields of frames transmitted by an HC with subtypes that do not include CF-Poll the TXOP limit field is set to 0 upon transmission and ignored upon reception.

7.1.3.5.5 Queue size field

The queue size field is an 8-bit field that indicates the amount of buffered traffic for a given traffic category at the QSTA sending this frame. The queue size field is present in all non-null QoS data type frames sent by WSTAs associated in a QBSS. The queue size field is also present in QoS null frames and control frames of subtype RR sent by these stations with bit 9 of the QoS control field set to 1. The queue size value is the ceiling of the total size, in units of 256 octets, of all MSDUs buffered at the QSTA (excluding the frame body of the present QoS data type frame) in the delivery queue used for MSDUs with TID values equal to the value in the TID subfield of this QoS Control field. At QSTAs which implement fewer than 8 access categories, the queue size value may include MSDUs with other TCID values that are assigned to the same access categories.

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 64768 octets. A queue size value of 255 is used to indicate an unspecified or unknown size. If a QoS data type 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.

7.1.3.5.6TXOP duration requested fieldThe TXOP duration requested field is an 8-bit field that indicates the duration, in units of 32 microseconds, which the sending station desires for its next TXOP. The range of time values is 32 to 8160 microseconds. The TXOP duration requested field is present in QoS null frames and control frames of subtype RR sent WSTAs associated a QBSS with bit 15 of the QoS control field set to 0. A value of zero in the TXOP duration requested field indicates that no TXOP is requested.

TXOP duration requested values are not cumulative. A TXOP duration requested for a particular priority supercedes any prior TXOP duration requested for that priority. A value of zero indicates that no TXOP is required for that priority. This may be used to cancel a pending unsatisfied TXOP request when its MSDU is no longer queued for transmission.

7.1.3.6 TAID field

The TAID field is 16-bit field that contains a TID value, which identifies a TC or TS; and an association identifier (AID) value, which identifies a QSTA in the QBSS. The TAID value is formed by concatenating the TID value (high-order 4 bits of the QoS Control field) with the AID value (low-order 12 bits of the AID field, as defined in 7.3.1.8). The TAID field includes 2 subfields, described below and illustrated in Figure 14.6.

0-10 AID
The AID subfield contains the association identifier assigned to the QSTA by the QAP at the time of its most recent (re)association with the present QBSS. For a detailed description of the AID, see 7.3.1.8.

11 Reserved
This bit is reserved for future use and shall beset to 0 upon transmission and ignored upon reception.

12-15 TID
The TID subfield identifies the TC or TS to which the present frame pertains. For a detailed description of the TID subfield, see 7.1.3.5.1.

bits 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AID (1-2007)											**rsrv (0)**	**TID (0-15)**			

Figure 14.6 – TAID field

Change the text of the subclause presently numbered 7.1.3.5 as shown:

7.1.3.7 Frame Body field

The Frame Body is a variable length field and contains information specific to individual frame types and subtypes. The minimum frame body is zero octets. The maximum length frame body is 2304 octets of MSDU or MMPDU content plus 0 or more (presently 8) octets of MPDU expansion to accommodate the fields added by the privacy (WEP or enhanced security) function, as specified in clause 8.

The following heading is present to show the new number of the FCS field subclause, which is referenced by inserted text in 7.5. The contents of the FCS subclause are not modified.

7.1.3.8 FCS field

7.2.1.1 Request To Send (RTS) frame format

Change the final paragraph of 7.2.1.1 and insert the note below this paragraph as shown:

For all RTS frames sent under DCF or EDCF rules, the duration value is the time, in microseconds, required to transmit the pending data or management frame, plus one CTS frame, plus one ACK frame, plus three SIFS intervals. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. For all RTS frames sent under during a polled TXOP under HCF rules, the duration value is set as specified in 9.10.3.2.

7.2.1.2 Clear To Send (CTS) frame format

Change the final paragraph of 7.2.1.2 as shown:

For all CTS frames sent in response to RTS frames, the duration value is the value obtained from the duration field of the immediately previous RTS frame, minus the time, in microseconds, required to transmit the CTS frame and its SIFS interval. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. For CTS frames sent at the start of a polled TXOP under HCF rules, the duration value is set as specified in 9.10.3.2.

7.2.1.3 Acknowledgement (ACK) frame format

Change the final paragraph of 7.2.1.3 as shown:

For ACK frames sent by STAs during the contention period, if the More Fragments bit was set to 0 in the Frame Control field of the immediately previous directed data or management frame, the duration value is set to 0. If the More Fragments bit was set to 1 in the Frame Control field of the immediately previous directed data or management frame, as well as for all ACK frames sent under HCF rules by QSTAs associated in a QBSS, the duration value is the value obtained from the duration field of the immediately previous data or management frame, minus the time, in microseconds, required to transmit the ACK frame and its SIFS interval. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. For ACK frames sent during the contention-free period (CFP) under PCF the Duration/ID field is set to 32768.

7.2.1.4 Power Save Poll (PS-Poll) frame format

Change the final two paragraphs of 7.2.1.4 as shown:

The BSSID is defined in 7.1.3.3.3. The TA is the address of the (Q)STA transmitting the frame. The AID is the value assigned to the (Q)STA transmitting the frame by the AP or QAP in the (re)association response frame which established that (Q)STA's current association.

The Duration/ID field contains the AID value in the 11 least-significant bits, and has the two most-significant bits each set to 1. All STAs, upon receipt of a PS-Poll frame, update their NAV settings as appropriate under the coordination function rules and data rate selection rules using a duration value equal to the time, in microseconds, required to transmit one ACK frame plus one SIFS interval.

7.2.1.5 CF-End frame format

Change the second paragraph of 7.2.1.5 as shown:

The BSSID is defined in 7.1.3.3.3. The RA is the broadcast group address.

7.2.1.6 CF-End + CF-Ack frame format

Change the second paragraph of 7.2.1.6 and insert a new paragraph at the end of this subclause as shown:

The BSSID is defined in 7.1.3.3.3. The RA is the broadcast group address.

The Duration field is set to 0.

Insert after 7.2.1.6 the following 4 subclauses 7.2.1.7 through 7.2.1.10, as well as the new figures contained therein, and renumber subsequent figures as necessary:

7.2.1.7 Burst Acknowledgement Request (BurstAckReq) frame format

The frame format of the Burst Acknowledgement Request (BurstAckReq) frame is defined in Figure 21.3.

Octets: 2	2	6	6	2			2	4
				BAR Control				
Frame Control	Duration /ID	RA	TA	*Bits: 0-10*	*11*	*12-15*	Burst Ack Starting Sequence Control	FCS
				Sent Count	Reserved	TID		

Figure 21.3 – BurstAckReq frame

The value of Duration/ID shall be such that it covers at least one SIFS and one Burst Ack frame. The BAR Control field contains the Sent Count and TID subfields. The sent count subfield contains the number of unique MPDU sent by the transmitter beginning with the MPDU indicated by the burst ACK starting sequence control subfield. The TID subfield of BAR Control contains the TID for which a BurstAck frame is requested. Bits 11 of BAR are reserved and set to 0. The Burst Ack Starting Sequence Control defines an MPDU sequence control number equal to (Starting Sequence number * 16) + Fragment Number.

7.2.1.8 Burst Acknowledgement (BurstAck) frame format

The frame format of the Burst Acknowledgement (BurstAck) frame is defined in Figure 21.4.

Octets: 2	2	6	6	2			2	128	4
				BA Control					
Frame Control	Duration	RA	TA	Bits: 0-7	8-11	12-15	Burst Ack Starting Sequence Control	Burst Ack Bitmap	FCS
				Re-ordering Buffer Size	Reserved	TID			

Figure 21.4 - BurstAck Frame

The Duration, RA and TA fields follows the rules defined in section 7.2.1.3 for the ACK frame.

The BA control field consists of the Re-ordering Buffer Size, and TID sub-fields. The Re-ordering Buffer Size indicates the number of buffers of size 2304 octets available for bursting for this particular TC or TS (see 7.4.3.2). The Re-ordering buffer size is the total buffer size allocated for this burst transmission, and shall not be less than the number of the buffer size last negotiated through management frame exchanges. Bits 8-11 of BA Control are reserved and set to 0.

The Burst Ack Starting Sequence Control field contains the fragment number and sequence number of the first MPDU for traffic class TID corresponding to bit 0 of the Ack Bitmap. The Burst Ack Starting Sequence Control field defines an MPDU sequence number equal to (Sequence Number * 16) + Fragment Number.The Burst Ack Bitmap is 128 octets in length and is for indicating the receiving status of upto 64 MSDUs.Bit position *n* of the Burst Ack bitmap, if set to a 1 acknowledges MPDU with MPDU sequence number equal to (Burst Ack Starting Sequence Control + *n*) and 0 otherwise. For MSDUs with less than 16 fragments, the bits corresponding to unused fragment numbers are set to 0.

7.2.1.9 Contention Control (CC) frame format

The frame format of the Contention Control (CC) frame is defined in Figure 21.5.

octets: 2	2	6	6	1	1	1	1	2*FbCount	4
Frame Control	Dur/ID	RA	BSSID	reserved		CCI Length	Feed-back Count	Feedback TAID (2 octets)	FCS
MAC Header									

Figure 21.5 – CC frameFor CC frames that initiate controlled contention, the Duration field contains the time in microseconds for the CCI CCI Length times the duration of each CCOP), plus two PIFS intervals. For CC frames used exclusively to provide feedback the Duration field contains zero.

The RA shall contain the broadcast address.

The BSSID is defined in 7.1.3.3.3.

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The CCI length (Nccop) field is a single octet that specifies the number of CCOPs in the CCI that follows this CC frame. A CCI length value of 0 is used in CC frames used exclusively to provide feedback on previously received RR frames, and do not initiate a new CCI.

The Feedback Count field is set to the number of Feedback TAIDs in this CC frame. Valid values are in the range 0-255. Each Feedback TAID is 2 octets in length and contains the TAID (in the format shown in 7.1.3.6) from an RR frame that was successfully received by the HC since the last transmission of a CC frame.

7.2.1.10 Reservation Request (RR) frame format

The frame format of the Reservation Request (RR) frame is defined in Figure 21.6.

octets: 2	2	6	6	2	2	4
Frame Control	Dur/ID	RA	BSSID	QoS Control	AID	FCS
MAC Header						

Figure 21.6 – RR frame

The Duration/ID field is set to 0.

The RA field shall contain the broadcast address.

The BSSID is defined in 7.1.3.3.3.

The QoS Control field contains the TID for which the request is being made, along with the requested TXOP duration or queue size, as specified for RR frames in 7.1.3.5. The AID field contains the AID of the station sending the request.

7.2.2 Data frames

Change the text, figures and tables in 7.2.2 as shown, renumber subsequent figures as necessary:

The frame format for a Data frame is dependent on the QoS bit of the subtype field (bit 7 of the frame control field). Data frames with a value of 0 in the QoS bit of the subtype field are used for basic transfers, and have the format defined in Figure 22.

octets: 2	2	6	6	6	2	*6 or 0*	n	4
Frame Control	Dur/ID	Address 1	Address 2	Address 3	Seq Ctrl	*Address 4*	Frame Body	FCS
MAC Header								

Figure 22 – Basic Data Frame

Data frames with a value of 1 in the QoS bit of the subtype field are used for QoS transfers, and have the format defined in Figure 22.1. These subtypes are collectively referred to as QoS data type frames. Each of these data subtypes contain "QoS" in their names, and this frame format is distinguished by the presence of a QoS Control field in the MAC header.

octets: 2	2	6	6	6	2	*6 or 0*	2	n	4
Frame Control	Dur/ID	Address 1	Address 2	Address 3	Seq Ctrl	*Address 4*	QoS Control	Frame Body	FCS
MAC Header									

Figure 22.1 – QoS Data Frame

The contents of the Address fields of data and QoS data frames are dependent upon the values of the To DS and From DS bits in the frame control field, and are defined in Table 4. Where the content of a field is shown as not applicable (N/A), the field is omitted. Note that Address 1 always holds the receiver address of the intended receiver (or, in the case of multicast frames, receivers), and that Address 2 always holds the address of the station that is transmitting the frame.

Table 4 - Address Field Contents

To DS	From DS	Address 1	Address 2	Address 3	Address 4	Usage
0	0	DA	SA	BSSID	N/A	STA-to-STA traffic in an IBSS and QSTA-to-QSTA traffic in a QBSS
0	1	DA	BSSID	SA	N/A	(Q)AP-to-(Q)STA traffic in a (Q)BSS
1	0	BSSID	SA	DA	N/A	(Q)STA-to-(Q)AP traffic in a (Q)BSS
1	1	RA	TA	DA	SA	WDS traffic among (Q)APs

A station uses the contents of the Address 1 field to perform address matching for receive decisions. In cases where the Address 1 field contains a group address, the BSSID also is validated to ensure that the broadcast or multicast originated in the same BSS.

A station uses the contents of the Address 2 field to direct the acknowledgment if an acknowledgment is necessary.

The DA is the destination of the MSDU (or fragment thereof) in the frame body field.

The SA is the address of the MAC entity which initiated the MSDU (or fragment thereof) in the frame body field.

The RA is the address of the (Q)STA contained in the (Q)AP in the wireless distribution system that is the next immediate intended recipient of the frame.

The TA is the address of the (Q)STA contained in the (Q)AP in the wireless distribution system that is transmitting the frame.

The BSSID is defined in 7.1.3.3.3.

The QoS Control field is defined in 7.1.3.5.

For DATA frames of Subtype Null (no data), CF-Ack (no data), CF-Poll (no data) and CF-Ack+CF-Poll (no data) and the corresponding four QoS data frame subtypes, the frame body is empty. Otherwise, the frame body contains all of or a fragment of an MSDU after any encapsulation for encryption and after any FEC encoding.

The maximum length of the frame body can be determined from the maximum MSDU length plus any overhead from encapsulation for encryption and FEC encoding.

The frame body is omitted in data frames of Subtype Null (no data), CF-Ack (no data), CF-Poll (no data) and CF-Ack+CF-Poll (no data) as well as the corresponding four QoS data frame subtypes.

Within all data type frames sent by STAs during the CFP under PCF, the Duration/ID field is set to the value 32768. Within all data type frames sent within a polled TXOP under HCF, the Duration/ID field is set as specified in 9.10.2.1. Within all data type frames sent during the contention period under DCF or EDCF, the Duration/ID field is set according to the following rules:

- If the Address 1 field contains a group address, the duration value is set to 0.

- If the More Fragments bit is set to 0 in the Frame Control field of a frame and the Address 1 field contains an individual address, the duration value is set to the time, in microseconds, required to transmit one ACK frame, plus one SIFS interval.

- If the More Fragments bit is set to 1 in the Frame Control field of a frame, and the Address 1 field contains an individual address, the duration value is set to the time, in microseconds, required to transmit the next fragment of this data frame, plus two ACK frames, plus three SIFS intervals.

The duration value calculation for the data frame is based on the rules in 9.6 that determine the data rate at which the control frames in the frame exchange sequence are transmitted. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. All stations process Duration field values less than or equal to 32767 from valid data frames to update their NAV settings as appropriate under the coordination function rules.

7.2.3 Management frames

Change the text in 7.2.3 as shown:

The frame format for management frames is independent of frame subtype and is as defined in Figure 23.

octets: 2	2	6	6	6	2	0-2312	4
Frame Control	**Dur/ID**	**DA**	**SA**	**BSSID**	**Seq Ctrl**	**Frame Body**	**FCS**
MAC Header							

Figure 23 – Management frame format

A (Q)STA uses the contents of the Address 1 (DA) field to perform the address matching for receive decisions. In the case where the Address 1 (DA) field contains a group address and the frame type is other than Beacon, the BSSID also is validated to ensure that the broadcast or multicast originated in the same BSS. If the frame type is Beacon, other address matching rules apply, as specified in 11.1.2.3.

The address fields for management frames do not vary by frame subtype.

The BSSID of the management frame is determined as follows:

a) If the station is an AP or is associated with an AP, the BSSID is the address currently in use by the STA contained in the AP.
b) If the station is a member of an IBSS, the BSSID is the BSSID of the IBSS.
c) In management frames of subtype Probe Request, the BSSID is either a specific BSSID, or the broadcast BSSID as defined in the procedures specified in clause 11.1.3.2.
d) If the QSTA is a QAP or is associated with a QAP, the BSSID is the address of the QSTA at which the MLME-START.request that started the QBSS was executed, and is equal to the BSSID in Beacon, Association Response, Reassociation Response and Probe Response frames sent by this QBSS.

The DA is the destination of the frame.

The SA is the address of the station transmitting the frame.

Within all management type frames sent by STAs during the CFP under PCF, the Duration field is set to the value 32768. Within all management type frames sent within a polled TXOP under HCF the Duration/ID field is set as specified in 9.10.2.1. Within all management type frames sent during the contention period under DCF or EDCF, the Duration field is set according to the following rules:

- If the DA field contains a group address, the duration value is set to 0.
- If the More Fragments bit is set to 0 in the Frame Control field of a frame and the DA contains an individual address, the duration value is set to the time, in microseconds, required to transmit one ACK frame, plus one SIFS interval.
- If the More Fragments bit is set to 1 in the Frame Control field of a frame, and the DA contains an individual address, the duration value is the time, in microseconds, required to transmit the next fragment of this Management frame, plus two ACK frames, plus three SIFS intervals.

The duration value calculation for the management frame is based on the rules in 9.6 that determine the data rate at which the control frames in the frame exchange sequence are transmitted. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. All stations process Duration field values less than or equal to 32767 from valid management frames to update their NAV settings as appropriate under the coordination function rules.

The frame body consists of the fixed fields followed by the information elements defined below for each management frame subtype. All fixed fields and information elements are mandatory unless stated otherwise, and only appear in the specified, relative order. STAs that encounter an element ID they do not recognize in the frame body of a management type frame received without errors, ignore that element and continue to scan the remainder of the management frame body (if any) for additional information elements with recognizable element IDs. Element ID codes not explicitly defined in the standard are reserved, and do not appear in any frames.

Change the text and table within 7.2.3.1 as follows:
A portion of the text in this subclause was added to 802.11 by the approval of 802.11d.

7.2.3.1 Beacon frame format

The frame body of a management frame of subtype Beacon contains the information shown in Table 5. If the dot11MultiDomainCapabilityEnabled attribute is true, a (Q)STA shall include a Country Information element in the transmission of Beacon frames. Optionally, the Beacon frame format may also include the information described in either or both of orders 12 and 13. If the information in both orders 12 and 13 are sent, they shall describe the same hopping pattern. Note that the information described in orders 12 and 13 may be also contained in the Probe Response frame.

Table 5 - Beacon frame body

Usage	Order	Information	Note
Always present	1	Timestamp	
	2	Beacon interval	
	3	Capability information	
	4	SSID	
	5	Supported rates	
Present if required by PHY type, BSS type, or an active point coordinator (see notes)	6	FH Parameter Set	The FH Parameter Set information element is present within Beacon frames generated by STAs using frequency hopping PHYs.
	7	DS Parameter Set	The DS Parameter Set information element is present within Beacon frames generated by STAs using direct sequence PHYs.
	8	CF Parameter Set	The CF Parameter Set information element is present within Beacon frames generated by APs with an active PC or by QAPs.
	9	IBSS Parameter Set	The IBSS Parameter Set information element is only present within Beacon frames generated by STAs in an IBSS.
	10	TIM	The TIM information element is only present within Beacon frames generated by APs or QAPs.
Multiple regulatory domains	11	Country Information	The Country Information element shall be present when dot11MultipleDomainCapbilityEnabled is true.
	12	FH Parameters	FH Parameters as specified in clause 7.3.2.13 may be included if dot11MultiDomainCapabilityEnabled is true.
	13	FH Pattern Table	FH Pattern Table information as specified in clause 7.3.2.14 may be included if dot11MultiDomainCapabilityEnabled is true
QBSS	14	QBSS Load	The QBSS Load information element is only present within Beacon frames generated by QAPs.
	15	QoS Parameter Set	The QoS Parameter Set information element is only present within Beacon frames generated by QAPs.
	16	Extended Capabilities	The Extended Capabilities information element is only present in Probe Response frames generated by QSTAs with Capability Information bit 15=1.
	17	QAPC-STA Parameter Set	The QoS Parameter Set information element is only present within Beacon frames generated by QAPs.

7.2.3.4 Association Request frame format

Change the contents of Table 7 in 7.2.3.4 as shown:

Table 7 – Association Request frame body

Usage	**Order**	**Information**
Always present	1	Capability information
	2	Listen interval
	3	SSID
	4	Supported rates
QBSS		
	5	Extended Capabilities (only if Capability[15]=1)

7.2.3.5 Association Response frame format

Change the contents of Table 8 in 7.2.3.5 as shown:

Table 8 – Association Response frame body

Usage	**Order**	**Information**
Always present	1	Capability information
	2	Status code
	3	Association identifier (AID)
	4	Supported rates
QBSS		
	5	Extended Capabilities (only if Capability[15]=1)
	6	QAPC-STA Parameter Set

7.2.3.6 Reassociation Request frame format

Change the contents of Table 9 in 7.2.3.6 as shown:

Table 9 – Reassociation Request frame body

Usage	Order	Information
Always present	1	Capability information
	2	Listen interval
	3	Current (Q)AP address
	4	SSID
	5	Supported rates
QBSS		
	6	Extended Capabilities (only if Capability[15]=1)

7.2.3.7 Reassociation Response frame format

Change the contents of Table 10 in 7.2.3.7 as shown:

Table 10 – Reassociation Response frame body

Usage	Order	Information
Always present	1	Capability information
	2	Status code
	3	Association identifier (AID)
	4	Supported rates
QBSS	5	
	5	Extended Capabilities (only if Capability[15]=1)
	6	QAPC-STA Parameter Set

7.2.3.8 Probe Request frame format

Change the text and contents of Table 11 in 7.2.3.8 as shown:
A portion of the text in this subclause was added to 802.11 by the approval of 802.11d.

The frame body of a management frame of subtype Probe Request contains at least the two items, shown in the top section of Table 11. These two items constitute the entire frame body under IEEE 802.11-1999. The additional items in the frame body of Probe Request frames vary depending on whether the frame is being used to request information pertaining to operation in multiple regulatory domains, shown in the middle section of Table 11; or to request information pertaining to QoS shown in the bottom section of Table 11. If the dot11MultiDomainCapabilityEnabled attribute is true, and this Probe Request frame is not being used to request information pertaining to QoS, a (Q)STA may include a Request information element in the Probe Request frame. The format of the Request Information Element is specified in Clause 7.3.2.15.

Table 11 – Probe Request frame body

Usage	Order	Information
Always present	1	SSID
	2	Supported rates
MRD optional	3	Request information may be included if dot11MultiDomainCapabilityEnabled is true
QoS optional		
	4	Capability information
	5	Extended Capabilities
	6	QAPC-STA Parameter Set

7.2.3.9 Probe Response frame format

Change the text and contents of Table 12 in 7.2.3.9 as shown:
A portion of the text in this subclause was added to 802.11 by the approval of 802.11d.

The frame body of a management frame of subtype Probe Response begins with the five items shown in the "always present" section at the top of Table 12, followed by one or more of the items of order 6 through 9 in Table 12, as appropriate for the characteristics of the active BSS and PHY. These items constitute the mandatory frame body. The additional items in the frame body of Probe Response frames vary depending on the items in the frame body of the Probe Request to which this frame is a response. If the Probe Request was requesting information pertaining to operation in multiple regulatory domains, and if the dot11MultiDomainCapabilityEnabled attribute is true, the Probe Response frame contains a Country information element and all information elements identified by the Requested Element IDs of a Request information element. Note that the information returned as a result of a Probe Request frame with a Request Information element may include the FH parameters and/or the FH Pattern Table possibly replicating optional elements identified by orders 12 and 13. A (Q)STA shall return only those information elements that it supports. In an improperly formed Request information element, a (Q)STA may ignore the first information element requested that is not ordered properly and all subsequent information elements requested. In the probe response frame, the (Q)STA shall return the requested information elements in the same order as requested in the request information element. If the Probe Request was requesting information pertaining to quality of service the Probe Response contains additional items as shown in the bottom section of Table 12.

Table 12 - Probe Response frame body

Usage	Order	Information	Note
Always present	1	Timestamp	
	2	Beacon interval	
	3	Capability information	
	4	SSID	
	5	Supported rates	
Present if required by PHY type, BSS type, or an active point coordinator	6	FH Parameter Set	The FH Parameter Set information element is present within Probe Response frames generated by STAs using frequency hopping PHYs.
	7	DS Parameter Set	The DS Parameter Set information element is present within Probe Response frames generated by STAs using direct sequence PHYs.
	8	CF Parameter Set	The CF Parameter Set information element is present within Beacon frames generated by APs with an active PC or by QAPs.
	9	IBSS Parameter Set	The IBSS Parameter Set information element is only present within Probe Response frames generated by STAs in an IBSS.
Multiple regulatory domains	10	Country Information	Included if dot11MultiDomainCapabilityEnabled is true
	11	FH Parameters	FH Parameters as specified in clause 7.3.2.13 may be included if dot11MultiDomainCapabilityEnabled is true
	12	FH Pattern Table	FH Pattern Table information as specified in clause 7.3.2.14 may be included if dot11MultiDomainCapabilityEnabled is true
	13 - n	Requested information elements	Elements requested by the Request information element of the Probe Request frame.
QBSS, always present	10	QBSS Load	The QBSS Load information element is only present within Probe Response frames generated by QAPs.
	11	Error Statistics	Reserved for future use. The Error Statistics information element is only present in Probe Response frames generated by QSTAs in a QBSS.
QBSS, present if required			
	12	Extended Capabilities	The Extended Capabilities information element is only present in Probe Response frames generated by QSTAs with Capability Information bit 15=1.
	13	QAPC-STA Parameter Set	The QAPC-STA Parameter Set is only present in Probe Response frames generated by QAPs in a QBSS which have the QAPC-STA active.

Insert following 7.2.3.9 the following subclause and the figures and tables included therein, renumbering subclauses, figures and tables as necessary:

7.2.3.10 Action frame format

The frame body of a management frame of subtype Action consists of a 4-octet fixed portion that identifies a functional category and a specific management action, followed by a variable-length portion that is interpreted in the context of that category and action. The fields in the fixed portion of an Action request are shown in Figure 23.1, and the fields in the fixed portion of an Action response are shown in Figure 23.2.

octets: 1	1	1	1	0-2300
Category Code	**Action Code** (even)	**Activation Delay**	**Dialog Token**	**Action Body**

Figure 23.1 – Action request frame body

octets: 1	1	1	1	0-2300
Category Code	**Action Code** (odd)	**Action-specific Status**	**Dialog Token**	**Action Body**

Figure 23.2 –Action response frame body

The Category Code field is a single octet whose value identifies a group of actions for a particular function, or, for administrative and editorial ease, a group of actions defined by a single task group. Category code assignments are defined in Table 15.1. In the remainder of this document, Action frames of a given category are referred to as <category name> Action frames. For example, frames in the "QoS" category are called "QoS Action frames," "QoS Action Requests," or "QoS Action Responses." QSTAs that receive an Action frame with a category code that they do not understand discard the frame without reporting an error.

Table 15.1 – Category codes

Code	Meaning
0	Reserved
1	QoS management
2	WARP
3	reserved
4	reserved
5 – 255	Reserved

The Action Code field is a single octet whose value specifies a particular management action in the context of the category code. There is no requirement for uniqueness nor uniformity of action code assignments between categories. There is a requirement that Action Requests which generate no response (sometimes referred to as advisory actions) and Action Requests which solicit an Action Response, use even action code values; while Action Responses (generated to report status or in reply to Action Requests) use the action code value of the request plus 1 as the action code value of the response. QSTAs that receive an Action Request frame with a recognized category code but an unrecognized request (even) action code return an Action Response frame using the action code of the request plus 1, and a status code value of 1, meaning "unrecognized action." QSTAs that receive an Action Response frame with a recognized category code but an unrecognized response (odd) action code discard the frame without reporting an error.

The Activation Delay field is a single octet, present only in Action Request frames. The Activation Delay value is interpreted as an unsigned integer. Action Requests received with an activation delay of 0, as well as all Action Requests with category and action code values not specified to permit non-zero delay values are processed immediately. Action Requests with category and action code values specified to permit delays that are received with an activation delay greater than zero are processed, and the corresponding Action Response (if any) is returned, after the specified number of TBTTs have occurred (e.g. an activation delay of 1 delays the action until after the next TBTT, and activation delay of 2 delays the action until after the second TBTT, etc.). A given Action Request frame starting with an activation delay greater than zero will ordinarily be repeated during successive superframes, with its activation delay value decremented by 1 for each superframe until the activation delay reaches 0. Non-zero activation delays may only be used with category and action codes that are specified to permit or to require such use. All retransmissions of Action Request frames may be sent with a changed Activation Delay to account for the duration elapsed from the previous (re)transmission..

The Dialog Token field is a single octet whose value is copied from each Action Request frame into the corresponding Action Response frame, but is otherwise ignored. The dialog token may be useful in the implementation of QSTAs that may issue multiple, concurrent Action Requests, to simplify the matching of Action Responses with particular, outstanding Action Requests. Unless specified otherwise for a particular category and action code, the dialog token value should remain constant during any repetitions of a particular Action Request, such as may occur on successive superframes when the activation delay value is non-zero. All retransmissions of Action Request frames shall be sent with the same dialog token as the original transmission.

The Action-specific Status field is a single octet, present only in Action Response frames, which indicates the completion status of the corresponding Action Request. The status code values are interpreted in the context of the category and action codes. There is no requirement for uniqueness nor uniformity of status value assignments between categories. However, there are 2, predefined status values:

Status =0: Action completed successfully
Status =1: Unrecognized Action Code value

The Action Body field contains zero or more fixed fields followed by zero or more elements in a format that is specific to the combination of Category Code and Action Code.

7.2.3.10.1 Action Codes for QoS management

Action Code	**QoS Action Frame**
0	ADDTS Request
1	ADDTS Response
2	DELTS Request
3	Unused
4-255	Reserved

7.3.1.4 Capability Information field

Change the contents of the text, Figure 27 and Tables 16 & 17 in 7.3.1.4 as shown:

The Capability Information field contains a number of subfields that are used to indicate requested or advertised capabilities. The length of the Capability Information field is 2 octets. The Capability Information field consists of the following subfields: ESS, IBSS, CF-Pollable, CF-Poll Request, Privacy, Short Preamble, PBCC, Channel Agility, QoS, FEC, FEC - Imm AckBurst Ack and Extended Capability Element. The remaining bits in the Capability Information field are reserved. The format of the Capability Information field is as illustrated in Figure 27.

bits: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ESS	IBSS	CF-pollable	CF-poll request	Privacy	Short preamble	PBCC	Channel agility	QoS	FEC – Imm Ack	FEC	rsrv (0)	rsrv (0)	rsrv (0)	Burst Ack	Extended capability element

Figure 27 – Capability Information fixed field

Editor's remark: As of the most recent circulated drafts, TGi is using 1 capability bit (11) and TGg is using 1 capability bits (13).

Each Capability Information subfield is interpreted only in the management frame subtypes for which the transmission rules are defined.

APs and QAPs set the ESS subfield to 1 and the IBSS subfield to 0 within transmitted Beacon or Probe Response management frames. STAs within an IBSS set the ESS subfield to 0 and the IBSS subfield to 1 in transmitted Beacon or Probe Response management frames. QSTAs within a QBSS set the ESS subfield to 1 and the IBSS subfield to 0 within transmitted Probe Response management frames.

STAs set the CF-Pollable and CF-Poll Request subfields in Association and Reassociation Request management frames according to the upper half of Table 16 (QoS subfield set to 0). QSTAs desiring to associate in a QBSS set the CF-Pollable and CF-Poll Request subfields in Association and Reassociation Request management frames according to the lower half of Table 16 (QoS subfield set to 1). QSTAs desiring to associate in a BSS set these bits as if they were STAs.

Table 16 - STA and QSTA usage of QoS, CF-Pollable and CF-Poll Request

QoS	CF-Pollable	CF-Poll Request	Meaning
0	0	0	STA is not CF-Pollable
0	0	1	STA is CF-Pollable, not requesting to be placed on the CF-Polling list
0	1	0	STA is CF-Pollable, requesting to be placed on the CF-Polling list
0	1	1	STA is CF-Pollable, requesting never to be polled
1	0	0	QSTA requesting association in a QBSS.
1	0	1	reserved
1	1	0	reserved
1	1	1	reserved

APs set the CF-Pollable and CF-Poll Request subfields in Beacon and Probe Response management frames according to the upper half of Table 17 (QoS subfield set to 0). An AP sets the CF-Pollable and CF-Poll Request subfield values in Association Response and Reassociation Response management frames equal to the values in the last Beacon or Probe Response frame that it transmitted, with the QoS subfield always set to 0. QAPs set the CF-Pollable and CF-Poll Request subfields in Beacon and Probe Response management frames to indicate the type of contention free service available to STAs, according to the lower half of Table 17 (QoS subfield set to 1). A QAP sets the CF-Pollable, CF-Poll Request, and QoS subfield values in Association Response and Reassociation Response management frames equal to the values in the last Beacon or Probe Response frame that it transmitted, with the QoS subfield always set to 1.

Table 17 - AP and QAP usage of QoS, CF-Pollable and CF-Poll Request

QoS	CF-Pollable	CF-Poll Request	Meaning
0	0	0	No Point Coordinator at AP
0	0	1	Point Coordinator at AP for delivery only (no polling)
0	1	0	Point Coordinator at AP for delivery and polling
0	1	1	Reserved
1	0	0	QAP which does not use a CFP for delivery of unicast data type frames
1	0	1	QAP which uses a CFP for delivery, but does not send CF-Polls to STAs
1	1	0	QAP which uses a CFP for delivery, and may send CF-Polls to STAs
1	1	1	Reserved

NOTE: While a QAP may indicate availability of CF-Polls to STAs, and thereby provide non-QoS contention free transfers during the CFP, this is not recommended. Implementers are cautioned that QSTAs are not required to interpret data subtypes that include +CF-Ack in frames not addressed to themselves, nor non-QoS (+)CF-Polls, and therefore QSTAs cannot be treated as CF-Pollable stations. This requires a QAP that provides non-QoS CF-polling to adhere to frame sequence restrictions considerably more complex than, and less efficient than, those specified for either PCF or HCF. In addition, the achievable service quality is likely to be degraded when non-QoS STAs are associated and being polled.

WSTAs shall not use the CF-ACK bit in non-QoS data frame subtypes. QSTAs shall not recognize the CF-Poll bit in non QoS-data frame subtypes.

APs set the Privacy subfield to 1 within transmitted Beacon, Probe Response, Association Response and Reassociation Response management frames if WEP encryption is required for all data type frames exchanged within the BSS. If WEP encryption is not required, the Privacy subfield is set to 0.

STAs within an IBSS set the Privacy subfield to 1 in transmitted Beacon or Probe Response management frames if WEP encryption is required for all data type frames exchanged within the IBSS. If WEP encryption is not required the Privacy subfield is set to 0.

APs (as well as STAs in IBSSs) set the Short Preamble subfield to 1 in transmitted Beacon, Probe Response, Association Response and Reassociation Response management frames to indicate that the use of the short preamble option, as described in subclause 18.2.2.2, is allowed within this BSS. To indicate that the use of the short preamble option is not allowed the Short Preamble subfield is set to 0.

STAs set the Short Preamble subfield to 1 in transmitted Association Request and Reassociation Request frames when the MIB attribute dot11ShortPreambleOptionImplemented is true. Otherwise STAs set the Short Preamble subfield to 0.

APs (as well as STAs in IBSSs) set the PBCC subfield to 1 in transmitted Beacon, Probe Response, Association Response and Reassociation Response management frames to indicate that the use of the PBCC modulation option, as described in subclause 18.4.6.6, is allowed within this BSS. To indicate that the use of the PBCC modulation option is not allowed the PBCC subfield is set to 0.

STAs set the PBCC subfield to 1 in transmitted Association Request and Reassociation Request frames when the MIB attribute dot11PBCCOptionImplemented is true. Otherwise STAs set the PBCC subfield to 0.

STAs set the Channel Agility subfield to 1 to indicate the usage of channel agility by the HR/DSSS PHY. Otherwise STAs set the Channel Agility subfield to 0.

QAPs and QSTAs that can decode FEC frames as described in section 7.5 may set the FEC subfield in all frames that include the Capability Information field.

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The FEC-Immediate ACK bit indicates, when the FEC bit (Bit 9) is set to 1, whether or not the STA is capable of replying to FEC coded data with an immediate acknowledgement. If the FEC-Immediate ACK bit is set to 0, the transmitter shall either use the Burst Acknowledgment mechanism or unacknowledged service for frames that are FEC encoded. If the FEC bit is set to zero, this field is reserved.

WSTAs set the Burst Ack subfield to 1 within the capability information field if they support burst ACK. Otherwise, it shall be set to 0.

The Extended Capability Element subfield is set to 1 to indicate that an Extended Capability information element is present in this frame.

7.3.1.7 Reason Code field

Change the contents of Table 18 in clause 7.3.1.7 as shown:

Table 18 - Reason codess

Reason code	Meaning
0	Reserved
1	Unspecified reason
2	Previous authentication no longer valid
3	Deauthenticated because sending station is leaving (or has left) the IBSS or ESS
4	Disassociated due to inactivity
5	Disassociated because (Q)AP is unable to handle all currently associated (Q)STA
6	Class 2 frame received from non-authenticated station
7	Class 3 frame received from non–associated station
8	Disassociated because sending station is leaving (or has left) the (Q)BSS
9	Station requesting (re)association is not authenticated with responding station
10	Disassociated for unspecified, QoS-related reason
11	Disassociated because QAP lacks sufficient bandwidth for this QSTA
12	Reserved
13	Disassociated because of excessive frame losses and/or poor channel conditions
14	Disassociated because QSTA is transmitting outside the limits of its polled TXOPs
15	Reserved
16	QBSS reconfiguration is in progress
17	Disassociated because sending QSTA is an active QAPC-STA that is about to become inactive.
18 - 65535	Reserved

7.3.1.9 Status Code field

Change the contents of Table 18 in clause 7.3.1.9 as shown:

Table 19 - Status codes

Status code	Meaning
0	Successful
1	Unspecified failure
2–9	Reserved
10	Cannot support all requested capabilities in the Capability Information field
11	Reassociation denied due to inability to confirm that association exists
12	Association denied due to reason outside the scope of this standard
13	Responding station does not support the specified authentication algorithm
14	Received an Authentication frame with authentication transaction sequence number out of expected sequence
15	Authentication rejected because of challenge failure
16	Authentication rejected due to timeout waiting for next frame in sequence
17	Association denied because (Q)AP is unable to handle additional associated (Q)STA
18	Association denied due to requesting station not supporting all of the data rates in the BSSBasicRateSet parameter
19	Association denied due to requesting station not supporting the short preamble option
20	Association denied due to requesting station not supporting the PBCC modulation option
21	Association denied due to requesting station not supporting the channel agility option
22	Unspecified, QoS-related failure
23	Association denied due to QAP having insufficient bandwidth to handle another QSTA
24	Association denied due to poor channel conditions
25	Association (with QBSS) denied due to requesting station not supporting the QoS facility
26	Association denied due to requesting station not supporting the FEC option
27 - 65535	Reserved

7.3.2 Information elements

Change the text and contents of Table 20 in 7.3.2 as shown:
A portion of the text in this subclause was added to 802.11 by the approval of 802.11d.

Elements are defined to have a common general format consisting of a 1 octet Element ID field, a 1 octet length field and a variable-length element-specific information field. Each element is assigned a unique Element ID as defined in this standard. The length field specifies the number of octets in the information field. See Figure 34.

Element ID (1 octet)	Length (1 octet)	Information (*length* octets)

Figure 34 – Element format

The set of valid elements is defined in Table 20.

Table 20 - Element IDs

Information Element	Element ID
SSID	0
Supported rates	1
FH Parameter Set	2
DS Parameter Set	3
CF Parameter Set	4
TIM	5
IBSS Parameter Set	6
Country	7
Hopping Pattern Parameters	8
Hopping Pattern Table	9
Request	10
QBSS Load	11
QoS Parameter Set	12
Traffic Specification	13
Error statistics (Reserved for future use)	14
QAPC-STA Parameter Set	15
Challenge text	16
Reserved for challenge text extension	17-31
Reserved	32
Reserved	33
Reserved	34
Extended Capability	35
Target Destination Address Element	36
Target Enable Status Element	37
Location Discovery Status Element	38
Current Transmit Rate Element	39
Reserved	40 - 255

A station that encounters an unknown or reserved element ID value in a management frame received without error shall ignore said element and shall proceed scanning the remainder of the management frame body (if any) for additional information elements with recognizable element ID values. The frame body components specified for many management subtypes results in elements ordered by ascending element ID,

Insert following 7.3.2.12 the 7.3.x subclauses with the figures and tables included therein, renumbering as necessary:

7.3.2.13 QBSS Load element

The QBSS Load element contains information on the current station population and traffic levels in the QBSS. The element information field comprises 5 items, the contents of which are defined below. The total length of the information field is 4 octets. See Figure 42.5.

Element ID (11)	Length (6)	Station Count (2 octets)	Channel Utilization (1 octet)	Frame Loss Rate (1 octet)

Figure 42.5 – QBSS Load element format

The station count field is 4 octets for an unsigned integer that indicates the total number of STAs and QSTAs currently associated with this QBSS.

The channel utilization field is 1 octet for an unsigned integer that indicates the portion of available WM bandwidth currently used to transport data within this QBSS. The value is calculated by taking the integer part of the quotient of <<100 * utilized bits/s>> divided by <<total available bits/s>>.

The frame loss rate field is 1 octet for an unsigned integer that indicates the portion of transmitted MPDUs that require retransmission or are discarded as undeliverable. The value is calculated by taking the integer part of the quotient of <<100 * (total retries + discarded MPDUs and MMPDUs)>> divided by <<total MPDU and MMPDU transmission attempts>>. These totals should be accumulated over the same period used to calculate the channel utilization value.

7.3.2.14 QoS Parameter Set element

The QoS Parameter Set element provides information needed by QSTAs for proper operation of the QoS facility during the contention period. This information includes the EDCF TXOP limit, the QoS parameter set count, the contention window values, and AIFS values for EDCF channel access. The format of the QoS Parameter Set element is shown in Figure 42.6.

The QoS Parameter Set element shall be transmitted by a QAP in Beacon Frames and Probe Response Frames although its use is not necessarily limited to those frames. The QoS Parameter Set element is used by the QAP to establish policy (by changing default MIB values), to change policies when accepting new stations or new traffic, or to adapt to changes in offered load. The most recent QoS parameter set element received by a QSTA is used to update the appropriate MIB values.

Element ID (12)	**Length** (20)	**reserved** (1 octet)	**QoS Parameter set Count** (1 octet)	**EDCF TXOP Limit** (2 octets)	**CWmin[UP] values** CWmin[0] … CWmin[7] (8 octets)	**AIFS[UP] values** AIFS[0]…AIFS[7] (8 octets)	**CWPFactor[UP] values** CWPFactor[0]… CWPFactor[7] (8 octets)

Figure 42.6 – QoS Parameter Set element format

The QoS Parameter set Count is a 1-octet field that is initialized to zero and incremented by one each time the parameter set changes. This field can be used by QSTAs to determine whether the QoS parameter set has changed and requires updating the appropriate MIB values.

The EDCF TXOP limit is a 2-octet field that specifies the time limit on TXOPs that are not granted by QoS (+)CF-Polls. All non-polled WSTA TXOPs during the CP last no longer than the number of 16-microsecond periods specified by the EDCF TXOP limit value. A EDCF TXOP limit value of 0 indicates that each EDCF TXOP during the CP can be used to transmit a single MPDU at any rate in the operational rate set of the QBSS.

The CWmin[UP] values field contains 8 octets which specify 8 contention window values, for traffic categories 0 through 7, respectively. Each contention window value is 1 octet in length and contains an unsigned integer. A QSTA must update the dot11CWmin[UP] MIB values according to the CWmin[UP] values in the most recent QoS parameter set element received by the QSTA from the QAP of a QBSS. A QSTA must effectively use the updated dot11CWmin[UP] MIB values for all transmissions following the reception of the updated QoS parameter set element.

The AIFS[UP] values field contains 8 octets which specify 8 AIFS values, for traffic categories 0 through 7, respectively. Each AIFS value is 1 octet in length and contains an unsigned integer. A QSTA must update the dot11AIFS[UP] MIB values according to the AIFS[UP] values in the most recent QoS parameter set element received by the QSTA from the QAP of a QBSS. A QSTA must effectively use the updated dot11AIFS[UP] MIB values for all transmissions following the reception of the updated QoS parametr set element.

7.3.2.15 Traffic Specification (TSPEC) element

The Traffic Specification (TSPEC) element contains the set of parameters that define the characteristics and QoS expectations of a unidirectional traffic stream, in the context of a particular WSTA, for use by the HC and WSTA(s) in support of parameterized QoS traffic transfer using the procedures defined in 11.6.. The element information field comprises the items as defined below and illustrated in Figure 42.7. The total length of the information field is 16 octets.

Element ID (13)	Length (16)				TS Info (2 octets)		Inactivity Interval (1 octet)	Inter-arrival Interval (1 octet)

Nominal MSDU Size (2 octets)	Minimum Data Rate (2 octets)	Mean Data Rate (2 octets)	Maximum Burst Size (2 octets)	Minimum Tx Rate (1 octet)	reserved (1 octet)	Delay Bound (1 octet)	Jitter Bound (1 octet)

Figure 42.7 – Traffic Specification element format

The Traffic Specification allows a set of parameters more extensive than may be needed, or may be available, for any particular instance of parameterized QoS traffic. The fields are set to zero for any unspecified parameter values.

The TS Info field is 2 octets which is subdivided as shown in Figure 42.8. The Traffic Type subfield is a single bit which is set to 1 for a continuous or periodic traffic pattern (e.g. isochronous traffic stream of MSDUs, with constant or variable sizes, that are originated at fixed rate), or is set to 0 for a non-continuous, aperiodic, or unspecified traffic pattern (e.g. asynchronous traffic stream of low-duty cycles). The TSInfo Ack Policy subfield is 2 bits that identify the acknowledgement policy for use on MSDUs belonging to this traffic category, with the alternatives specified in the paragraph just below Figure 42.8. The FEC field is 1 bit which is set to 1 if FEC as specified in clause 7.5 is to be applied to MPDUs containing MSDUs, or fragments thereof, belonging to this traffic stream. The User Priority subfield is 3 bits that hold the actual priority value to be used for the transport of MSDUs belonging to this traffic stream in cases where relative prioritization is required. The TSID subfield is 4 bits in length and contains the TSID values in the format defined in 7.1.3.5.1. The combination of TSID and Direction identify the traffic stream, in the context of the WSTA, to which the traffic specification applies. The same TSID may be used for multiple traffic streams to streams at different WSTA.

bits:0	1	2-3	4	5-7	8-11	12-15
Traffic Type	reserved	TSInfo Ack Policy	FEC	User Priority	reserved	TSID

Figure 42.8 – TS Info field

The TSInfo Ack Policy sub-field is 2 bits in length and indicates whether MAC acknowledgement is required for MPDUs belonging to this traffic stream, and the desired form of those acknowledgements. Certain, selectable and/or optional facilities (e.g. FEC) may require the use of a particular TSInfo Ack Policy setting. The encoding of the TSInfo Ack Policy field is shown in Table 20.1. If the TS Info Ack Policy is set to Burst Acknowledgement, the HC shall assume, for TXOP scheduling, that the Immediate Burst Ack policy is being used (see 9.10.5).

Table 20.1 – TSInfo Ack Policy field encoding

Bit 2	Bit 3	Usage
0	0	Normal IEEE 802.11 acknowledgement. The addressed recipient returns an ACK or QoS (+)CF-Ack frame after a SIFS period, according to the procedures defined in 9.2.8, 9.3.3 and 9.10.3.
1	0	No acknowledgement The recipient(s) shall not acknowledge the transmission, and the sender treats the transmission as successful without regard for the actual result.
0	1	Alternate acknowledgement Reserved for future use, interpreted as normal IEEE 802.11 acknowledgement if received.
1	1	Burst Acknowledgement A separate Burst Ack set up mechanism described in 9.10.5 shall be used.

The direction field defines the direction of DATA carried by the traffic stream as defined in table 20.1.1. The WSTA may use the TSID value for a downlink TSPEC and either an uplink or a sidelink TSPEC at the same time. The WSTA shall not use the same TSID for both uplink and sidelink TSPECs.

Table 20.1.1 – Direction field encoding

Bit 8	Bit 9	Usage
0	0	Uplink (WSTA to HC)
1	0	Downlink (HC to WSTA)

0	1	Sidelink (WSTA to WSTA)
1	1	reserved

The Inactivity Interval field is 1 octet in length, and a non-zero value specifies the maximum amount of time in units of 32 ms that may elapse without arrival or transfer of an MSDU belonging to this TS before this TS is deleted by the MAC entity at the HC. A value of 0 disables the Inactivity Interval .

The Interarrival Interval field is 1 octet in length, and a non-zero value specifies the nominal interarrival interval, in units of TU, of MSDUs belonging to this traffic stream at the MAC SAP. Actual interarrival interval may differ from the value of this field and may not be a constant. This field provides a reference value for choosing the interval between consecutive MSDU transmissions from the traffic stream under this traffic specification. A value of 0 indicates unspecified interarrival interval.

The Nominal MSDU Size field is 2 octets in length, and a non-zero value specifies the nominal size, in octets, of MSDUs belonging to the TS under this traffic specification. A value of 0 indicates unspecified or variable size.

The Minimum Data Rate field is 2 octets in length, and a non-zero value specifies the lowest data rate, in units of1 kbit/s (1k = 1000), that is acceptable for transport of MSDUs belonging to this TS within the delay and jitter bounds under this traffic specification. A value of 0 indicates unspecified minimum data rate.

The Mean Data Rate field is 2 octets in length, and a non-zero value specifies the nominal sustained data rate, in units of 1 kbit/s (1k = 1000), for transport of MSDUs belonging to this TS within the delay and jitter bounds under this traffic specification. A value of 0 indicates unspecified mean data rate.

The Maximum Burst Size field is 2 octets in length, and a non-zero value specifies the maximum data burst, in units of eight octets, of MSDUs belonging to this TS that may occur for transport within the delay and jitter bounds under this traffic specification. The field A value of 0 indicates unspecified maximum burst size.

The Minimum Tx Rate field is 1 octet in length and specifies the minimum PHY rate, in units of 0.5Mbit/s that is necessary for successful transport of this TS. A value of 0 indicates that any supported rate is acceptable.

NOTE: This rate information is intended to ensure that the TSPEC parameter values resulting from an admission control negotiation are sufficient to provide the required throughput for the traffic stream. In a typical implementation, a TS is admitted only if the defined traffic volume can be accommodated at the specified rate within an amount of WM occupancy time that the admissions control entity is willing to allocate to this TS.

The Delay Bound field is 1 octet in length, and a non-zero value specifies the maximum amount of time in units of eight ms allowed to transport an MSDU belonging to this TS, measured between the time marking the arrival of the MSDU at the local MAC sublayer from the local MAC SAP and the time starting the successful transmission or retransmission of the MSDU to the destination. A value of 0 indicates the maximum amount of time allowed to transport an MSDUs belonging to this TS is dot11MaxTransmitMSDULifetime, measured from the attempt to transmit the first fragment of the MSDU, as specified in 9.4.

The Jitter Bound field is 1 octet in length, and a non-zero value specifies the acceptable maximum delay difference in units of TU in the transport of MSDUs belonging to this TS, with the delay in the transport of an MSDU measured between the time marking the arrival of the MSDU at the local MAC sublayer from the local MAC SAP and the time starting the successful transmission or retransmission of the MSDU to the destination. A value of 0 indicates unspecified jitter bound.

7.3.2.16 QAPC-STA parameter set element

This element is present only in Beacon, Probe Response, Association Response and Reassociation Response MMPDUs transmitted by an active QAPC-STA.

Element ID (xxxx)	Length (2)	QAPC-STA Control Field (2 Octets)

Figure 42.9 – QAPC-STA parameter set element format

The QAPC-STA Control Field is defined in figure 42.10.

bits: 0-3	4-7	8	9	10	11-12	13-14	15
Infrastructure Bandwidth	**Highest Supported PHY Rate**	**reserved**	**Global Connectivity**	**Line Power**	**reserved**	**User Priority**	**Inhibit QAPMobility**

Figure 42.10 – QAPC-STA Control Field

Note: As with other fields in 802.11, when interpreted as a 16 bit number, bit 15 will be the most significant bit.

Ed Note: HC Capability is not included in the ranking on the understanding that all QAP devices must support HC. If this is not the case, an "HC Capable" must be added to the ranking in bit position 12.

The *Inhibit QAP Mobility* field is 1 when the active QAPC-STA is not willing to become inactive. Otherwise it contains 0. See 11.4.1.3.

The *User Priority* field is set to the value specified in the MLME-START.request primitive. The settings of this field are not defined here. The recommended values are in Table 20.2:

Table 20.2 – Recommended User Priority field values

Value	Name	Description
0	WSTA	The primary role of the device is intended to be an WSTA
1	Normal	The normal setting for this value if there is no strong preference as to role
2	AP	The primary role of the device is intended to be an AP
3	External Selection	The device has been configured by an external agency to prefer it

Fields marked as *Reserved* shall be set to zero on transmission.

The *Line Power* field is set to the value specified in the MLME-START.request primitive, and should be 1 when the QAPC-STA is operating off line power. Otherwise it is 0.

The *Global Connectivity* bit is set to the value specified in the MLME-START.request primitive, and should be 1 when the DS to which the QAPC-STA is connected includes a portal that connects to the internet. Otherwise it should be zero.

The *Highest Supported PHY Rate* should be set to the highest PHY rate supported by the QAPC-STA, encoded as shown in Table 20.3.

Table 20.3 – Highest Supported PHY Rate field

Highest Supported PHY rate Value	Description
0	0 to 1 Mbps
1	>1Mbps to 5Mbps
2	>5Mbps to 10Mbps
3	>10Mbps to 20Mbps
4	>20Mbps to 50Mbps
5	>50Mbps to 100Mbps
6	>100 Mbps to 1Gbps
7	>1 Gbps

The *Infrastructure Bandwidth* field is set according to 20.4 based on the bandwidth of its (receive) connection to an infrastructure.

Table 20.4 – Infrastructure Bandwidth Field

Infrastructure Bandwidth Value	Description
0	No connection
1	0 to 64 kbps
2	>64 to 128 kbps
3	>128 kbps to 1 Mbps
4	>1Mbps to 10Mbps
5	>10Mbps to 100Mbps
6	>100 Mbps to 1Gbps
7	>1 Gbps

7.3.2.17 Extended Capability element

The Extended Capability element is present in any management frame body that includes a Capability Information field with bit 15 set to 1. This element provides additional bits to indicate optional or configurable capabilities. The element information field is a positive integer multiple of 2 octets in length, with a default length of 2 octets, as shown in Figure 42.11.

Element ID (35)	Length (2*n)	Extended Capabilities (2*n octets)

Figure 42.11 – Extended Capability element format

The Extended Capabilities field is (at least) 2 octets in length, and contains capability information bits as defined in Figure 42.12. Once assigned, the posits of individual capability bits within this field remain fixed. This allows the length of this field to be extended over time without ambiguity. The mutually available capabilities for a pair of QSTAs which use Extended Capability elements of different lengths are, by definition, capabilities indicated by bits starting with bit 0 of the first octet of the element information field and ending with bit 15 of the last octet pair in the shorter of the two elements.

bits: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)	rsrv (0)

Figure 42.12 – Extended Capabilities field (first 2 octets)

7.3.2.18 Traffic Classification (TClas) Element

Traffic Classification (TClas) element contains the set of parameters necessary to identify incoming MSDUs with a particular traffic stream to which they belong. The element information field contains Search Priority, Classifier Type, and Frame Classifier as defined below and illustrated in Figure 42.16 and Table 20.2. The total length of the information field is 2 octets plus the length of the Frame Classifier which is specified in the context of the Classifier Type.

Element ID (32)	**Length** (L+2)	**Search Priority** (1 octet)	**Classifier Type** (1 octet)	**Frame Classifier** (L octets)

Figure 42.16 – Listen Epoch element format

Table 20.2 – Category codes

Classifier Type	Meaning
0	TSID parameter
1	TCP/UDP IP parameters
2	802.2 LLC parameters
3	802.1 D/Q parameters
4	802.3 MAC parameters
5 – 255	Reserved

The Search Priority field is 1 octet in length and specifies the search order for this frame classifier relative to other frame classifiers maintained in a classification table located above the MAC SAP at an ESTA. Frame classifiers are used in order of ascending unsigned integer values of the Search Priority value until either the MSDU is matched with a frame classifier or the set of frame classifiers in the classification table is exhausted. In the former case, the MSDU belongs to the traffic stream referenced to by the TSID included in the Traffic Specification element accompanied with the Traffic Classification element containing the matched Frame Classifier, and is transported with parameterized QoS support according to that traffic specification. The TSID is passed down to the MAC as the Priority parameter in the range of 8-15, inclusive, in the MA-UNITDATA.request primitive containing that MSDU. In the later case, the MSDU is considered to be a best effort frame and is transported without specific QoS support. The maintenance and operation of the classification table is beyond the scope of this specification.

The Classifier Type field is 1 octet in length and specifies the type of frame classifier in this traffic classification.

The Frame Classifier field is 0-2266 octets in length and specifies the parameter(s), for the given classifier type, that match(es) with the corresponding parameter(s) contained in the incoming MSDUs of a particular traffic stream. Five frame classifiers are currently defined.

The frame classifier of type 0 contains the TSID of the traffic stream to which an incoming MSDU has been determined to belong by higher-layer signaling and multiplexing mechanisms. Technically, this frame classifier may not be maintained in the classification table, and the MSDU requires no further classification as it is already classified to a particular traffic stream.

The frame classifier of type 1 contains the following parameters in a TCP or UDP header: Source Port (2 octets) and Destination Port (2 octets). It further contains the following parameters in an IPv4 header: Version (1 octet), Type of Service (1 octet), Protocol (1 octet), Reserved (1 octet), Source Address (4 octets), and Destination Address (4 octets); or the following parameters in an IPv6 header: Version (1 octet), Flow Label (3 octets), Source Address (4 octets), and Destination Address (4 octets).

The frame classifier of type 2 contains the following parameters in an IEEE 802.2 LLC header: DSAP Address (1 octet) and SSAP Address (1 octet).

The frame classifier of type 3 contains the following parameters in an IEEE 802.1Q tag header: Reserved (1 bit), IEEE 802.1D User Priority (3 bits), and IEEE 802.1Q VLAN ID (12 bits).

The frame classifier of type 4 contains the following parameters in an IEEE 802.3 MAC header: Destination Address (6 octets), Source Address (6 octets), and Type (2 octets).

Insert following the last 7.3.x subclause the following 7.4.x subclauses with the figures and tables included therein, renumbering as necessary:

7.4 QoS management actions

The management action codes within the QoS category are defined in Table 20.3.

Table 20.6 – QoS Action codes

Code	Meaning
0	Add TS request
1	Add TS response
2	Delete TS
3	Reserved
4	Define Burst Ack request
5	Define Burst Ack response
6	Delete Burst Ack request
7 – 255	Reserved

7.4.1 ADDTS QoS Action frame formats

The ADDTS QoS Action frames are used to carry TSPEC and optionally TClas Elements to set up and maintain traffic streams using the procedures defined in 11.6.

The ADDTS Request QoS Action frame has Category set to QoS and Action Code set to 0. The Activation Delay shall be 0.

The ADDTS Response QoS Action frame has Category set to QoS and Action Code set to 1. The action-specific status codes are defined in table 20.3.1 below.

Table 20.3.1 Result Codes

Code value	Result Code	Definition
0	Success	The TS has been created with the parameters contained in the Action Body of the request frame.
1	Unrecognised Action Code	This should not occur.
2	INVALID_PARAMETERS	No TS has been created because one or more parameters have invalid values.
3	ALTERNATIVE	The TS has been created with the parameters contained in the Action

		Body of the response frame. These are not the same as the parameters in the request frame.
4	REFUSED	The TS has not been created because the request cannot be honored at this time due to other QoS commitments.
5-255	Reserved	

The Action Body of the ADDTS QoS Action frames is shown in Figure 42.16.1. The Dialog Token, Traffic Specification, and Traffic Classification in this frame are contained in an MLME-ADDTS.xxx primitive, where xxx denotes request, confirm, indication, or response, which causes the frame to be sent to a WSTA or the HC or which is issued due to receipt of the frame.

The TSPEC element and optional TClas Element contain QoS parameters that define the TS. The TS is identified by the TSID and Direction fields within the TSPEC. The TClas is optional at the discretion of the WSTA that sends the ADDTS QoS Request frame. The HC shall support receiving and sending ADDTS QoS Action request and response frames that include this element.

				12	
				TSPEC Element	**TClas Element (optional)**

Figure 42.16 – Add TS QoS Action frame body

7.4.2 DELTS QoS Action frame format

The DELTS QoS Action request frame is used to delete a traffic stream using the procedures defined in 11.6.

The DELTS Request QoS Action frame has Category set to QoS and Action Code set to 2. The Activation Delay shall be 0.

The Action Body of a DELTS QoS Action frame is shown in Figure 42.17. Only the TSID and Direction fields of the TSPEC element are significant, all other fields are considered to be undefined.

				12
				TSPEC Element

Figure 42.17 – Delete TS QoS Action frame body

A Delete TS QoS Action frame is used to delete a traffic stream characterized by the TSPEC element included in the frame. A Delete TS QoS Action frame may be sent from the HC to the source station and/or destination station(s) of that traffic stream, or vice versa, to indicate an imperative request, to which no response is required from the recipient station(s).

Insert following 7.4.2 the 7.4.x subclauses with the figures and tables included therein, renumbering as necessary:

7.4.3 Define Burst Ack QoS Action frame format

7.4.3.1 Define Burst Ack request QoS Action frame format

The frame body of a Define Burst Ack request QoS Action frame is shown in 42.18.1. The dialog token can be of any value but should have the same value in all future QoS action frame exchanges. TID contains the value of the TC or TS for which the burst ack is being requested. The transmit buffer size is the available buffer for the burst in the sender side. This field is intended to provide guidance for the receiver to decide its Re-ordering buffer size, and is advisory only. When this subfield is set to 0, this information is not available from the transmiter. The reserved bits are all set to 0.

octets: 1	1	1	1	2		
1 (Category QoS)	4 (Define Burst Ack request)	0 (no activation delay)	Dialog Token	*Bits: 0-3*	*4-7*	8-15
				reserved	TID	Transmit Buffer Size

Figure 42.18.1 Define Burst Ack request QoS Action frame body

A Define Burst Ack request QoS Action frame is used to initiate burst acknowledgement for a specific TC or TS between the SA and RA in the header. A response is required for this frame from the recipient of the frame.

7.4.3.2 Define Burst Ack response QoS Action frame format

The frame body of a Define Burst Ack response QoS Action frame format is shown in Figure 42.18.2. This frame is sent in response to a Define Burst Ack request QoS Action frame. The dialog token should be copied from the original Define burst Ack request Action frame format. The Reject subfield is set to 1 if the recipient is unable to accommodate the burst ack request and is set to 0 to indicate the recipient's readiness to participate in the burst ack. When the Reject subfield is set to 1, the Burst Ack Policy and the Re-ordering Buffer size subfields become reserved and set to 0. The Burst Ack Policy subfield is set to 1 for immediate Burst Ack and 0 for delayed Burst Ack.

octets:1	1	1	1	2				
1 (Category QoS)	5 (Define Burst Ack response)	0 (no activation delay)	Dialog Token	Bit: 0-1	2	3	4-7	8-15
				reserved	Reject	Burst Ack Policy	TID	Re-ordering Buffer Size

Figure 42.18.2 Define Burst Ack response QoS Action frame body

TID contains the value of the TC or TS for which the burst ack is being requested. The Re-ordering buffer size indicates the number of of buffers of size 2304 octets available for bursting for this particular TID. The reserved bits are all set to 0.

If the Reject bit is 1, the BurstAckReq has been rejected by the intended recipient, and no burst ack has been set up. In this case, the BurstAckPolicy, TID and Re-ordering buffer size fields are undefined. Otherwise, the Re-ordering buffer size indicates the number of full-size (2304) buffers available for bursting using this TID. This number shall be at least 1.

Note: For Re-ordering Buffer size, the recipient advertizes a single scalar number, N, which is the number of full-size (2304 octet) buffers available for bursting. The semantics are that every MPDU will consume one of these full-length buffers whether the frame is an MSDU or whether it is a fragment. In other words, ten full-size MSDUs will consume the same amount of buffer space at the recipient as 10 small fragments.

7.4.3.3 Delete Burst Ack request QoS Action frame format

The frame body of a Delete Burst Ack request QoS Action frame format is shown in Figure 42.18.3. This frame is sent to terminate the burst ack participation by either the originator of the traffic or the recipient. There is no response QoS action frame and the immediate acknowledgement that is sent by the receiver of this frame is considered as a positive response.

Octets: 1	1	1	1	2		
1 (Category QoS)	6 (Delete Burst Ack request)	0 (no activation delay)	Dialog Token	***Bits:0-10***	***11***	***12-15***
				reserved	**Direction**	**TID**

Figure 42.18.3 Delete Burst Ack request QoS Action frame body

The dialog token should be copied from the original Define burst Ack request Action frame format. The Direction field indicates if the originator or the recipient of the data sends this frame. It is set to 0 to indicate the originator and 1 the recipient. TID field indicates the TSID or the TCID for which the burst ack has been originally set up.

7.4.4 QAPC-STA assertion action frame format

The QAPC-STA assertion management action frame and its response are class 1 frames.

The frame body of a QAPC-STA assertion action request frame contains a QAPC-STA parameter set element as defined in 7.3.2.17.

The frame body of a QAPC-STA assertion response frame is null (zero length).

One additional status code is defined for the QAPC-STA assertion action response frame in Table 20.7.

Table 20.7 – QAPC-STA assertion action frame status field

Status Code	Definition
2	The request is refused because the active QAPC-STA has a higher rank than the requesting QAPC-STA.

Insert after the last 7.4.x subclause the following new subclause, including figures and tables therein, renumber items as appropriate:

7.5 WARP Action Frames

The management action codes within the WARP category are as defined in Table 20.8.

Table 20.8 – WARP Action Codes

Code	Meaning
0	Direct enable request
1	Direct enable response
2	Direct disable request
4	Location discovery request
5	Location discovery response
6	Direct communication request
7	Direct communication response
8	Status change notify request
9	Status change notify response
10	Wakeup notify request
11	Wakeup notify response

7.5.1 Direct Enable Request

A direct enable request action frame contains.no action-specific fixed fields or elements.

7.5.2 Direct Enable Response

A direct enable response action frame contains no fixed body fields and must contain a direct enable status element and no other elements.

7.5.3 Direct Disable Request

A direct disable request action frame contains no action-specific fixed fields or elements.

7.5.4 Location Discovery Request

A location discovery request action frame contains no action-specific fixed fields and must contain a target destination address element and no other elements.

7.5.5 Location Discovery Response

A location discovery response action frame contains no action-specific fixed fields and must contain a target destination address element, a transmit rate element and a location discovery status element.

7.5.6 Direct Communication Request

The frame body of the Direct Communication Request contains the information shown in Table 20.8.1

Table 20.8.1 – Direct Communication Request frame body

Usage	Order	Information
Always present	1	SSID
	2	Supported rates
MRD optional	3	Request information may be included if dot11MultiDomainCapabilityEnabled is true

7.5.7 Direct Communication Response

The frame body of the Direct Communication Response contains the information shown in Table 20.8.2

Table 12 – Direct Communication Response frame body

Usage	Order	Information	Note
Always present	1	Capability information	
	2	SSID	
	3	Supported rates	
Present if required by PHY type, BSS type, or an active point coordinator	4	FH Parameter Set	The FH Parameter Set information element is present within Probe Response frames generated by STAs using frequency hopping PHYs.
	5	DS Parameter Set	The DS Parameter Set information element is present within Probe Response frames generated by STAs using direct sequence PHYs.
	6	CF Parameter Set	The CF Parameter Set information element is present within Beacon frames generated by APs with an active PC or by QAPs.
	7	IBSS Parameter Set	The IBSS Parameter Set information element is only present within Probe Response frames generated by STAs in an IBSS.
Multiple regulatory domains	8	Country Information	Included if dot11MultiDomainCapabilityEnabled is true
	9	FH Parameters	FH Parameters as specified in clause 7.3.2.13 may be included if dot11MultiDomainCapabilityEnabled is true
	10	FH Pattern Table	FH Pattern Table information as specified in clause 7.3.2.14 may be included if dot11MultiDomainCapabilityEnabled is true
	11 - n	Requested information elements	Elements requested by the Request information element of the Probe Request frame.
QBSS, always present	8	QBSS Load	The QBSS Load information element is only present within Probe Response frames generated by QAPs.
	9	Error Statistics	Reserved for future use. The Error Statistics information element is only present in Probe Response frames generated by QSTAs in a QBSS.
QBSS, present if required	10	Extended Capabilities	The Extended Capabilities information element is only present in Probe Response frames generated by QSTAs with Capability Information bit 15=1.
	11	QAPC-STA Parameter Set	The QAPC-STA Parameter Set is only present in Probe Response frames generated by QAPs in a QBSS which have the QAPC-STA active.

7.5.8 Wakeup Notify Request

A wakeup notify request action frame contains no action-specific fixed fields and must contain a target destination address element and no other elements.

7.5.9 Wakeup Notify Response

A wakeup notify response action frame contains no action-specific fixed fields and must contain a target destination address element and no other elements.

7.6 MAC-Level FEC and FEC frame formats

MAC-Level FEC is an option that may be used to reduce both the frequency of retransmissions and the MSDU loss rate for transfers via the WM. The following conditions apply to the use of MAC-Level FEC:

- MAC-Level FEC is a separate option from the QoS facility, the support for which is indicated by a separate bit in the Capability Information field. The use of MAC-Level FEC may be negotiated between QSTAs when desired, and may be used for transfers with no QoS delivery requirements. Note that a support for the QoS facility is a prerequisite to support for MAC-Level FEC, because the indication that an MPDU has been FEC-encoded is bit 15 of the Frame Control field and bit 9 of the QoS Control field, and the QoS Control field is only present in QoS data type frames and only exchanged by QSTAs in a QBSS.

- When using the TSPEC, if the recipient QSTA is capable of performing FEC decoding within a SIFS duration, it may be possible to use immediate ackowledgements. In such a case, FEC may be enabled using the Add TS Request QoS action frame with the FEC bit set to 1 and Ack Policy set to immediate acknowledgement. If such a combination of FEC and ACK policy is sent to a recipient who cannot do immediate acknowledgement, the recipient QSTA shall set the FEC bit to zero in the TSPEC of Add TS Response QoS action frame to indicate its inability to respond with an ACK frame within a SIFS duration. If the requestor desires, it may retry the request by sending Add TS request QoS action frame for the traffic stream with FEC set to 0 or with FEC set to 1 and Ack Policy set to either Burst Acknowledgement or No Acknowledgement in the TSPEC. The recipient QSTA shall reply according to the QSTA's ability to support FEC with or without Burst Acknowledgment.- The MAC FEC operation allows for error detection to take longer than a SIFS interval. FEC-capable QSTAs that are unable to distinguish receptions with uncorrectable errors from receptions with correctable errors or no errors within a SIFS interval may require that all FEC-encoded frames be sent to them using an acknowledgment policy that does not include immediate acknowledgment. The non-use of immediate acknowledgement is negotiated as part of the TSPEC and/or Burst Acknowledgement signaling as in subclauses 7.3.2.15 and 9.10.5 respectively.

Note: in any practical implementation of the FEC, the RxTXTurnaroundTime happens during the decoding process, and so medium sensing can be done even while the FEC frame is being decoded.

- A valid FCS check is required in order to forward an MSDU containing error-corrected data to higher layers. When the post-correction FCS check, using the "FEC FCS" as shown in Figure 42.19, fails, the MAC shall not indicate the erroneous MSDU to higher layers at the MAC SAP.

- The FEC bit in the Frame Control Field together with the FEC bit in the QoS control field should be used by transmitting stations to indicate if a frame is FEC encoded. If a frame is FEC encoded, both bits must be set to 1. If a frame is not FEC encoded, both bits must be set to 0. This allows for resiliency in the case that an FEC bit is incorrectly received.

- The FEC bit in the Frame Control Field together with the FEC bit in the QoS control field (if the QoS control field is present) should be used exclusively by receiving stations to determine if a frame is FEC encoded.

The FEC shall not be used in frames of subtype QoS (+) CF-Poll..

MAC-Level FEC may be performed on a given traffic stream. QSTAs announce their FEC capability by setting bit 9 of the Capability Information Field (7.3.1.4 and Figure 27) to 1. FEC is enabled for MPDUs belonging to a specific TS to/from a FEC-capable QSTA by defining a TSPEC for that TS which has bit 4 of its TS Info field set to 1. This TSPEC may be defined either by the local MLME, using an MLME-ADDTS.request; or by the MLME at the peer QSTA, using an Add TS request QoS Action frame.

QSTAs that are not capable of FEC decoding will still be able to read the MPDU, since the code is a systematic code, and, via management frames, the receiving station is made aware of the flow's encoding. A non-FEC capable QSTA can therefore interpret the MAC header and FCS, and can ignore erroneous frames based on the FCS result Unicast MPDUs directed to a non-FEC-capable QSTA shall not be FEC encoded. It is up to the implementation whether a non-FEC-capable QSTA shall discard or receive FEC-encoded multicast MPDUs directed to it. In the latter case, the QSTA shall interpret the MPDU according to the FEC frame format, receiving the data and ignoring the parity check fields.The MAC-Level FEC is based on shoterned versions of the (255,239) Reed-Solomon code over GF(256). An (m,m+16) shortened Reed-Solomon code, where 0 < m < 256, is obtained by treating m octets as though they were the last m octets of 239 information octets to be encoded by the (255,239) Reed-Solomon code. The first (239-m) octets are assumed all zeros for the encoding purpose while they are not transmitted. The (255,239) and any shortened version are capable of correcting up to 9 octet errors per block. Figure 42.19.1 illustrates how the shortened code is generated.

Note: The codes chosen were made to be variants of the (255, 239) code to facilitate the transmission of MPEG-2 Transport Streams, as defined in IEC 61883-4. Such streams, assuming payload allocated for overhead, is expected to fit within a single RS block of 208 octets.

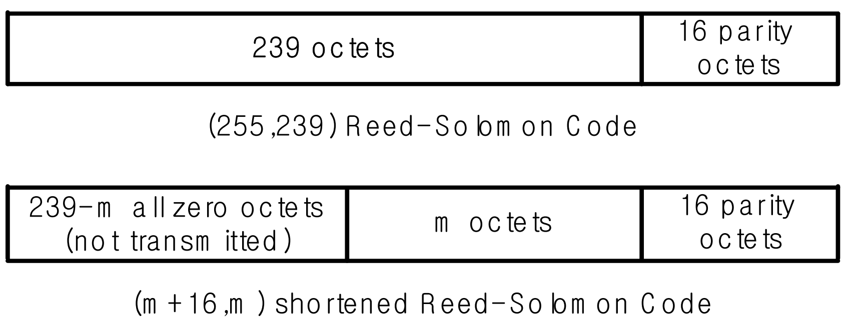

Figure 42.19.1 FEC frame format

The format of MAC-Level FEC MPDUs is given in Figure 42.19.2, where the upper part shows an non-FEC-encoded MPDU while the lower part shows an FEC-encoded MPDU counterpart for the same payload from an MSDU or a fragment of an MSDU for the comparison purpose. The Data portion in the figure represent the frame body of non-FEC-encoded frame, which may include IV and ICV fields as specified in Figure 46 if the WEP option is used. The MAC-Level FEC uses a (48,32) and (224,208) Reed-Solomon codes, which are both shoretened versions of the (255,239) code over GF(256), for the MAC header and the frame body part of the MPDU, respectively. FEC encoding is performed on successive 208-octet blocks of the frame body of the MPDU. The FEC coding adds 16 parity octets per block. If the unencoded frame body is not an integral multiple of 208 octets, then the last block of the frame body with m octets is encoded with a (m+16, m) Reed-Solomon code, which is a shortened version of the (255,239) code over GF(256).

Two FCS fields are used for the FEC-encoded frames. Before the FEC encoding, the FCS is calculated over all the fields of the MAC header and the frame body field. The resulting 4-octet FCS, called "FEC FCS", is appended to the frame body. The resuling frame should look like the upper part of Figure 42.19. The non-FEC-encoded frame is encoded using the above-desribed FEC. Finally, in order for STAs and non-FEC capable QSTAs to perform validate the received MPDU (in order to use information from fields in the MAC header), the MPDU FCS is calculated on the FEC-encoded frame, including all Reed-Solomon parity octets, resulting in the MPDU format as shown in the lower part of Figure 42.19. The receiving QSTA, which is FEC-capable, can recalculate the FEC FCS on the corrected MPDU, to determine whether the error correction has recovered the original frame contents. If the FEC FCS check is invalid for a received, corrected MPDU, that MPDU is discarded due to an uncorrectable error. Both the FEC FCS and the MPDU FCS are computed, and transmitted in the bit order, specified in 7.1.3.8.

For QoS data frames of types that do not utilize an Address 4 field, in order to facilitate decoding and separation of the header from the frame body, a 6-octet pad of ones is inserted between the Sequence Control field and the QoS Control field. All FCSs are calculated after this padding is added, as it is part of the transmitted frame.

Note: One method for handling the decoding procedure of an FEC frame is as follows: If both FEC bits are received as 0, the frame is handled as a non-FEC encoded frame, if however at least one of the FEC bits (or both FEC bits) are received as 1, the frame is handled as an FEC encoded frame. (If the frame were not FEC encoded, it would fail the FCS in any event.) The inner FCS is used to determine if the RS decoding was successful when used. This method (the implementer is free to use whatever methods fit his design constraints) works under the assumption that at the expected BER of operation when FEC coding is used, the probability of receiving both FEC bits in error is negligible, and allows for a simple implementation.

Alternatively, the outer FCS may be done before any FEC decoding is; if this FCS fails, then FEC decoding is performed as above.

MAC Header	Frame Body Data (*N*=1~ 12)	FCS
32	208*(*N*-1)+1 ~ 208 * *N*	4

MAC Header		Frame Body (*N* Blocks, *N*=1~ 12)							FCS
Header	Header FEC	$Data_1$	FEC	$Data_2$	FEC	----	$Data_N$ + "FEC FCS"	FEC	FCS
32	16	208	16	208	16	----	1 ~ 208	16	4

Figure 42.19.2 FEC frame format

All the FEC computations are based on the polynomial operations in GF(2) and GF(256). Both the RS (224, 208) and RS (48, 32) used are shortened versions of the RS (255, 239) code over GF(256). GF(256) is generated by a polynomial *f(x)* in GF(2). The polynomial *f(x)* for the GF(256) is:

$$f(x) = x^8 + x^4 + x^3 + x^2 + 1$$

The field that this polynomial generates is listed in Table 6 of Appendex A of Lin and Costello, *Error Control Coding: Fundamentals and Applications*, Prentice-Hall, 1983, as well as in other coding books. Each code (a code space with collection of all code words) contains a unique nonzero code word of smallest degree polynomial with the coefficient of highest degree equal to 1. This polynomial is called ***generator polynomial***. All code words can be constructed using generator polynomial for the Reed-Solomon code:

$$g(x) = \prod^{2t} (x - \beta^i) = \sum^{2t} g_j * x^j$$

i=1 j= 0

t = the number of correctable errors = 8

β^i = roots of g(x) on (primitive elements of) GF(256)

The generator polynomial's coefficiencts are given by the following, with a^m as primitive roots of f(x):

g_{15} : a^{121}
g_{14} : a^{106}
g_{13} : a^{110}
g_{12} : a^{113}
g_{11} : a^{107}
g_{10} : a^{167}
g_9 : a^{83}
g_8 : a^{11}
g_7 : a^{100}
g_6 : a^{201}
g_5 : a^{158}
g_4 : a^{181}
g_3 : a^{195}
g_2 : a^{208}
g_1 : a^{240}
g_0 : a^{136}

The decimal values of the roots of g(x) are given in Table 20.3.

Table 20.3. Roots of Reed-Solomon Polynomial g(x)

Coefficients of a^m represented as a[m]	Decimal Value
a[121]	118
a[106]	52
a[110]	103
a[113]	31
a[107]	104
a[167]	126
a[83]	187
a[11]	232
a[100]	17
a[201]	56
a[158]	183
a[181]	49
a[195]	100
a[208]	81
a[240]	44
a[136]	79

To obtain the parity check octets, the MAC header or the message block is represented as a polynomial c(x) over GF(256), with the rightmost octet corresponding to the coefficient of x^0 in c(x). The remainder polynomial b(x) is formed by dividing x^{16}c(x) by the generator polynomial g(x). The 16 parity check octets are the coefficients of the remainder polynomial b(x), with the rightmost parity check octet corresponding to the coefficient of x^0 in b(x).

Insert after 7.5 the following new subclause, including the table therein, renumber items as appropriate:

7.7 Frame usage guidelines

Table 20.10 shows which frame subtypes are transmitted and received by different kinds of MAC entities operating in the different types of BSS and under the available coordination functions.

Table 20.10 – Frame subtype usage by BSS type, MAC entity type, and coordination function

Frame subtype	IBSS	non-QoS				QoS	
	CP	CP		CFP		CP & CFP	
	STA	STA	AP	STA	PC	QSTA	HC
(Re)Association Request	- - -	T	R	- - -	- - -	T	R
(Re)Association Response	- - -	R	T	- - -	- - -	R	T
Probe Request	T, Rbe	T	R	- - -	- - -	T, R	R
Probe Response	Tbe, R	R	T	- - -	- - -	T, R	T
Beacon	Tb, R	R	T	R	T	R	T, R
ATIM	T, R	- - -	- - -	- - -	- - -	- - -	- - -
Disassociation	T, R	T, R	T, R	T, R	T, R	T, R	T, R
Authentication	T, R	T, R	T, R	T, R	T, R	T, R	T, R
Deauthentication	T, R	T, R	T, R	T, R	T, R	T, R	T, R
Action Req/Rsp	- - -	- - -	- - -	- - -	- - -	T, R	T, R
RR	- - -	- - -	- - -	- - -	- - -	Tcc	R
BurstAck/BurstAckReq	- - -	- - -	- - -	- - -	- - -	T, R	T, R
CC	- - -	- - -	- - -	- - -	- - -	R	T
PS-Poll	- - -	T	R	- - -	- - -	T	R
RTS	T, R	T, R	T, R	- - -	- - -	T, R	T, R
CTS	T, R	T, R	T, R	- - -	- - -	T, R	T, R
ACK	T, R	T, R	T, R	T, R	T, R	T, R	T, R
CF-End	(R)	(R)	(R)	R	T	R	T
CF-End+CF-Ack	(R)	(R)	(R)	R	T	(R)	- - -
Null	T, R	T, R	T, R	T, R	T, R	T, R	T, R
Data	T, R	T, R	T, R	T, R	T, R	T, R	T, R
(Data+)CF-Poll+(CF-Ack)	- - -	- - -	- - -	R	T	- - -	- - -
(Data+)CF-Ack	- - -	- - -	- - -	T, R	T, R	- - -	- - -
QoSNull	- - -	- - -	- - -	- - -	- - -	T, R	T, R
QoSData	- - -	- - -	- - -	- - -	- - -	T, R	T, R
(QoSData+)CF-Poll	- - -	- - -	- - -	- - -	- - -	R	T
(QoSData+)CF-Poll+CF-Ack	- - -	- - -	- - -	- - -	- - -	Rda	Tda
(QoSData+)CF-Ack	- - -	- - -	- - -	- - -	- - -	T, Rda	Tda, R

Symbols:
- T — frame subtype for row is transmitted by MAC entity for column
- R — frame subtype for row is received by MAC entity for column
- (R) — frame subtype for row is received, but only from other BSSs, by MAC entity for column
- Tb, Tbe — frame subtype for row is transmitted by station that most recently won beacon arbitration; if "Tbe" is also transmitted by a QSTA in an IBSS pursuant to receiving directed request

Rbe	frame subtype for row is received by station that most recently won beacon arbitration, also received as directed request by a QSTA in an IBSS
Tcc	frame subtype for row is transmitted only during controlled contention intervals.
Tda	frame subtype for row is transmitted only if recipient of +Cf-Ack function is addressee.
Rda	frame subtype for row is received if QSTA is addressee
- - -	frame subtype for row is neither received nor transmitted by MAC entity for column

9. MAC sublayer functional description

Change the text in the introductory paragraph of 9 as shown below:

The MAC functional description is presented in this clause. The architecture of the MAC sublayer, including the distributed coordination function (DCF), the point coordination function (PCF), the hybrid coordination function (HCF), and their coexistence in an IEEE 802.11 LAN are introduced in 9.1. These functions are expanded on in 9.2 (DCF and HCF contention access), 9.3 (PCF) and 9.10 (HCF polled access), and a complete functional description of each is provided. Fragmentation and defragmentation are covered in 9.4 and 9.5. Multirate support is addressed in 9.6. The allowable frame exchange sequences are listed in 9.7 (DCF and PCF) and 9.10 (HCF).A number of additional restrictions to limit the cases in which MSDUs are reordered or discarded are described in 9.8. Operation across regulatory domains is defined in 9.9. The QoS facility is discussed in 9.10.

9.1 MAC architecture

Update Figure 47 to show both EDCF and HCF when these functions are sufficiently stable.

Change the text in 9.1.1 as shown below:

9.1.1 Distributed Coordination Function (DCF)

The fundamental access method of the 802.11 MAC is a DCF known as carrier sense multiple access with collision avoidance, or CSMA/CA. The DCF shall be implemented in all STAs, for use within both IBSS and infrastructure network configurations.

A STA that needs to transmit shall sense the medium to determine if another STA is transmitting. If the medium is not determined to be busy (see 9.2.1), the transmission may proceed. The CSMA/CA distributed algorithm mandates that a gap of a minimum specified duration exist between contiguous frame sequences. A transmitting STA shall ensure that the medium is idle for this required duration before attempting to transmit. If the medium is determined to be busy, the STA shall defer until the end of the current transmission. After deferral, or prior to attempting to transmit again immediately after a successful transmission, the STA shall select a random backoff interval and shall decrement the backoff interval counter while the medium is idle. A refinement of the method may be used under various circumstances to further minimize collisions — here the transmitting and receiving STA exchange short Control frames [RTS and CTS frames] after determining that the medium is idle and after any deferrals or backoffs, prior to data transmission. The details of CSMA/CA, deferrals, and backoffs are described in 9.2. RTS/CTS exchanges are also presented in 9.2.

Insert after 9.1.2 the following subclause and renumber the current 9.1.3, 9.1.4 and 9.1.5 as 9.1.4, 9.1.5 and 9.1.6, respectively:

9.1.3 Hybrid coordination function (HCF)

The QoS facility includes an additional access method called HCF, which is only usable in QoS network (QBSS) configurations. The HCF shall be implemented in all QSTAs. The HCF combines functions from the DCF and PCF with some enhanced, QoS-specific mechanisms and frame subtypes to allow a uniform set of frame exchange sequences to be used for QoS transfers during both the CP and CFP. The HCF uses a contention-based channel access method, called the enhanced DCF (EDCF), which operates at WSTAs, concurrently with a controlled channel access mechanism, which includes a polling mechanism. QSTAs may obtain transmission opportunities (TXOPs) using one or both of the channel access mechanisms specified in 9.10.3. If a TXOP is obtained using the contention-based channel access, it is called a EDCF TXOP while it is called a polled TXOP if it is obtained using the controlled channel access. If a CFB initiated during any TXOP needs local NAV protection, the intiating STA may precede the CFB with a CTS frame with the RA equal to the own MAC address, with the appropriate duration to protect the pending CFB.

9.1.3.1 HCF contention-based channel access (EDCF)

The EDCF provides differentiated, distributed access to the WM for 8 user priorities. EDCF channel access shall have up to 8 ACs to support 8 user priorities. One or more user priorities shall be assigned to each access category. A QAP shall provide at least 4 ACs. Each AC is an enhanced variant of the DCF that contends for TXOPs using one set of EDCF channel access parameters from the QoS Parameter Set element, where in

1) the minimum specified idle duration time is not the constant value (DIFS) as defined for DCF, but is a distinct value (dot11AIFS[UP], see sections 9.2.3, 9.2.4 and 9.2.10) assigned to each UP either by a management entity or by a QAP;

2) the contention window limits aCWmin and aCWmax, from which the random backoff is computed, are not fixed per PHY, as with DCF, but are variable dot11CWmin[UP] and dot11CWmax[UP] values, assigned to each UP either by a management entity or by a QAP;

3) when multiple user priorities are assigned into AC[i], the dot11AIFS[UP], aCWmin[UP], and aCWmax[UP] are used for the contention from that AC, where UP is the lowest user priority assigned to AC[i];

4) lower priority ACs defer to higher priority ACs within the same QSTA, where the priority of an AC refers to the lowest user priority assigned to that AC;

5) collisions between contending ACs within a QSTA are resolved within the QSTA such that the higher priority AC receives the TXOP and the lower priority colliding AC(s) behave as if there were an external collision on the WM. Note, however, that this collision behavior does not include setting retry bits in the MAC headers of MPDUs at the heads of lower priority ACs, as would be done after a transmission attempt that was unsuccessful due to an actual external collision on the WM.

6) during an EDCF TXOP won by AC[i], a QSTA may initiate multiple frame exchange sequences to transmit MMPDUs and/or MSDUs, of which user priorities are higher than or equal to the lowest user priority assigned to AC[i]. The duration of the EDCF TXOP is bounded by the smaller of EDCF TXOP Limit from the most recently received QoS Parameter Set element and dot11EDCFCFBLimit[UP], where UP is the lowest user priority assigned to AC[i]. A value of 0 in the smaller of EDCF TXOP Limit from the most recently received QoS Parameter Set element and dot11EDCFCFBLimit[UP], where UP is the lowest user priority assigned to AC[i] mandates that the EDCF TXOP is bounded to a single MPDU at any rate in the operational set of the QBSS.

NOTE: it is suggested that implementations provide at least 2 ACs, because otherwise they cannot take advantage of the one channel access priority above legacy DCF that is available under HCF contention access.

All QSTAs shall update the MIB values of the EDCF access parameters within one bacon interval after receiving the updated QoS parameter set.

Management type frames and BurstAckReq and BurstAck Control frames shall be sent by the access category for which the highest user priority is assigned.

The operation rules of the HCF contention-based channel access is described in Clause 9.2 along with the DCF operation9.1.3.2 HCF controlled channel access

The HCF controlled channel access mechanism uses a QoS-aware point coordinator, called a hybrid coordinator (HC), that operates under different rules than the point coordinator (PC) of the PCF. The HC, which is collocated with the QoS enhanced access point (QAP) of the QBSS, uses the PC's higher priority of access to the WM to initiate frame exchange sequences and to allocate TXOPs to WSTAs so as to provide limited-duration controlled access periods (CAPs) to transfer QoS data. HC traffic delivery and TXOP allocation may be scheduled at appropriate times, during both the CFP and CP, to meet the QoS requirements of particular TCs or TSs. TXOPs and contention free transfers of QoS traffic from the HC can be based on the HC's QBSS-wide knowledge of the amounts of pending traffic belonging to different TSs and/or TCs and subject to QBSS-specific QoS policies. These CAPs may also include controlled contention intervals (CCIs) during which contention occurs only among QSTAs needing to request new TXOPs, and which can further be limited by user priority. The HCF protects the transmissions during each CAP using the virtual carrier sense mechanism. A QSTA may initiate multiple frame exchange sequences during a polled TXOP of sufficient duration to perform more than one such sequence. The use of virtual carrier sense by the HC provides improved protection of the CFP, which is no longer dependent for protection solely on having all (Q)STAs in the BSA setting their NAVs to dot11CFPMaxDuration at TBTT of DTIM Beacons.

The operation rules of the HCF controlled channel access are detailed in Clause 9.10.

Change the heading and text of clause 9.1.3 (renumbered 9.1.4 due to the insertion above) as follows:

9.1.4 Coexistence of DCF, PCF and HCF

The DCF and a point coordination function (either PCF or HCF) shall coexist in a manner that permits both to operate concurrently within the same (Q)BSS. When a PC is operating in a BSS, the PCF and DCF access methods alternate, with a contention-free period (CFP) followed by a contention period (CP). This is described in greater detail in 9.3. When an HC is operating in a QBSS, there is a CFP and a CP in each superframe, and STAs treat the HC as if it were a PC, using the DCF access method only during the CP. The HCF access methods (polled and contention-based) operate concurrently, throughout the superframe. Concurrent operation allows the polled and contention-based access methods to alternate, within intervals as short as the time to transmit a pair of frame exchange sequences, under rules defined in 9.10.

Change the heading and text of clause 9.1.5 (renumbered 9.1.5 due to the insertion above) as follows:

9.1.5 Fragmentation/defragmentation overview

The process of partitioning a MAC service data unit (MSDU) or a MAC management protocol data unit (MMPDU) into smaller MAC level frames, MAC protocol data units (MPDUs), is called fragmentation. Fragmentation creates MPDUs smaller than the original MSDU or MMPDU length to increase reliability, by increasing the probability of successful transmission of the MSDU or MMPDU in cases where channel characteristics limit reception reliability for longer frames. QSTAs may also use fragmentation to increase Media Efficiency by allowing TXOP's to be used which otherwise would be too small for a buffered MSDU. Fragmentation is accomplished at each immediate transmitter. The process of recombining MPDUs into a single MSDU or MMPDU is defined as defragmentation. Defragmentation is accomplished at each immediate recipient.

Only MPDUs with a unicast receiver address shall be fragmented. Broadcast/multicast frames shall not be fragmented even if their length exceeds aFragmentationThreshold. When a directed MSDU is received from the LLC or a directed MMPDU is received from the MAC sublayer management entity (MLME) with a length greater than aFragmentationThreshold, the MSDU or MMPDU shall be fragmented. The MSDU or MMPDU is divided into MPDUs. Each fragment is a frame no larger than aFragmentationThreshold. It is possible that any fragment may be a frame smaller than aFragmentationThreshold.

An illustration of fragmentation is shown in Figure 48.

The MPDUs resulting from the fragmentation of an MSDU or MMPDU are sent as independent transmissions, each of which is separately acknowledged. This permits transmission retries to occur per fragment, rather than per MSDU or MMPDU. Unless interrupted due to medium occupancy limitations for a given PHY or TXOP limitations for QSTA, the fragments of a single MSDU or MMPDU are sent as a burst during the CP, using a single invocation of the DCF medium access procedure. The fragments of a single MSDU or MMPDU are sent during a CFP as individual frames obeying the rules of the PC medium access procedure.

Change the heading and text of clause 9.1.5 (renumbered 9.1.6 due to the insertion above) as follows:

9.1.6 MAC Data Service

The MAC Data Service shall translate MAC service requests from LLC into input signals utilized by the MAC State Machines. The MAC Data Service shall also translate output signals from the MAC State Machines into service indications to LLC. The translations are given in the MAC Data Service State Machine defined in Annex C.

The MAC Data Service for QSTAs shall incorporate a traffic identifier (TID) with each output service request. This TID will associate the output data with the AC queue for the indicated traffic.

9.2 (E)DCF

Change the first paragraph in Clause 9.2 as follows:

The basic medium access protocol is a DCF that allows for automatic medium sharing between compatible PHYs through the use of CSMA/CA and a random backoff time following a busy med ium condition. In addition, all non-QoS directed traffic uses immediate positive acknowledgment (ACK frame) where retransmission is scheduled by the sender if no ACK is received. QoS directed traffic also has the additional option of using unacknowledged frames.

Change the fifth paragraph in Clause 9.2 as follows:

Another means of distributing the medium reservation information is the Duration/ID field in directed frames. This field gives the time that the medium is reserved, either to the end of the immediately following ACK if an ACK is expected, or in the case of a fragment sequence, to the end of the ACK following the next fragment if an ACK is expected and to the end of the next fragment if an ACK is not expected, or in the case of frame exchange sequences during an EDCF TXOP, to the end of the ACK following the next MPDU if an ACK is expected and to the end of the next MPDU if an ACK is not expected.

9.2.3 Inter-Frame Space (IFS)

Change the text and figure 49 in clause 9.2.3 as follows:

The time interval between frames is called the IFS. A STA shall determine that the medium is idle through the use of the carrier sense function for the interval specified. Five different IFSs are defined to provide priority levels for access to the wireless media; they are listed in order, from the shortest to the longest except for AIFS. Figure 49 shows some of these relationships.

a) SIFS Short Interframe Space
b) PIFS Point Coordination Function (PCF) Interframe Space
c) DIFS Distributed Coordination Function (DCF) Interframe Space
d) AIFS Arbitration Interframe Space (used by the QoS facility)
e) EIFS Extended Interframe Space

The different IFSs shall be independent of the STA bit rate. The IFS timings shall be defined as time gaps on the medium, and those except for AIFS shall be fixed for each PHY (even in multi-rate capable PHYs). The IFS values are determined from attributes specified by the PHY.

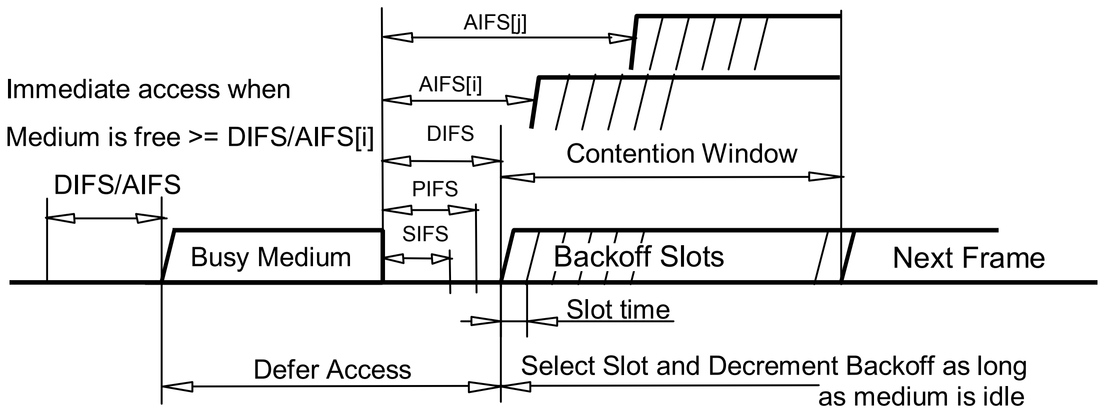

Figure 49 - Some IFS Relationships

Insert after 9.2.3.3 the following subclause and renumber the current 9.2.3.4 as 9.2.3.5

9.2.3.4 Arbitration IFS (AIFS)

The Arbitration Interframe Space shall be used by QSTAs to transmit Data type frames (MPDUs) and Management type frames (MMPDUs). A QSTA using the EDCF shall obtain a TXOP for AC[i] if the QSTA's carrier sense mechanism (see 9.2.1) determines that the medium is idle at the TxAIFS[UP] slot boundary (see 9.2.10), where UP is the lowest user priority assigned to AC[i], after a correctly-received frame, and the backoff time for AC[i] has expired. A QSTA using the EDCF shall not transmit within an EIFS after that QSTA determines that the medium is idle following reception of a frame for which the PHYRXEND.indication primitive reported an error or a frame for which the MAC FCS value (after correction, using MAC-level FEC, if applicable) was not correct, unless subsequent reception of an error-free frame resynchronizes the station, allowing it to transmit using the TxAIFS[UP] following that subsequent frame.

The minimum settings for TxAIFS[UP] is PIFS for each UP. The time periods for each TxAIFS[UP] are obtained from the dot11AIFS[UP] attributes in the MAC MIB. QSTAs update their dot11AIFS[UP] values using information in the most recent QoS Parameter Set element of Beacons received from the QAP of the QBSS (see 7.3.2.14).

NOTE: After a CCA busy period without a frame reception, which can be caused by an energy detection-based CCA, AIFS, not EIFS, is used by QSTAs to transmit its pending frame.

9.2.4 Random Backoff Time

Change the text of 9.2.4 as follows:

A STA desiring to initiate transfer of Data MPDUs and/or management MMPDUs shall invoke the carrier sense mechanism (see 9.2.1) to determine the busy/idle state of the medium. If the medium is busy, the STA shall defer until the medium is determined to be idle without interruption for a period of time equal to DIFS when the last frame detected on the medium was received correctly, or after the medium is determined to be idle without interruption for a period of time equal to EIFS when the last frame detected on the medium was not received correctly. After this DIFS or EIFS medium idle time, the STA shall then generate a random backoff period for an additional deferral time before transmitting, unless the backoff timer already contains a non-zero value, in which case the selection of a random number is not needed and not performed. This process minimizes collisions during contention between multiple STAs that have been deferring to the same event.

Backoff Time = Random() x aSlotTime

where

Random() = Pseudorandom integer drawn from a uniform distribution over the interval [0,CW], where CW is an integer within the range of values of the PHY characteristics aCWmin and aCWmax, aCWmin <= CW <= aCWmax. It is important that designers recognize the need for statistical independence among the random number streams among stations.

aSlotTime = The value of the correspondingly named PHY characteristic.

A QSTA desiring to initiate a transfer using the EDCF uses a similar random backoff time mechanism, except that the QSTA calculates and maintains a backoff time and contention window for each AC[i] when there are Data MPDUs and/or management MMPDUs to be transmitted for that AC. Prior to each transmission when the medium is busy, the QSTA shall defer until the medium is determined to be idle without interruption for a period of time equal to AIFS[UP], where UP is the lowest user priority assigned to AC[i], when the last frame detected on the medium was received correctly, or for a period of time equal to EIFS when the last frame detected on the medium was not received correctly. The backoff calculation uses the DCF method, but draws from different intervals and replicates the contention window state for each AC[i] as follows:

Backoff Time[i] = [Random(i) + X] x aSlotTime

where

Random(i) = Pseudo random integer drawn from a uniform distribution over the interval [0,CW[i]], where CW[i] is an integer within the range of values of the MIB attributes dot11CWmin[UP] and dot11CWmax[UP], dot11CWmin[UP] <= CW[i] <= dot11CWmax[UP], where UP is the lowest user priority assigned to AC[i]. The default values of dot11CWmin[UP] and dot11Cwmax[UP] are found in Annex D. It is important that designers recognize the need for statistical independence among the random number streams among stations and among ACs within stations.

X = 0 if AIFS[UP] > PIFS, and 1 if AIFS[UP] = PIFS, where UP is the lowest user priority assigned to AC[i].

aSlotTime = The value of the correspondingly named PHY characteristic.

The Contention Window (CW) parameter shall take an initial value of aCWmin. Every STA shall maintain a STA Short Retry Count (SSRC) as well as a STA Long Retry Count (SLRC), both of which shall take an initial value of zero. The SSRC shall be incremented whenever any Short Retry Count associated with any MSDU is incremented. The SLRC shall be incremented whenever any Long Retry Count associated with any MSDU is incremented. The CW shall take the next value in the series every time an unsuccessful attempt to transmit an MPDU causes either STA Retry Counter to increment, until the CW reaches the value of aCWmax. A retry is defined as the entire sequence of frames sent, separated by SIFS intervals, in an attempt to deliver an MPDU, as described in 9.7. Once it reaches aCWmax the CW shall remain at the value of aCWmax until it is reset. This improves the stability of the access protocol under high load conditions. See Figure 50.

QSTAs shall maintain a Contention Window plus Short and Long Retry Counts for each AC[i]: CW[i], QSRC[i] and QLRC[i]. The retry procedure for each AC shall be the same as for DCF, substituting CW[i], QSRC[i] and QLRC[i] for CW, SSRC and SLRC respectively. The CW[i] values shall be calculated as described below. QSTAs may choose to provide differentiated dot11CWmax[UP] values, although this is not required, and the value of aCWmax may be used for every dot11CWmax[UP] value. The values of dot11CWmin[UP] and dot11AIFS[UP] are updated by information in the most recent QoS Parameter Set element of Beacons received from the QAP of the QBSS (see 7.3.2.14). A QSTA must effectively use the updated dot11Cwmin[UP] and dot11AIFS[UP] MIB values for all transmissions following the reception of the updated QoS parametr set element.

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The set of CW values shall be sequentially ascending integer powers of 2, minus 1, beginning with a PHY-specific aCWmin value, and continuing up to and including a PHY-specific aCWmax value. The set of CW[i] values of AC[i] shall be sequentially ascending integer powers of 2, minus 1, beginning with aCWmin[UP] value, and continuing up to and including aCWmax[UP] value, where UP is the lowest user priority assigned to AC[i].

The CW shall be reset to aCWmin after every successful attempt to transmit an MSDU or MMPDU, when SLRC reaches aLongRetryLimit, or when SSRC reaches aShortRetryLimit. The SSRC shall be reset to 0 whenever a CTS frame is received in response to an RTS frame, whenever an ACK frame is received in response to an MPDU or MMPDU transmission, or whenever a frame with a group address in the Address1 field is transmitted. The SLRC shall be reset to 0 whenever an ACK frame is received in response to transmission of an MPDU or MMPDU of length greater than aRTSThreshold, or whenever a frame with a group address in the Address1 field is transmitted.

The CW[i] of AC[i] shall be reset to aCWmin[UP], after every successful attempt to transmit an MSDU or MMPDU by AC[i], when QLRC[i] reaches aLongRetryLimit, or when QSRC[i] reaches aShortRetryLimit. UP is the lowest user priority assigined to AC[i]. The QSRC[i] for AC[i] shall be reset to 0 whenever a CTS frame is received in response to an RTS frame transmitted for AC[i], whenever an ACK frame is received in response to an MPDU or MMPDU transmission by AC[i], or whenever a frame with a group address in the Address1 field is transmitted by AC[i]. The QLRC[i] for AC i shall be reset to 0 whenever an ACK frame is received in response to transmission of an MPDU or MMPDU of length greater than aRTSThreshold by AC[i], or whenever a frame with a group address in the Address1 field is transmitted by AC[i].

9.2.5.1 Basic Access

Change the text and Figure 51 in 9.2.5.1 as follows:

Basic access refers to the core mechanism a STA uses to determine whether it may transmit.

In general, a STA may transmit a pending MPDU when it is operating under the DCF access method, either in the absence of a PC, or in the CP of the PCF access method, when the STA determines that the medium is idle for greater than or equal to a DIFS period, or an EIFS period if the immediately-preceding medium-busy event was caused by detection of a frame that was not received at this STA with a correct MAC FCS value. If, under these conditions, the medium is determined by the carrier sense mechanism to be busy when a STA desires to initiate the initial frame of one of the frame exchanges described in 9.7, exclusive of the CF period, the Random Backoff algorithm described in 9.2.5.2 shall be followed. There are conditions, specified in 9.2.5.2 and 9.2.5.5, where the random backoff algorithm shall be followed even for the first attempt to initiate a frame exchange sequence.

A QSTA operates according to the same general rules defined for DCF by providing separate output ACs, where each AC[i] instantiates a DCF state machine that contends for the wireless medium using dot11AIFS[UP] (see sections 9.2.3, 9.2.4 and 9.2.10) rather than DIFS, employs dot11CWmin[UP] rather than aCWmin and employs dot11CWmax[UP] rather than aCWmax, where UP is the lowest user priority assigned to AC[i]. Contention between ACs within a QSTA is resolved within that QSTA, such that the higher priority AC receives the TXOP and the lower priority colliding AC(s) behave as if there were an external collision on the WM. Note, however, that this collision behavior does not include setting retry bits in the MAC headers of MPDUs at the heads of lower priority ACs, as would be done after a transmission attempt that was unsuccessful due to an actual external collision on the WM.

In a STA having an FH PHY, control of the channel is lost at a dwell time boundary and the STA shall have to contend for the channel after the dwell boundary. It is required that STAs having an FH PHY complete transmission of the entire MPDU and associated acknowledgment (if required) before the dwell time boundary. If, when transmitting or retransmitting an MPDU, there is not enough time remaining in the dwell to allow transmission of the MPDU plus the acknowledgment (if required), the STA shall defer the transmission by selecting a random backoff time, using the present CW (without advancing to the next value in the series). The short retry counter and long retry counter for the MSDU are not affected.

The basic access mechanism is illustrated in Figure 51.

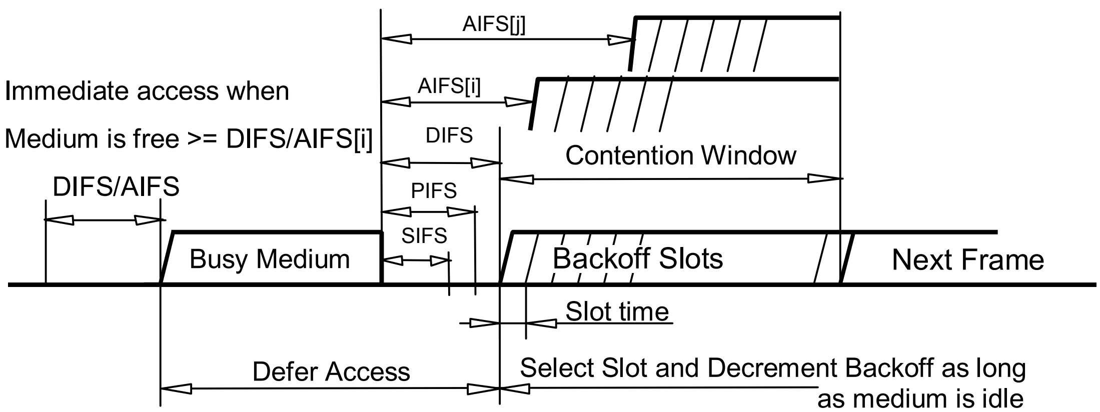


Figure 51 - Basic Access Method

9.2.5.2 Backoff Procedure

Change the text in 9.2.5.2 as follows (Figure 52 is unchanged):

The backoff procedure shall be invoked whenever a STA desires to transfer a frame and finds the medium busy as indicated by either the physical or virtual carrier sense mechanism (see Figure 52). The backoff procedure shall also be invoked when a transmitting STA infers a failed transmission as defined in clauses 9.2.5.7 or 9.2.8.

To begin the backoff procedure, the STA shall set its Backoff Timer to a random backoff time using the rules specified in 9.2.4. All backoff slots occur:

a) for STAs, and for QSTAs not associated in a QBSS, following a DIFS period during which the medium is determined to be idle for the duration of the DIFS period;
b) for all STAs and QSTAs, following an EIFS period during which the medium is determined to be idle for the duration of the EIFS period following detection of a frame that was not received correctly; or
c) for QSTAs associated in a QBSS, for each AC[i], following a dot11AIFS[UP] period during which the medium is determined to be idle for the duration of the current dot11AIFS[UP] period, where UP is the lowest user priority assigned to AC[i].

A STA performing the backoff procedure shall use the carrier sense mechanism (9.2.1) to determine whether there is activity during each backoff slot. If no medium activity is indicated for the duration of a particular backoff slot, then the backoff procedure shall decrement its backoff time by aSlotTime.

If the medium is determined to be busy at any time during a backoff slot, then the backoff procedure is suspended, that is, the backoff timer shall not decrement for that slot. The medium shall be determined to be idle for the duration of a DIFS, EIFS or dot11AIFS[UP] period, where UP is the lowest user priority assigned to AC[i], as appropriate (see 9.2.3), before the backoff procedure is allowed to resume. Transmission shall commence whenever the Backoff Timer reaches zero.

For QSTAs, if the Backoff Timers for more than one AC reach zero at the same slot, then the frame from the highest priority AC shall be transmitted, and the contending frames from all lower priority AC(s) shall not be transmitted. These lower priority ACs shall execute the retry procedure, as specified in 9.2.5.3 and shall set their CW[i] values for the deferred frames as specified in 9.2.4, as if they had experienced a transmit failure. However, the retry bits in the MAC headers of these lower priority frames shall not be set solely as a result of an instance of this contention between ACs within a single QSTA.

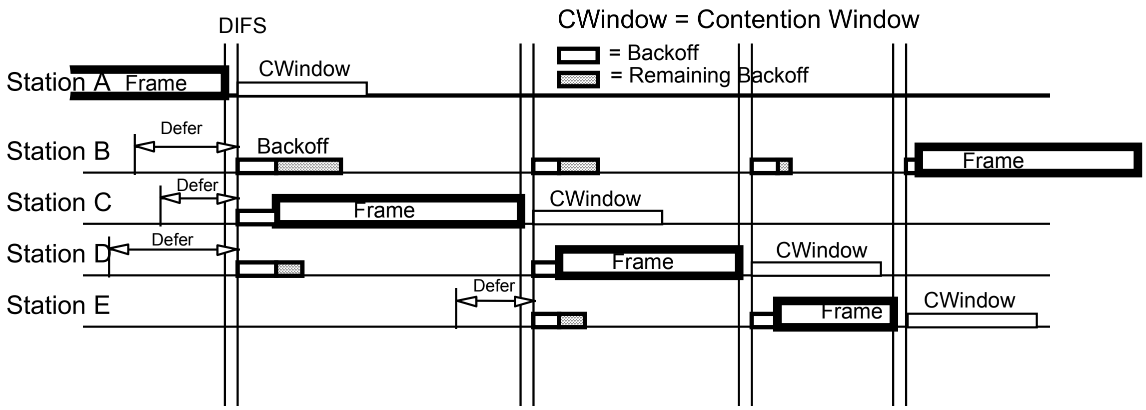


Figure 52 - Backoff Procedure

A backoff procedure shall be performed immediately after the end of every transmission with the More Fragments bit set to 0 of an MPDU of type Data (including QoS Data for QSTAs), Management, or Control with subtype PS-Poll, when the transmission is the last transmission within an EDCF TXOP even if no additional transmissions are currently pending. In the case of successful acknowledged transmissions, this backoff procedure shall begin after an appropriate deference at the end of the received ACK frame. In the case of unsuccessful transmissions requiring acknowledgment, this backoff procedure shall begin at the end of the ACK timeout interval. For QSTAs, "transmissions requiring acknowledgment" in the previous sentence pertains exclusively to normal ACK policy, with all other ACK policies considered for the purposes of this backoff procedure as unacknowledged transmissions. If the transmission was successful (which includes all unacknowledged transmissions), the CW value reverts to aCWmin before the random backoff interval is chosen, and the Station Short Retry Count and/or Station Long Retry Count are updated as described in 9.2.4. QSTAs use CW[i], dot11CWmin[UP], QSRC[i] and/or QLRC[i] as specified in 9.2.4 rather than CW, aCWmin, SSRC and SLRC. This assures that transmitted frames from a STA, or from AC[i] at a QSTA, are always separated by at least one backoff interval.

The effect of this procedure is that when multiple STAs and/or AC(s) of equal priority at QSTA(s) are deferring and go into random backoff, then the entity selecting the smallest backoff time using the random function will win the contention. In the case of AC(s) of unequal priority at QSTA(s), the shorter dot11AIFS[UP] periods used for higher priority ACs mean that it is possible for the entity that selects the smallest backoff time to lose the contention to a higher-priority entity.

In an IBSS, the backoff time for a pending non-Beacon or non-ATIM transmission shall not decrement in the period from the Target Beacon Transmission Time (TBTT) until the expiration of the ATIM window and the backoff time for a pending ATIM Management frame shall decrement only within the ATIM window. (See clause 11). Within an IBSS, a separate backoff interval shall be generated to precede the transmission of a Beacon, as described in 11.1.2.2.

9.2.5.3 Recovery Procedures and Retransmit Limits

Change the text in 9.2.5.3 as follows:

Error recovery is always the responsibility of the STA which initiates a frame exchange sequence, as defined in 9.7. Many circumstances may cause an error to occur which requires recovery. For example, the CTS frame may not be returned after an RTS frame is transmitted. This may happen due to a collision with another transmission, due to interference in the channel during the RTS or CTS frame, or because the station receiving the RTS frame has an active virtual carrier sense condition (indicating a busy medium time period).

Error recovery shall be attempted by retrying transmissions for frame exchange sequences which the initiating station infers have failed. Retries shall continue, for each failing frame exchange sequence, until the transmission is successful, or until the relevant retry limit is reached, whichever occurs first. Stations shall maintain a Short Retry Count and a Long Retry Count for each MSDU or MMPDU awaiting transmission. These counts are incremented and reset independently of each other.

QSTAs shall maintain a transmit MSDU timer for each MSDU passed to the MAC. The MIB value dot11MSDULifetime[i] specifies the maximum amount of time allowed to transmit an MSDU of TC i. The transmit MSDU timer shall be started when the MSDU is passed to the MAC. If the value of this timer exceeds the value of dot11MSDULifetime[i] where i is the TC indicated for this MSDU, then the MSDU, or any remaining, undelivered fragments of that MSDU, shall be discarded by the source QSTA without any further attempt to complete delivery of that MSDU. If an MSDU belongs to a TS for which the TSPEC specifies an non-null value for Delay Bound, this value from the TSPEC is used as limit for the transmit MSDU timer instead of the value of dot11MSDULifetime[i].

After an RTS frame is transmitted, the STA shall perform the CTS procedure, as defined in 9.2.5.7. If the RTS transmission fails, the Short Retry Count for the MSDU or MMPDU and the Station Short Retry Count are incremented. This process shall continue until the number of attempts to transmit that MSDU or MMPDU reaches dot11ShortRetryLimit. In a QSTA, the attempts to send an RTS may end prior to reaching dot11ShortRetryLimit if the transmit MSDU timer for that MSDU exceeds the value of dot11MSDULifetime[i] for its TC or the value of Delay Bound from the TSPEC of its TS.

After transmitting a frame which requires acknowledgment, the STA shall perform the ACK procedure, as defined in 9.2.8. The short retry count for an MSDU or MMPDU and the STA short retry count shall be incremented every time transmission of a MAC frame of length less than or equal to dot11RTSThreshold fails for that MSDU or MMPDU. This short retry count and the STA short retry count shall be reset when a MAC frame of length less than or equal to dot11RTSThreshold succeeds for that MSDU or MMPDU. The long retry count for an MSDU or MMPDU and the STA long retry count shall be incremented every time transmission of a MAC frame of length greater than dot11RTSThreshold fails for that MSDU or MMPDU. This long retry count and the STA long retry count shall be reset when a MAC frame of length greater than dot11RTSThreshold succeeds for that MSDU or MMPDU. All retransmission attempts for an MSDU or MMPDU that has failed the ACK procedure one or more times shall be made with the Retry field set to 1 in the Data or Management Type frame.

Retries by a STA for failed transmission attempts shall continue until the short retry count for the MSDU or MMPDU is equal to dot11ShortRetryLimit or until the long retry count for the MSDU or MMPDU is equal to dot11LongRetryLimit. When either of these limits is reached, retry attempts shall cease, and the MSDU or MMPDU shall be discarded. However, retries for failed transmission attempts by a QSTA shall end prior to reaching the relevant retry limit if the transmit MSDU timer for that MSDU exceeds the value of dot11MSDULifetime[i] for its TC or the value of Delay Bound from the TSPEC of its TS. A QSTA uses the same algorithm defined here to retry failed transmission attempts from AC[i] by substituting QSRC[i] and QLRC[i] for the Short Retry Count and Long Retry Count, respectively.

A STA in power save mode, in an ESS, initiates a frame exchange sequence by transmitting a PS-Poll frame to request data from an AP. In the event that neither an ACK frame or a Data frame is received from the AP in response to a PS-Poll frame, then the STA shall retry the sequence, by transmitting another PS-Poll frame, at its convenience. If the AP sends a Data frame in response to a PS-Poll frame, but fails to receive the ACK frame acknowledging this Data frame, the next PS-Poll frame from the same STA may cause a retransmission of the last MSDU. This duplicate MSDU shall be filtered at the receiving STA using the normal duplicate frame filtering mechanism. If the AP responds to a PS-Poll by transmitting an ACK frame, then responsibility for the Data frame delivery error recovery shifts to the AP because the data is transferred in a subsequent frame exchange sequence, which is initiated by the AP. The AP shall attempt to deliver one MSDU to the STA which transmitted the PS-Poll, using any frame exchange sequence valid for a directed MSDU. If the power save STA which transmitted the PS-Poll returns to Doze state after transmitting the ACK frame in response to successful receipt of this MSDU, but the AP fails to receive this ACK frame, the AP will retry transmission of this MSDU until the relevant retry limit is reached. See Clause 11 for details on filtering of extra PS-Poll frames.

9.2.5.4 Setting and resetting the NAV

Add the following paragraph after the last paragraph in 9.2.5.4:

A QSTA that used information from an RTS frame as the most recent basis to update its NAV setting may set its NAV to

max [0, saved old NAV value - ((2 x aSIFSTime) + (CTS_Time) + (2 x aSlotTime))]

if no PHY-CCA.indication(busy) is detected from the PHY during a period with a duration of

((2 x aSIFSTime) + (CTS_Time) + (2 x aSlotTime))

starting at the PHY-RXEND.indication corresponding to the detection of the RTS frame, where "saved old NAV value" is the NAV value at the time of the update due to the RTS frame reception. The "CTS_Time" shall be calculated using the length of the CTS frame and the data rate at which the RTS frame used for the most recent NAV update was received.

9.2.5.7 CTS Procedure

Add the followings between the first and second paragraphsThe source STA shall wait CTSTimeout amount of time without receiving a CTS before concluding that the RTS failed, where the value of CTSTimeout depends on whether PHY-CCA.indication(busy) is detected during a period with a duration of PIFS starting at the PHY-TXEND.confirm.

CTSTimeout is equal to PIFS if no PHY-CCA.indication(busy) is detected during a period with a duration of PIFS starting at the PHY-TXEND.confirm.

CTSTimeout is equal to PIFS + CTS_Time if PHY-CCA.indication(busy) is detected during a period with a duration of PIFS starting at the PHY-TXEND.confirm. CTS_Time is the transmission duration of a CTS frame at the PHY rate determined according to the rule found in Clause 9.6.

9.2.8 ACK Procedure

Add the following at the end of the third paragraph:

The value of ACKTimeout depends on whether PHY-CCA.indication(busy) is detected during a period with a duration of PIFS starting at the PHY-TXEND.confirm.

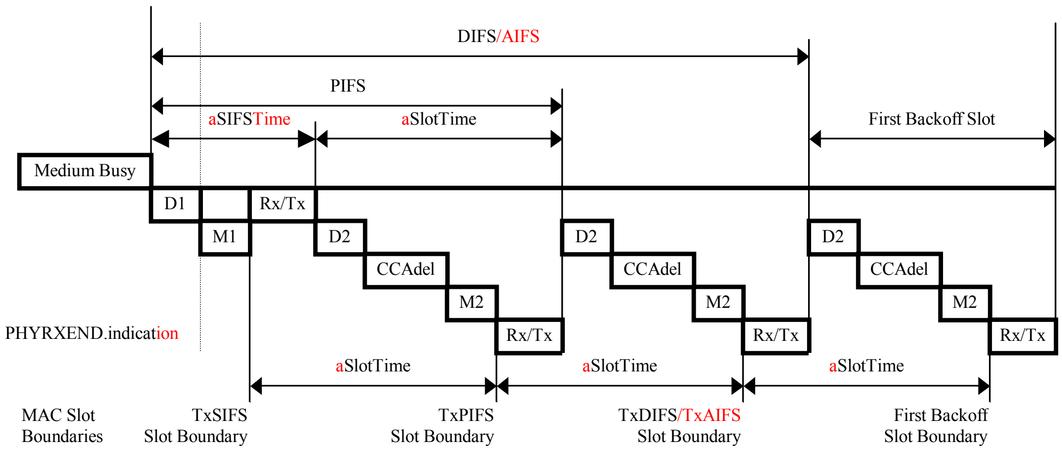
ACKTimeout is equal to PIFS if no PHY-CCA.indication(busy) is detected during a period with a duration of PIFS starting at the PHY-TXEND.confirm.

ACKTimeout is equal to PIFS + ACK_Time if PHY-CCA.indication(busy) is detected during a period with a duration of PIFS starting at the PHY-TXEND.confirm. ACK_Time is the transmission duration of an ACK frame at the PHY rate determined according to the rule found in Clause 9.6.

9.2.10 DCF timing relations

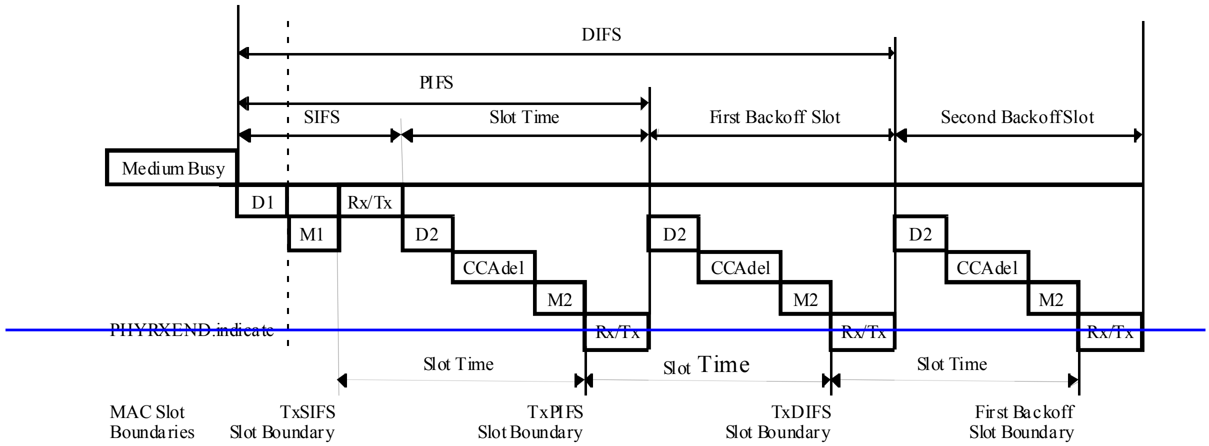
Change the text and Figure 58 in 9.2.10 as follows:

The relationships between the IFS specifications are defined as time gaps on the medium. The associated attributes are provided by the specific PHY (see Figures 58).



D1 = aRxRFDelay + aRxPLCPDelay (starts at the end of the last symbol of a frame on the medium)
D2 = aAirPropagationTime
Rx/Tx = aRxTxTurnaroundTime (starts when the MAC issues the PHY-TXSTART.request)
M1 = M2 = aMACProcessingDelay
CCAdel = aCCATime

Figure 58 - DCF Timing Relationships and EDCF Timing Relationships for the Example Case in which AIFS = DIFS



D1 = aRxRFDelay + aRxPLCPDelay (referenced from the end of the last symbol of a frame on the medium)
D2 = D1 + Air Propagation Time
Rx/Tx = aRXTXTurnaroundTime (begins with a PHYTXSTART.request)
M1 = M2 = aMACPrcDelay
CCAdel = aCCATime - D1

All timings that are referenced from the end of the transmission are referenced from the end of the last symbol of a frame on the medium. The beginning of transmission refers to the first symbol of the next frame on the medium.

aSIFSTime and aSlotTime are the values of the like-named parameters returned by the PLME-CHARACTERISTICS.confirm primitive (10.4.3), and are fixed per PHY.

aSIFSTime is: aRxRFDelay + aRxPLCPDelay + aMACPrcDelay + aRxTxTurnaroundTime.

aSlotTime is: aCCATime + aRxTxTurnaroundTime + aAirPropagationTime
+ aMACProcessingDelay

The PIFS and DIFS are derived by the following equations, as illustrated in Figure 58.

PIFS = aSIFSTime + aSlotTime

DIFS = aSIFSTime + (2 x aSlotTime)

The EIFS is derived from the SIFS and the DIFS and the length of time it takes to transmit an ACK Control frame at the PHY's lowest mandatory rate by the following equation:

EIFS = aSIFSTime + ACKTime+ DIFS

where

ACKSize is the length, in bytes, of an ACK frame,
MinPHYRate is the lowest mandatory data rate for the active PHY, in Mbit/s, and
ACKTime = ((8 x ACKSize) + aPreambleLength + aPLCPHeaderLength) / MinPHYRate

Figure 58 illustrates the relation between the SIFS, PIFS and DIFS as they are measured on the medium and the different MAC Slot Boundaries TxSIFS, TxPIFS and TxDIFS. These Slot Boundaries define when the transmitter shall be turned on by the MAC to meet the different IFS timings on the medium, after subsequent detection of the CCA result of the previous slot time.

The following equations define the MAC Slot Boundaries, using attributes provided by the PHY, which are such that they compensate for implementation timing variations. The starting reference of these slot boundaries is again the end of the last symbol of the previous frame on the medium.

TxSIFS = SIFS – aRxTxTurnaroundTime

TxPIFS = TxSIFS + aSlotTime

TxDIFS = TxSIFS + (2 x aSlotTime).

TxAIFS[UP] = TxSIFS + (dot11AIFS[UP] x aSlotTime).

The tolerances are specified in 9.2.3.1, and shall only apply to the SIFS specification, so that tolerances shall not accumulate.

NOTE: The minimum value for dot11AIFS[UP] is 1 for each user priority (UP). Therefore, the minimum settings for TxAIFS[UP] are equivalent to PIFS for each UP. The default value for dot11AIFS[UP] for each UP is found in Annex D.

9.6 Multirate support

Change the text in 9.6 as follows:

Some PHYs have multiple data transfer rate capabilities that allow implementations to perform dynamic rate switching with the objective of improving performance. The algorithm for performing rate switching is beyond the scope of this standard, but in order to ensure coexistence and interoperability on multirate-capable PHYs, this standard defines a set of rules that shall be followed by all STAs.

All Control frames except the BurstAckReq and BurstAck frames shall be transmitted at one of the rates in the BSSBasicRateSet (see 10.3.10.1), or at one of the rates in the PHY mandatory rate set so they will be understood by all STAs.

All frames with multicast and broadcast RA shall be transmitted at one of the rates included in the BSSBasicRateSet, regardless of their type.

Data MPDUs, BurstAckReq and BurstAck frames and/or management MPDUs with a unicast immediate address shall be sent on any supported data rate selected by the rate switching mechanism (whose output is an internal MAC variable called MACCurrentRate, defined in units of 500 kbit/s, which is used for calculating the Duration/ID field of each frame). A STA shall not transmit at a rate that is known not to be supported by the destination STA, as reported in the supported rates element in the management frames. For frames of type Data+CF-ACK, Data+CF-Poll+CF-ACK, and CFPoll+CF-ACK, the rate chosen to transmit the frame must be supported by both the addressed recipient STA and the STA to which the ACK is intended.

Under no circumstances shall a STA initiate transmission of a data or management frame at a data rate higher than the greatest rate in the OperationalRateSet, a parameter of the MLME-JOIN.request primitive.

In order to allow the transmitting STA to calculate the contents of the Duration/ID field, the responding STA shall transmit its Control Response frame (either CTS or ACK), other than the BurstAck control frame at the same rate as the immediately previous frame in the frame exchange sequence (as defined in 9.7), if this rate belongs to the PHY mandatory rates, or else at the highest possible rate belonging to the PHY rates in the BSSBasicRateSet. . The BurstAck control frame shall be sent at the same rate as the BurstAckReq frame if it is sent in response to a BurstAckReq frame.

Insert the following subclause, including tables and figures included therein, after 9.9 (which is added by 802.11d), renumbering tables and figures as necessary:

9.10 HCF controlled channel access

The hybrid coordination function (HCF) controlled channel access mechanism manages allocation of WM data transfer bandwidth, using a hybrid coordinator (HC) that has higher medium access priority than WSTAs in order transfer traffic from itself and to allocate transmission opportunities (TXOPs) and controlled contention opportunities (CCOs) to WSTAs. The HC is a type of point coordinator (PC), but differs from the point coordinator used in PCF in several significant ways, although it may optionally implement the functionality of a PC. Most important is that HCF frame exchange sequences may be used among QSTAs associated in a QBSS during both the CP and the CFP. Another significant difference is that the HC grants a polled TXOP with duration specified in a QoS (+)CF-Poll frame. WSTAs may transmit multiple frame exchange sequences within given polled TXOPs, subject to the limit on TXOP duration. All STAs and QSTAs inherently obey the medium access rules of the HCF, because these rules are based on the DCF, and because each frame transmitted under HCF, by the HC or by a WSTA, contains a duration value to cause STAs and QSTAs in the BSS to set their NAV to protect the frames expected to follow that frame. All QSTAs shall be able to respond to QoS (+)CF-Polls received from an HC. The HC shall perform delivery of queued broadcast and multicast frames following DTIM beacons in a CFP. The HC may use a longer CFP for QoS delivery and/or QoS polling by continuing with HCF frame exchange sequences, after broadcast/multicast delivery, for a total duration not to exceeddot11CFPMaxDuration. The HC may also operate as a PC, providing (non-QoS) CF-Polls to associated CF-Pollable STAs using the frame formats, frame exchange sequences, and other applicable rules for PCF specified in 9.3. Implementers are cautioned that attempting to intersperse HCF frame exchange sequences and PCF frame exchange sequences in a single CFP may be extremely complex.

An HC may perform a backoff following an interruption of a frame exchange sequence due to lack of an expected response under the rules described in clause 9.10.1.2, using dot11HCCWmin, dot11HCCWmax and dot11HCAIFS.

9.10.1 HCF controlled channel access procedure

The HCF transfer protocol is based on a polling scheme controlled by an HC operating at the QAP of the QBSS. The HC gains control of the WM as needed to send QoS traffic to QSTAs and to issue QoS (+)CF-Polls to QSTAs by waiting a shorter time between transmissions than the stations using the EDCF or DCF access procedures. The duration values used in QoS frame exchange sequences reserve the medium for a aSlotTime period longer than the end of the sequence (see Figure 62.1) to permit continuation of a NAV-protected CF transfer by concatenation of CFBs. This extra WM reservation allows the HC to initiate a subsequent TXOP with reduced risk of collision because STAs and all QSTAs other than the TXOP holder and the HC will not be able to begin contending until a DIFS interval later than end of the last transfer within the TXOP.

Because the HC is a type of point coordinator, the HC shall include a CF Parameter Set element in the Beacon frames it generates. This causes a QBSS to appear to be a point-coordinated BSS to STAs. This causes all STAs as well as all QSTAs (other than the HC of the same QBSS) to set their NAVs to the dot11CFPMaxDuration value at TBTT, as specified in 9.3.3.2. This prevents most contention with the CFP by preventing non-polled transmissions by STAs and QSTAs whether or not they are CF-Pollable.

9.10.1.1 CAP generation

When the HC needs access to the WM to start a CFB or CFP the HC shall sense the WM. When the WM is determined to be idle for one PIFS period, the HC shall transmit the first frame of any permitted frame exchange sequence, with the duration value set as provided in 9.10.2.1.

During a CFB or CFP, after each data, QoS data or management type frame with a group address in the Address1 field, the HC shall wait for one PIFS period, and shall only continue to transmit if CCA is idle. After the last frame of all other frame exchange sequences (e.g., sequences which convey unicast QoS data or management type frames) during a TXOP, except the sole or final frame exchange sequence in a TXOP, the HC or holder of the current TXOP shall wait for one SIFS period and then commence transmitting the first frame of the next frame exchange sequence.

9.10.1.2 Recovery from the absence of an expected reception

QSTAs, including the HC, are required to respond within any frame exchange sequence after a SIFS period. If the beginning of reception of an expected response, as detected by the occurrence of PHY-CCA.indication(busy) at the QSTA which is expecting the response, does not occur during the first slot time following SIFS, that QSTA may initiate recovery by transmitting after PIFS from the end of the last transmission. This recovery after PIFS is only permitted by the QSTA expecting the response. This QSTA is the HC in the case of a QoS (+)CF-Poll frame, and is the TXOP holder in the case of a QoS data type frame transmitted during a CFB.

If an erroneous frame, as detected by an FCS error after occurrence of PHY-RXSTART.indicate followed by PHY-RXEND.indicate(no error) is received at a QSTA which expects a response to its transmission, the QSTA may initiate the recovery by transmitting a frame after SIFS from the end of the last reception.

NOTE: This restriction is intended to avoid collisions due to inconsistent CCA reports in different QSTAs, not to optimize the bandwidth usage efficiency

QSTAs receiving a QoS (+)CF-Poll are required to respond within a SIFS period. If the polled QSTA has no queued traffic to send, or if the MPDUs available to send are all too long to transmit within the specified TXOP limit, the QSTA shall send a QoS Null frame. In the case of no queued traffic, this QoS Null has a QoS control field that reports a queue size of 0 for any TID. In the case of insufficient TXOP size, this QoS Null has a QoS control field that reports the requested TXOP duration needed to send the selected MPDU and TID for the highest priority MPDU that is ready for transmission.

If PHY-CCA.indication(busy) occurs during the slot following SIFS, followed by PHY-RXSTART.indication or PHY-RXEND.indication prior to PHY-CCA.indication(idle) then an HC may assume that a QoS (+)CF-Poll frame was successfully received by the QSTA.

9.10.1.3 CFP generation by the HC

Every HC functions as a point coordinator that uses the CFP for delivery, generating a CFP as shown in Figure 59, with the restriction that the CFP initiated by an HC shall always end with a CF-End frame. The HC may also issue QoS (+)CF-Polls to associated QSTAs during the CFP. However, because the HC can also grant polled TXOPs, by sending QoS (+)CF-Poll frames, during the CP, it is not mandatory for the HC to use the CFP for QoS data transfers.

NOTE: Only a QAP which also issues non-QoS CF-Polls to associated CF-Pollable STAs may end a CFP with a CF-End+CF-Ack frame, and only in the case where the CF-End+CF-Ack is acknowledging a reception from a CF-Pollable STA. Issuance of non-QoS CF-Polls by a QAP is not recommended, for further discussion see the informative note in 7.3.1.4.

9.10.2 TXOP structure and timing

Under HCF the basic unit of allocation of the right to transmit onto the WM is the TXOP. Each TXOP is defined by a particular starting time, relative to the end of a preceding frame, and a defined maximum length. The TXOP may be obtained by a QSTA receiving a QoS (+)CF-Poll during the CP or CFP, or by the QSTA winning an instance of EDCF contention during the CP. In the case of the former case, which is referred to as a polled TXOP, the entire TXOP is protected by the NAV set by the duration of the frame that contained the QoS (+)CF-Poll function, as shown in Figure 62.1.

Any QoS data type frame of a subclass that includes CF-Poll shall contain the TXOP limit in its QoS control field. For TXOPs resulting from EDCF contention the TXOP limit value from the QoS Parameter Set element in the most recent Beacon frame shall be used. Within a polled TXOP a QSTA may initiate the transmission of one or more frame exchange sequences, with all such sequences nominally separated by a SIFS interval. The QSTA shall not initiate transmission of a frame unless the transmission, and any acknowledgement or other immediate response expected from the peer MAC entity, are able to complete prior to the end of the remaining TXOP duration. Furthermore, neither TXOP nor transmission within a TXOP, shall extend across TBTT, dot11CFPMaxDuration (if during CFP), dot11MaxDwellTime (if using an FH PHY) or dot11CAPLimit. Because this rule applies to TXOPs as well as transmissions within TXOPs, it is the responsibility of the HC to ensure that the full duration of any granted TXOP does not cross any of these boundaries. QSTAs may use the time prior to the TXOP limit of a polled TXOP without checking for other transmission boundaries. However, it is necessary for the QSTA to avoid transmission boundaries during contention-based (EDCF) TXOPs. Subject to these limitations, all decisions regarding what MSDUs and/or MMPDUs are transmitted during any given TXOP are made by the QSTA which holds the TXOP.

NOTE: In certain regulatory domains, channel sensing should be done at periodic intervals (for example, in Japan, this period is 4 ms). This means that the duration of a TXOP in these regulatory domains should not be more than this periodic interval. If longer durations are desired then the TXOP holder needs to sense the channel at least once in dot11MediumOccupancyLimit TU by waiting for at least for the duration of one PIFS during which it will sense the channel. If it does not detect any energy, it may continue by sending the next frame. Implementers of HCs and QSTAs should be mindful of these regulations and shall ensure that they are compliant with the regulations. This means that the total TXOP size assigned should include an extra time allocated (i.e., n x aSlotTime, where n is the number of times the QSTA needs to sense the channel and is given by floor(TXOP limit/aMediumOccupancyLimit) for the channel sensing.NOTE: The TID value in the QoS Control field of a QoS (+)CF-Poll frame pertains only to the MSDU or fragment thereof in the Frame Body field of that frame. This TID value does not pertain to the TXOP limit value, and does not place any constraints on what frame(s) the addressed QSTA may send in the granted TXOP.

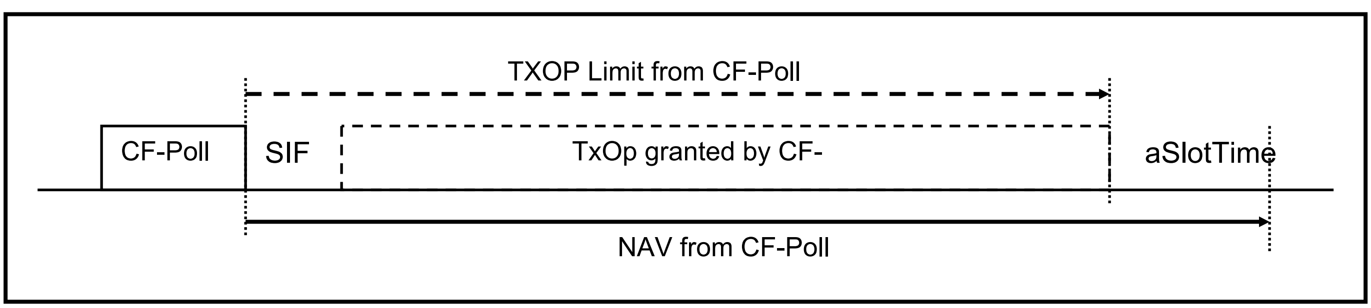


Figure 62.1 – TXOP

9.10.2.1 NAV operation during a CAP

The Duration/ID field in any QoS data frame of a subtype that includes CF-Poll shall contain a value which exceeds the TXOP limit specified in the QoS control field by one aSlotTime period. The Duration/ID in any QoS data type frame sent within a polled TXOP shall be set to the number of microseconds remaining until the specified end of the TXOP.

When a QSTA updates its NAV setting using the duration value from a QoS (+)CF-Poll containing the BSSID of this QBSS, that QSTA shall also save the TXOP holder address, which is the MAC address from the Address1 field of the frame containing the QoS (+)CF-Poll. If an RTS, management type, data type or QoS data type frame is received with a MAC address in the SA field (TA field in the case of RTS) which matches this saved TXOP holder address, the QSTA sends the appropriate response after SIFS, without regard for, and without resetting, its NAV. This saved TXOP holder address shall be cleared whenever the NAV is reset or when the NAV counts down to 0,. When a QSTA receives a CF-End frame containing the BSSID of this QBSS, that QSTA shall reset its NAV. When a WSTA receives a QoS CF-Poll with a MAC address in the Address1 which matches the HC's MAC address and a Duration/ID value equal to zero, that QSTA shall clear its NAV.

Within a polled TXOP, if there will be time left in the TXOP after the transmission of the final frame and its expected ACK response, then the recipient of this final frame shall be HC. If there are no frames to be sent to the HC, then the WSTA shall send to the HC a QoS Null with No Ack bit and the TXOP duration requested field both set to 0. If the beginning of the reception of an expected ACK response does not occur, detected as the non-occurrence of PHY-CCA.indication(busy) at the WSTA which is expecting the response during the first slot time following SIFS, that WSTA shall retransmit the frame or transmit a QoS Null frame, with the No Ack bit and queue size fields all set to 0, after PIFS from the end of last transmission, until such time that it receives an acknowledgement or when there is not enough time remaining in the TXOP for sending such a frame. This is to avoid the situation where the HC may not receive the frame and may result in an inefficient use of the channel. If the HC does not have any more QSTAs to be polled, it shall send a QoS CF-Poll with the RA matching its own MAC address and with the Duration/ID set to zero. If a PHY-CCA.indication(busy) occurs at the WSTA which is expecting the ACK response during the first slot following SIFS after the end of the transmission of the final frame, it shall be interpreted as indicating that the channel control has been successfully transferred and no further action is necessary, even though the ACK from HC may by incorrectly received.

When a QSTA receives a frame, which requires an acknowledgement, addressed to itself, it shall respond with an ACK or QoS (+)ACK whichever relevant irrespective of whether its NAV is set or not. A WSTA shall accept a polled TXOP by initiating a frame exchange sequence irrespective of its NAV.

9.10.2.2 Duration values within polled TXOPs

The Duration/ID value in each of the second and subsequent frames sent by a QSTA during a TXOP shall be the Duration/ID value of the preceding frame in the sequence, diminished by the time required to send the response frame plus one SIFS period.

The initial frame of a non-final frame exchange sequence sent by a QSTA within a TXOP shall contain a duration value which is the remaining duration of the TXOP. The initial frame of the sole or final frame exchange sequence of the TXOP shall contain a duration value which covers the actual remaining time needed for this frame exchange sequence plus one DIFS period.

9.10.3 HCF controlled channel access transfer rules

A TXOP obtained by receiving a QoS (+)CF-Poll uses the specified TXOP limit, resulting in a CFB that consists of one or more frame exchange sequences with the sole time-related restriction being that the final sequence shall end not later than the TXOP limit. MSDUs may be fragmented in order to fit within TXOPs.

QSTAs shall use QoS data type frames for all MPDU transfers to/from an HC, and should use QoS data type frames for direct QSTA-to-QSTA transfers. The TID in the QoS control fields of these frames shall indicate the TC or TS to which the MPDU belongs, and the queue size field shall indicate the amount of queued traffic present in the output queue that the QSTA uses for traffic belonging to this TC or TS. The queue size value reflects the amount on the appropriate queue immediately after the present MPDU was removed from the queue in preparation for transmission. A WSTA should acknowledge the receipt of a QoS data type frame received from the HC, subject to normal Ack policy, using a QoS CF-Ack in cases where that WSTA has new or changed bandwidth requirements, and wants to send the TID and TXOP duration request along the required acknowledgement (also see 9.10.3.1).

QSTAs shall be able to transmit and receive QoS CF-Ack frames. QSTAs are not required to be able to transmit QoS data type frames with subtypes that include +CF-Ack. QSTAs shall be able to handle received QoS data type frames with subtypes that include +CF-Ack when the QSTA to which the acknowledgement is directed is the same as the QSTA addressed by the Address1 field of that QoS data type frame. QSTAs are not required to handle received QoS data type frames in which the +CF-Ack function pertains to a different QSTA than is addressed by the Address1 field of that QoS data type frame. The net effect of these restrictions on the use of QoS +CF-Ack is that the principal QoS +CF-Ack subtype that is useful is the QoS Data+CF-Ack, which can be sent by a WSTA as the first frame in a polled TXOP when that TXOP was conveyed in a QoS Data+CF-Poll(+CF-Ack) and the outgoing frame is directed to the HC's QSTA address. QoS (Data+)CF-Poll+CF-Ack frames are only useful if the HC wants to grant another TXOP to the same QSTA a SIFS after receiving the final transmission of that QSTA's previous TXOP.

The HC assumes that all QSTA transfers using non-QoS frames are best effort traffic.

HCF contention-based channel access shall not be used to transmit MSDUs belonging to traffic streams for which the traffic specification as furnished to/by the HC has a specified minimum data rate and a specified delay bound, except as may be necessary to obtain the first polled TXOP from the HC for a newly added or modified traffic stream.

9.10.3.1 TXOP requests

QSTAs may send TXOP requests during polled TXOPs or EDCF TXOPs as well as during CCIs. The RR frame may only be used to send requests during CCIs (see 9.10.4), but similar functionality during ordinary TXOPs is achieved using a QoS Null frame, or QoS CF-Ack frame directed to the HC, with the request duration or queue size and TID value indicated to the HC. During the CP, if the No Ack bit in the QoS control field of this QoS Null frame is =0 the HC shall respond to this QoS Null with a CF-Poll+CF-Ack frame, but the HC is not required to grant a TXOP of the requested length in this frame.

RR frames should not be used to request TXOPs for traffic streams for which the TSPEC, as furnished by the HC, has a periodic type, a specified minimum data rate, and a specified delay bound, except as may be necessary to obtain the first polled TXOP from the HC for a newly added or modified traffic stream.

9.10.3.2 Use of RTS/CTS

QSTAs may send an RTS as the first frame of any frame exchange sequence for which improved NAV protection is desired, during either the CP or CFP, and without regard for dot11RTSThreshold. For a RTS frame sent at the beginning of a non-final frame exchange within a polled TXOP, as well as for an RTS frame sent by the HC at the beginning of a frame exchange which grants a TXOP, the Duration/ID field shall be set to the number of microseconds remaining until the end of the specified TXOP. For an RTS frame sent at the beginning of the sole or final frame exchange within a polled TXOP, including the case of a polled TXOP with a TXOP limit value of 0, as well as for an RTS frame sent by the HC at the beginning of a frame exchange which does not grant a TXOP, the Duration/ID field shall be set to the time, in microseconds, required to transmit the data or management type frame of the pending frame exchange, plus one CTS time, plus one ACK time, plus three SIFS intervals, plus one DIFS interval. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer.

The HC and TXOP holder after transmitting RTS may recover from the failure of the successful CTS reception by transmitting a frame after PIFS following the end of the RTS transmission if the PHY-CCA.indication(busy) does not occur, or after SIFS following the end of the last frame reception if the frame after the RTS transmission is received incorrectly, as determined by an FCS error, after occurrence of PHY-RXSTART.indication and PHY-RXEND.indication(no error).

If NAV protection is desired for a transmission to the HC in response to a QoS data frame with a subtype that includes CF-Poll, the QSTA is allowed to send a CTS frame with RA containing its own MAC address in order to set the NAV in its own vicinity without the extra time to send an RTS (which is unnecessary because the NAVs in vicinity of the HC were set by the QoS (+)CF-Poll frame). For a CTS frame sent to the QSTA's own MAC address at the start of a polled TXOP, the Duration/ID field shall be set to the number of microseconds until the end of the TXOP.

NOTE: The sending of RTS during the CFP is usually unnecessary, but may be used to ensure that the addressed recipient QSTA is within range and awake, and to elicit a CTS response that will set the NAV at STAs in the vicinity of the addressed recipient. This is useful when there are nearby STAs that are members of other BSSs and are out of range to receive beacons from this BSS. Sending an RTS during the CFP is only useful when the recipient is a QSTA, because a STA in the same BSS will have its NAV set to protect the CFP, which will render those STAs unable to respond. Using the same duration calculation during the CFP as specified for the CP is directly applicable for all cases except when the RTS is sent by the HC, and the following frame includes a QoS (+)CF-Poll.

9.10.4 Controlled Contention

The HCF controlled contention mechanism allows WSTAs to request the allocation of polled TXOPs without having to contend with (E)DCF traffic. These requests may be to initiate periodic polled TXOPs to handle traffic under a TSPEC that specifies periodic traffic type, or for one-time TXOPs to handle a traffic burst or to create an initial TXOP for a new QSTA or newly-active TS.

9.10.4.1 CC transmission

Each instance of controlled contention occurs during a controlled contention interval (CCI) which begins a PIFS interval after the end of a CC control frame. Only the HC is permitted to transmit CC control frames. CC frames may be transmitted during both the CP and CFP, subject to the restriction that the entirety of the CC frame and the CCI which follows that CC frame shall fit within a single CP or CFP, as well as a single instance of medium occupancy pursuant to dot11MaxDwellTime and/or dot11MediumOccupancyLimit.

When initiating controlled contention, the HC shall generate and transmit a control frame of subtype CC that includes the Priority Mask, the duration of each CCOP (Dccop, defined as the number of microseconds to send an RR frame at the same data rate, coding and preamble options as used to send the CC frame, plus one SIFS period.) and the number of CCOPs within the CCI (Nccop) as specified in 7.2.1.8. The Priority Mask value allows the HC to specify a subset of the user priority values for which requests are permitted within this particular CCI in order to reduce the likelihood of collisions under high load conditions. The HC sets the Priority Mask field to contain 1s at bit positions that correspond to the priorities for which responses may be sent during the CCI. The default value for the Priority Mask is 255, which allows the sending of requests for all priorities. The HC also can alter the likelihood of collisions when selecting the number of CCOPs in the CCI (Nccop) which can vary over the range 1 to 255.

Figure 62.2 shows an instance of controlled contention, including the CC frame and the individual CCOPs within the CCI.

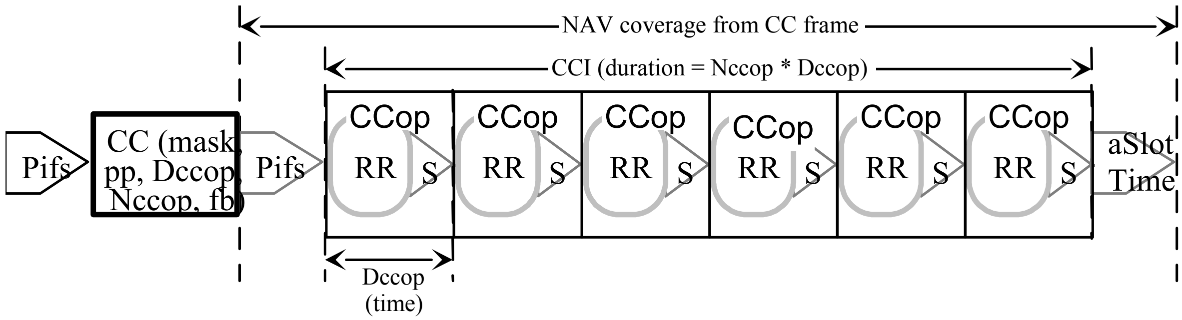


Figure 62.2 – Controlled contention interval

9.10.4.2 CCI response procedure

Upon receipt of a control frame of subtype CC with the BSSID of the QBSS with which they are associated, QSTAs shall perform the CCI response procedure as specified below.

a) If the CCI Length value in the received CC frame is 0, or if the QSTA has no pending request, that QSTA proceeds to step (d), otherwise the QSTA continues with step (b).

b) If the user priority of the traffic with the TID for which the request is pending corresponds to a bit position which is set to 0 in the Priority Mask field of the CC frame, no request shall be transmitted for that TID during the current CCI. Each QSTA may transmit no more than one request during each CCI; however, a QSTA with multiple TIDs in need of a new or modified TXOP is permitted to select the TID for which a request is sent based on the value in the Priority Mask field of the CC frame. At the end of this step (b) of the CCI response procedure, each potential contending QSTA proceeds to step (c) having selected exactly one request to be transmitted during the current CCI; while all other QSTAs proceed to step (d).

c) The QSTA transmits a control frame of subtype RR with values in the QoS Control field that specify the TID and either TXOP duration or queue size of the request in accordance with the frame and field formats specified in 7.2.1.9. To request polled TXOPs based on a TSPEC, the QoS Control field contains a TSID for the appropriate TSPEC in the TID field along with a queue size field (since the TXOP duration in this case is determined using parameter values in the TSPEC). To request polled TXOP(s) to handle current traffic, the QoS control field contains the user priority in the TID field along with a TXOP duration requested (or a queue size) field. The start of the RR transmission shall follow the end of the CC frame by number of microseconds calculated using the following formula:

   PIFS + (R x Dccop)

   where

   R is a random integer drawn from a uniform distribution over the interval [0, (Nccop-1)].

   This transmission shall only occur if the QSTA's NAV, without update from the Duration/ID field of the CC frame, indicates the WM is idle. Because of the possibility of transmissions by other contending QSTAs during the preceding CCOP, contending QSTAs ignore CCA in determining whether to initiate this transmission. The RR shall be transmitted at the same data rate as the CC frame that initiated this CCI. After transmitting the RR frame, or determining that the RR cannot be transmitted because the NAV is set, the QSTA proceeds to step (d).

d) The QSTA makes no further transmissions until after the CCI, determined by an elapsed time, following the end of the CC frame, equal to the number of microseconds indicated in the Duration/ID field of that CC frame.

9.10.4.3 CCI feedback procedure

Successful receipt of RR frames is acknowledged in the Feedback field of the next sequential CC frame transmitted by the HC. The HC may transmit a CC frame exclusively for the purpose of providing feedback by specifying a CCI length of zero.

A TXOP request for a particular TID at a QSTA shall remain pending until occurrence of any of the following:

a) Detection of this QSTA's AID in the feedback field of the next CC frame received after transmission of an RR for that request.

b) Receipt of an acknowledgement to transmission of a QoS data type frame with the same TID as the pending request, independent of whether this transmission occurs during a polled TXOP or an EDCF TXOP.

c) Discarding, by the QSTA, of the MPDU for which the request was pending, due to exceeding TC-specific or TSPEC-defined delay limits or other criteria.

d) The end of the QSTA's association in the QBSS.

A previously transmitted request that remains unacknowledged after inspection of the Feedback field of the next CC frame may be retried by the QSTA if that request satisfies the criteria for transmission during the new CCI as specified by the CCI response procedure. A QSTA awaiting a requested TXOP and/or RR feedback may attempt to send the pending QoS data frame (or any other pending traffic) using the contention-based access method.

9.10.4.4 CCI generation by HC

The HC may send a CC in the CP or CFP. Every HC shall initiate at least one instance of controlled contention, usable for requests of each user priority level, during the first CAP of each DTIM interval, if MSDU transfers from traffic streams with a specified minimum data rate and a specified delay bound are not preempted.. The number of CCOPs in the CCI shall be at least

max(2, ceiling(0.2 * (#Assoc_QSTAs - #QSTAs_with_TXOPs)))

where: "#Assoc_QSTAs" is the number of QSTAs presently associated with the QAP, and "#QSTAs_with_TXOPs" is the number of QSTAs that the HC is presently polling on a periodic basis plus the number of distinct QSTAs for which at least one aperiodic poll is presently pending.

Multiple CCIs, following CC frames with differing subsets of the user priority levels enabled by the priority mask, may be used if a single CC with all priorities enabled is not used.

If collisions are inferred in more than half of the CCOPs in a CCI, the subsequent CC frame should reduce contention. A collision is inferred when the HC detects the channel to be busy due to the occurrence of PHY-CCA.indication(busy) during the CCOP, but the PHY does not generate a PHY-RXSTART.indicate during that CCOP. The HC may also infer a collision based on an invalid FCS in a received RR frame.

9.10.5 Burst Acknowledgment

9.10.5.1 Introduction

The Burst Acknowledgement mechanism allows a burst of QoS DATA MPDUs to be transmitted separated by a SIFS period. The mechanism provides solutions to two different problems: improve the channel efficiency by aggregrating several acknowledgements into one frame and allow for the decoding delay for FEC encoded frames Consequently, there are two types of burst ack mechanisms: immediate and delayed. Immediate burst ack is suitable for high-bandwidth, low latency traffic while the delayed burst ack is suitable for applications that can tolerate moderate latency. In this clause, the QSTA with data to send will be referred to as originator and the receiver of that data as the recipient.

Note: The delayed burst ack mechianism is primarily intended to allow the existing implementations to use this feature with minimal hardware changes and also to allow inexpensive implementations that would use the processing power on the host.

The burst ack mechanism is set up by initialization through an exchange of Define Burst Ack QoS Action request/response frames. Once the initialization is performed, bursts of QoS data type frame bursts can be transmitted from the originator to the recipient. A burst can be started within a polled TXOP or by winning EDCF contention. The MPDUs within this exchange usually fit within a single TXOP and are all separated by a SIFS. The burst length is limited, and the amount of state that must be kept by the recipient of the DATA MPDUs is bounded. The MPDUs within the burst are acknowledged by a BurstAck control frame, which is requested by a BurstAckReq control frame. This “request”/”response” mechanism gives the recipient to perform any necessary FEC decoding and can be extended by the recipient if necessary.

Burst Ack mechanism does not require setting up of a TS, however QSTAs using the TS facility may choose to signal their intention to use burst ack mechanism for the scheduler’s consideration in assigning transmission opportunities. Acknowledgements of frames belonging to the same TID, transmitted during multiple TXOPs may also be combined into a single Burst Ack frame. It applies to FEC-encoded frames as well as non-FEC encoded frames.. It also provides a means for a recipient to delay a burst acknowledgement while performing FEC operations.

The originator is given great flexibility regarding the ordering. The originator can split bursts across TXOPs, separate the burst and the burst acknowledgement exchange, interleave bursts for different TIDs or RAs.

Figure 62.3 illustrates the message sequence chart for the set up, data and burst acknowledgement transfer and tear down of Burst Ack mechanism which are discussed in detial in the following subclauses.

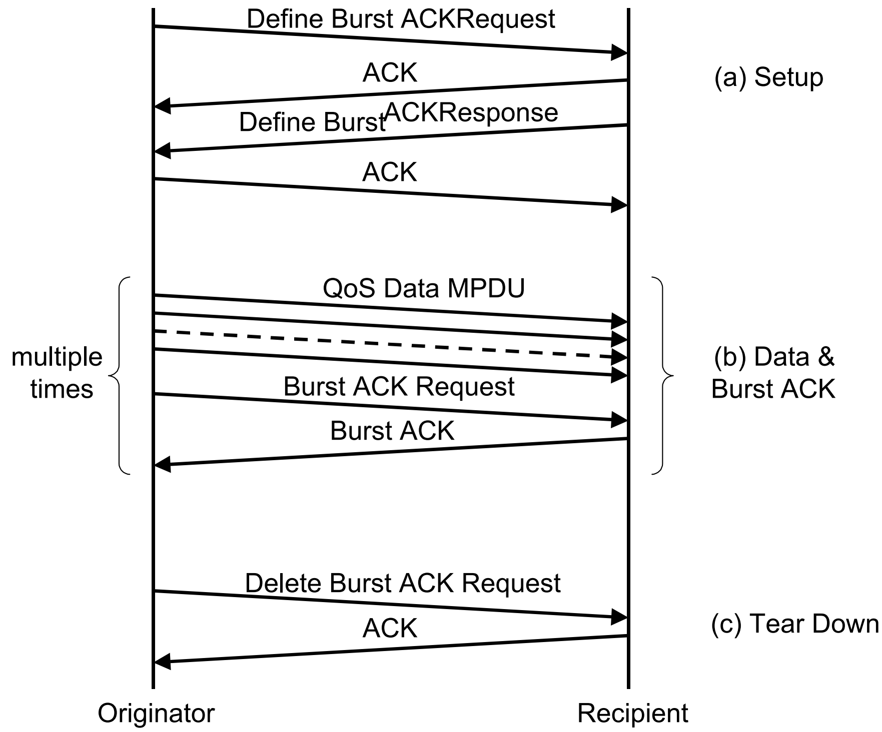


Figure 62.3 Message Sequence Chart for Burst Ack Mechanism: (a) Set up, (b) Data and acknowledgement transfer and (c) Tear down

9.10.5.2 Set up and modification of the Burst Ack parameters

The transmitting QSTA (i.e., originator) that has data traffic to send and intends to use Burst Ack facility mechanism should first check if the receivering QSTA (i.e., recipient) is capable of participating in Burst Ack mechanism by examining the capability bit in the beacon, probe response, association request or the reassociation request. If the recipient is capable of participating, the originator sends a Define Burst Ack request QoS Action request frame indicating the TID. The receiving QSTA recipient will respond by a Define Burst Ack response QoS Action response frame. The receiving QSTArecipient has the option of accepting or rejecting. When the recipient QSTA accepts, it indicates the type of Burst Ack and the amount of buffer size that it will allocate for the support of this burst. If the QSTA recipient rejects, then the originator shall not invoke burst ack mechanism and will use either the IEEE 802.11 acknowledgement or not rely on acknowledgements.

If the Burst Ack mechanism is being set up for a TSID, the bandwidth negotiation (using ADDTS request and response QoS Action management frames) should preceed the set up of the Burst Ack mechanism.

Once the burst ack exchange has been set up, data and acknowledgements are transferred following the procedure described in clause 9.10.5.3.

9.10.5.3 Data and acknowledgement transfer

After setting up the burst exchange following the procedure in 9.10.5.2, the originator shall transmit a burst of QoS data type frames separated by SIFS period, not exceeding the Re-ordering buffer size subfield in the associated Define Burst Ack response QoS action management frame. Each of the frames shall have the Ack policy subfield in the QoS Control set to 11. When the originator is ready to receive an acknowledgement, it shall seek the acknowledgement by sending a BurstAckReq frame. The recipient shall maintain a Burst Ack record for the burst.

Subject to any constraints herein about permitted use of TXOP according to the channel access mechanism used: the originator can separate the burst and the BurstAckReq into separate TXOPs; the originator can split a burst across multiple TXOPs; the originator can sequence bursts with different TIDs in the same TXOP; the originator can interleave MPDUs from bursts with different TIDs within the same TXOP; the originator can sequence or interleave MPDUs for different RA within a TXOP.

The duration values of burst DATA MPDUs and any burst Ack exchange transmitted within a polled TXOP shall follow the rules defined in 9.2.2.2.

The duration rules during an EDCF TXOP shall be as follows: the duration field of any burst data shall protect any following transmitted MPDU and its response MPDU if there is one; the duration field of the final frame of the burst shall protect at least the BurstAck frame. In this context “protect” means that the duration value causes the NAV to expire at the end of the protected MPDU.

The originator shall use the Burst Ack Starting Sequence Control to signal the first MPDU for which an acknowledgement is expected. The recipient shall interpret that all the outstanding MPDUs with the Sequene Control preceeding the value in Burst Ack Starting Sequence Control at the originator have been dropped and releases the MPDUs for the delivery to the higher layer thus freeing the buffer.

The recipient shall maintain a burst acknowledgement record consisting of originator address, TID, and a bitmap with size of Re-ordering Buffer Size of received MPDU sequence number, where the MPDU sequence number is defined as (Sequence Number * 16 + Fragment number). These hold the acknowledgement state of the burst data received from the originator.

If the immediate Burst Ack policy is used, the recipient shall respond to BurstAckReq, with either the BurstAck frame or with an ACK or QoS CF-Ack frame. If the recipient of the burst sends the BurstAck frame, the originator will update its own record and will retry any frames that are not acknowledged in the BurstAck frame, either in another burst or individually. If the recipient of the burst sends an ACK or a QoS CF-Ack frame, as long as there is sufficient time within the TXOP, the originator will immediately transmit a BurstAckReq and will continue to seek the acknowledgement either in the same TXOP or in a subsequent TXOP.

If the delayed Burst Ack policy is used, the recipient shall respond to BurstAckReq with either an ACK frame or a QoS (+) CF-Ack frame. The recipient shall then resend the BurstAck frame in a subsequently obtained TXOP. The recipient should endeavor to expedite the transmission of the BurstAck frame and when ready shall send it in the earliest TXOP that it obtains by placing the BurstAck at the head of the highest priority queue. The originator shall respond with an ACK frame upon the receipt of the BurstAck frame.

The BurstAck contains acknowledgements for the MPDUs of up to 64 previous MSDUs. If the BurstAck indicates that an MPDU was not received correctly, the originator shall retry that MPDU subject to that MPDU’s appropriate retry limit.

A typical Burst Ack frame exchange sequence using the immediate burst ack, for a single TID is shown in figure 62.4

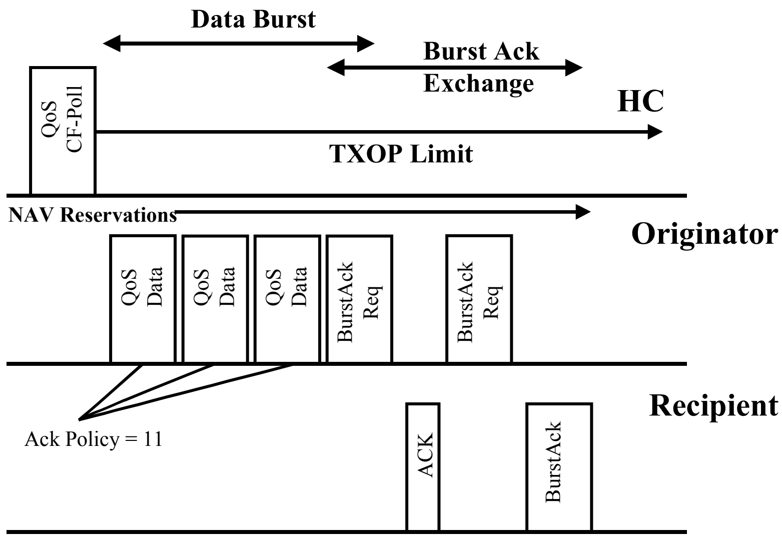


Figure 62.4: A typical Burst Ack sequence when immediate policy is used

A typical Burst Ack sequence using the delayed Burst Ack is shown in Fig 62.5

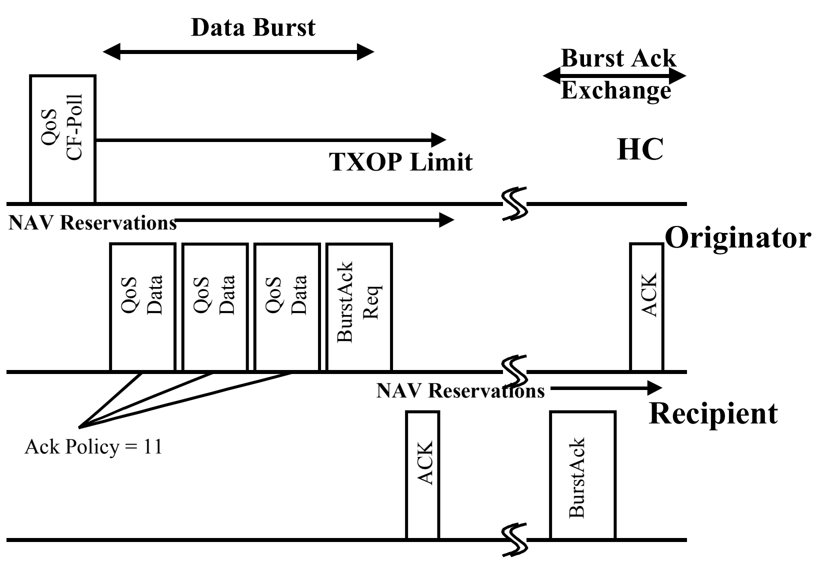


Figure 62.5: A typical Burst Ack sequence when delayed policy is used

If there is no response (i.e., neither a BurstAck nor an ACK) to the BurstAckReq frame, the originator can retransmit BurstAckReq within the current TXOP (if time permits) or within a subsequent TXOP. This retransmission is subject to the short retry limit times the number of MSDUs referenced by this BurstAckReq. If the BurstAckReq is discarded due to reaching its retry limit, all MPDUs in the burst are considered to have failed transmission and are discarded.

The BurstAckReq shall be discarded if all MSDUs referenced by this BurstAckReq have been discarded from the transmit buffer due to expiry of their lifetime limit.

Originators using Burst Ack facility, to improve efficiency, may send MPDU frames with Ack policy in QoS Control frames set to 00 if only a few MPDUs are in their buffer. When there are sufficient number of MPDUs, the originator may switch back to the use of Burst Ack. Originators, however, may not switch from immediate to delayed or delayed to immediate without renegotiation by deleting and re-defining the burst ack parameters.

9.10.5.4 Receive Buffer Operation

The recipient flushes received MSDUs from its receive buffer as described in this section.

If a BurstAckReq is received, all MSDUs with lower sequence numbers than the starting sequence number contained in the BurstAckReq shall be indicated to the MAC client using the MAC-UNIDATA.indication primitive.

If, after an MSDU is received, the receive buffer is full, the MSDU with the earliest sequence number shall be indicated to the MAC client using the MAC-UNIDATA.indication primitive.

All comparisons of sequence numbers are performed circularly modulo 2**12.

The Sent Count subfield in the Burst ACK request message contains the number of MPDUs that should be present in the receive buffer starting with Burst ACK starting sequence control. If the number of MPDUs present is equal to the Sent Count, then all of the complete MSDU in the receive buffer shall be indicated to the MAC client using the MAC-UNIDATA.indication primitive.

If the receive buffer is not full and the number of received buffers does not match Sent Count, then an MSDU in the receive buffer that matches the Burst ACK starting Sequence count shall be indicated to the MAC client using the MAC-UNIDATA.indication primitive. No other MSDUs can be indicated.

9.10.5.5 Tear down of the Burst Ack mechanism

When the originator has no data to send it shall signal the end of the bursts by sending the Delete Burst Ack QoS Action Management frame to the recipient of the burst. There will not be any response from the recipient except for the IEEE 802.11 acknowledgement to this management frame.

The data transfer for a TS may also be terminated through the Delete TS QoS Action Management frame, in which case, the recipient of the Delete TS shall also assume that any Burst Ack that has been set up between the originator and the recipient is also terminated.

9.10.5.6 Error recovery upon a peer failure

An originator or a recipient would assume that there is a peer failure, if its peer fails to respond within a certain duration. This duration shall be same as Inactivity Interval if the data belongs to a TS and shall be dot11PeerLivenessTimeout if the data belongs to a TC. If it is the originator, it shall cease its transmission. If it is the recipient, it shall release the buffer that has been allocated for Burst Ack purposes. If the QSTA that released the buffer is the recipient and if the peer becomes active after such a release of the buffer and sends data MPDUs, then the recipient shall ignore them and shall send a Delete Burst Ack request frame to indicate the status. The originator may again start a negotiation for the set up of the Burst Ack or send the MPDUs using an alternative acknowledgement mechanism.

9.10.6 HCF frame exchange sequences

The allowable frame exchange sequences for use between and among QSTAs and the QAP in a QBSS are shown in Table 25.1. This table uses the same notation as tables 21 and 22 (see 9.7).

Table 25.1 – QBSS frame sequences

HCF Frame Sequence (in CP or CFP unless noted)	Frames in Sequence	Usage
Beacon(CF)	1	beacon during CF period
Data(bc/mc)	1	broadcast or multicast MSDU
Mgmt(bc)	1 or 2	broadcast MMPDU
Mgmt(dir) – ACK	2 or 3	directed MMPDU
CC <CCI>	1 + CCI	controlled contention
RR (only within <CCI>)	1	reservation request during CCI
QoS CF-Poll{+CF-Ack}(no data) [– CTS self] – QoS Data(dir) – ACK [– QoS Data(dir) – ACK]	3 +	polled TXOP, QSTA has frames to send
QoS CF-Poll{+CF-Ack}(no data) – QoS Null	2 or 4	polled TXOP, QSTA has nothing to send (that will fit in TXOP)
[RTS – CTS –] QoS Data(dir) – (QoSCF-)Ack(no data)	2 or 4	frame delivery by QSTA or HC, continuation of TXOP
[RTS – CTS –] QoS Data(dir)+CF-Poll{+CF-Ack} – {(QoS CF-)ACK –} QoS Data(dir) –	2, 3 or 5	start of TXOP sent with MPDU

9.11 Direct Frame Transfer Procedures

9.11.1 Wireless ARP Cache

All non-AP stations wishing to transmit direct frames, that is frames sent directly to other stations within the same BSS without traversing the DS, must implement a wireless ARP cache which contains a list of known receiving stations and their status with respect to their current ability to receive direct frames. The size of the cache is implementation dependent and entries may be flushed from the cache at any time, but a station shall not send direct frames to a receiving station for which it has no wireless ARP cache entry.

For each entry in the cache, the following information must be stored:

a) The MAC address of the station

b) An indication of whether the MAC address corresponds to a STA in this BSS, and is possibly able to receive direct traffic. If it is, the following must also be stored:

  i) An indication of whether the station is currently able to receive direct traffic. If it is, the following information must also be stored:

    i. An indication of whether the station is operating in CAM or PSP mode

    ii. An indication of whether the station is currently considered to be in the wake or doze state

9.11.2 Registration Procedures at AP

If use of direct transfer is not prohibited by security policy for this BSS, the AP shall store state information for each associated STA in support of direct transfer functions.

In this case, the access point shall store an indication of whether each associated station in the BSS has indicated its ability to currently receive direct frames, and shall also store for each associated station that has its direct receive state set to “enabled” a list of other associated stations which have previously requested a change notification.

On receipt of a direct enable request frame, the AP shall update its state if necessary and respond with a direct enable response frame according to its security policy:

a) If the security policy prohibits direct traffic in this BSS, the AP shall send a direct enable response frame with direct enable status code set to “enable prohibited”

b) If the security policy permits direct traffic in this BSS, the AP shall change its state table for the requesting STA to “enabled” and send a direct enable response frame with direct enable status code set to “enable accepted”

On receipt of a direct disable request frame, the AP shall update its direct traffic state information for the transmitting STA to mark it as “disabled”. If the state information for that STA lists addresses of STAs which have requested notification of a status change, the AP shall send each of those STAs a status change notify response frame containing a target destination address element set to the address of the now disabled STA.

If a station wishes to be notified of a change in the state of another associated station from “enabled” to “disabled” it may send a status change notification request frame to the AP, containing the MAC address of the station for which it wishes to receive notification.

If, on receipt of a status change notification request frame, the AP either does not have an entry for the indicated station, or it already has a state of “disabled”, it shall immediately return a direct traffic disable notification response frame containing the same address as the request frame. Otherwise, it shall add the requesting station to the notification list for the indicated receiving station.

9.11.3 Registration Procedure at a STA

A STA that is capable of receiving direct traffic maintains a state variable indicating whether direct traffic to it is enabled. This state variable is set to “disabled”

If a STA wishes to receive direct traffic, it may send a direct traffic enable frame to the AP.

If the STA subsequently receives a direct enable response frame from the AP with status code “enable accepted” it shall set its direct traffic receive state to “enabled”.

If a STA has its direct traffic receive state set to “disabled” it shall not respond to direct communication request frames.

If a station no longer wishes to receive direct traffic, it may send a direct traffic disable frame to the AP and change its direct traffic receive state to “disabled”.

A station which has its direct traffic receive state set to “enabled” should modify its state to “disabled” using this procedure if it expects to roam to another BSS imminently, therefore allowing any transmitting stations to modify their wireless ARP caches to transfer frames via the DS.

9.11.4 Location Discovery Procedure at a STA

A station that does not have a cache entry for a particular destination address must perform a location discovery procedure in order to add it. The station initiates a location discovery procedure by sending a location discovery request frame to the AP, containing the MAC address of the station that it wishes to locate.

If the request times out, that is, no matching location discovery response frame is returned within dot11DirectDiscoveryTimeout, the station shall either create no entry in its cache, or create a cache entry indicating that the station with that MAC address is not able to receive direct traffic.

If the station receives a valid matching location discovery response frame within the timeout period indicating that the station is not able to receive direct traffic, the station shall create a cache entry indicating that the station with that MAC address is not able to receive direct traffic.

If the station receives a valid matching location discovery response frame within the timeout period indicating that the station is able to receive direct traffic, the station may initiate a direct communication negotiation with that station by sending it a direct communication request frame.

If the direct communication request times out, that is, no matching direct communication response frame is returned within dot11DirectDiscoveryTimeout, the station shall either create no entry in its cache, or create a cache entry indicating that the station with that MAC address is not able to receive direct traffic.

If the station receives a valid matching direct communication response frame within the timeout period, it may create an entry in its cache indicating that the destination address is possibly capable of receiving direct traffic, but is not currently capable of doing so.

If a STA receives a status change notification frame from the AP, indicating that a specific destination address no longer corresponds to a STA capable of receiving direct traffic, it shall either remove any corresponding entry from its cache or mark it as no longer able to receive direct traffic.

9.11.5 Location Discovery Procedure At An Access Point

If an AP receives a location discovery request frame:

a) If direct traffic is permitted by security policy, the address contained in the request corresponds with an associated STA and that STA's direct traffic enable state is set to "enabled", the AP shall respond with a location discovery response frame with location discovery status element indicating "success".

b) If direct traffic is permitted by security policy, but the address contained in the request does not correspond with an associated STA, the AP shall respond with a location discovery response frame with location discovery status element indicating "fail, not associated".

c) If direct traffic is permitted by security policy and the address contained in the request corresponds with an associated STA, but that STA's direct traffic enable state is set to "disabled", the AP shall respond with a location discovery response frame with location discovery status element indicating "fail, in this BSS but not enabled for direct traffic".

d) If direct traffic is not permitted by security policy, the AP shall respond with a location discovery response frame with location discovery status element indicating "fail, direct traffic prohibited in this BSS".

9.11.6 Direct Negotiation Setup Procedure

A STA wishing to initiate direct communication with another STA shall invoke the direct negotiation setup procedure to do so, but only if it has an entry in its cache indicating that the target address corresponds to a STA which is possibly able to receive direct traffic.

To initiate a direct negotiation setup procedure, the STA must send a direct communication request action frame to the target address. This frame shall have the toDS and fromDS subfields of the control field both set to zero.

If the transmission fails, the STA may retry it, using the same or lowered transmission rate. ? add timeout or retry limit.

If the STA receives a direct communication response frame from a station from which it was expecting to receive such a frame it may update the entry in its cache to indicate that the STA is now capable of receiving direct traffic.

If a transmitter receives a direct communication response frame from a receiver that it had not previously sent a direct communication request frame, it shall silently discard the frame.

If a STA receives a direct communication request frame, and its direct receive state is enabled, it shall return a direct communication response using the same transmit rate as the received frame.

If a STA receives a direct communication request frame, and its direct receive state is disabled, it shall silently discard the frame.

9.11.7 Wake Request And Notification Procedure At The Transmitting Station

If the transmitting STA receives any frame from a STA corresponding to an entry in its cache with the PS subfield of the control field set to one, it shall set the power mode field of that entry in the cache to CAM.

If the transmitting STA receives any frame from a STA corresponding to an entry in its cache with the PS subfield of the control field set to zero, it shall set the power mode field of that entry in the cache to PSP.

When the entry in the cache at a transmitter shows a specific receiver to be in PSP mode, if it transmits a frame to that receiver with more data bit set to zero it shall set the current power state to doze.

A receiver may only go into the doze state if the last data frame received from all addresses had the more subfield of the control field set to zero.

If a transmitter wishes to send a data frame to a receiver that has an entry in its cache indicating that it is in the doze state, it must first use the wakeup procedure to change its state to wake. In order to do so, it must transmit a wake notify request frame to the AP. If it subsequently receives a wake notify response frame from the AP, it shall change the entry for that receiver in its cache to indicate that it is in the wake state.

9.11.8 Wake Request And Notification Procedure At Access Point

If an AP receives a wake notify request frame for a receiver in its association table that is currently in the wake state, it shall respond with a wake notify response frame.

If an AP receives a wake notify request frame for a receiver in its association table that is currently in the doze state, it shall behave as if a data frame for that receiver was buffered for transmission, and set the corresponding bit in the TIM element of subsequent beacons, until it receives a PS-Poll frame from the receiver. On receipt of a PS-Poll frame from the receiver, it shall respond to the requester with a wake notify response frame.

10. Layer management

Change 10.3.2 as shown below:

10.3.2 Scan

10.3.2.1 MLME-SCAN.request

10.3.2.1.1 Function

This primitive requests a survey of potential (Q)BSSs which the (Q)STA may later elect to try to join.

10.3.2.1.2 Semantics of the Service Primitive

The primitive parameters are as follows:

```
MLME-SCAN.request     (
                       BSSType,
                       BSSID,
                       SSID,
                       ScanType,
                       ProbeDelay,
                       ChannelList,
                       MinChannelTime,
                       MaxChannelTime
                       )
```

Name	Type	Valid Range	Description
BSSType	Enumeration	INFRASTRUCTURE, INDEPENDENT, ANY_BSS, ONLY_QOS	Determines whether Infrastructure BSS, Independent BSS, or both are included in the scan. These scans will report QBSSs of the appropriate type. At QSTAs the ONLY_QOS value may be specified to limit the report to QBSSs.
BSSID	MACAddress	any valid individual or broadcast MAC address	Identifies a specific or broadcast BSSID.
SSID	octet string	0 - 32 octets	Specifies the desired SSID or the broadcast SSID.
ScanType	Enumeration	ACTIVE, PASSIVE	Indicates either Active or Passive scanning.
ProbeDelay	integer	N/A	Delay (in μs) to be used prior to transmitting a Probe frame during active scanning
ChannelList	Ordered Set of Integer	Each channel will be selected from the valid channel range for the appropriate PHY and Carrier Set.	Specifies a list of channels which are examined when scanning for a BSS.
MinChannelTime	integer	greater than or equal to ProbeDelay	The minimum time (in TU) to spend on each channel when scanning
MaxChannelTime	integer	greater than or equal to MinChannelTime	The maximum time (in TU) to spend on each channel when scanning

10.3.2.1.3 When Generated

This primitive is generated by the SME when a (Q)STA wishes to determine if there are other (Q)BSSs which it may join.

10.3.2.1.4 Effect of Receipt

This request initiates the scan process when the current frame exchange sequence is completed.

10.3.2.2 MLME-SCAN.confirm

10.3.2.2.1 Function

This primitive returns the descriptions of the set of (Q)BSSs detected by the scan process.

10.3.2.2.2 Semantics of the Service Primitive

The primitive parameters are as follows:

```
MLME-SCAN.confirm    (
                      BSSDescriptionSet,
                      ResultCode
                      )
```

Name	Type	Valid Range	Description
BSSDescriptionSet	Set of BSSDescription	N/A	The BSSDescriptionSet is returned to indicate the results of the scan request. It is a set containing zero or more instances of a BSSDescription.
ResultCode	enumeration	SUCCESS, INVALID_ PARAMETERS	Indicates the result of the MLME-SCAN.confirm.

Each BSSDescription consists of the following elements:

Name	Type	Valid Range	Description
BSSID	MACAddress	N/A	The BSSID of the found BSS
SSID	octet string	1 - 32 octets	The SSID of the found BSS
BSSType	Enumeration	INFRASTRUCTURE, INDEPENDENT	The type of the found BSS
Beacon Period	integer	N/A	The Beacon period of the found BSS (in TU)
DTIM Period	integer	As defined in Frame Format	The DTIM Period of the BSS (in Beacon Periods)
Timestamp	integer	N/A	The timestamp of the received frame (probe response/beacon) from the found BSS
Local Time	integer	N/A	The value of the station’s TSF timer at the start of reception of the PHY symbol which contains the first bit of

			the first octet of the timestamp field of the received frame (probe response or beacon) from the found BSS.
PHY parameter set	As defined in Frame Format	As defined in Frame Format	The parameter set relevant to the PHY
CF parameter set	As defined in Frame Format	As defined in Frame Format	The parameter set for the CF periods, if found BSS supports CF mode.
IBSS parameter set	As defined in Frame Format	As defined in Frame Format	The parameter set for the IBSS, if found BSS is an IBSS.
CapabilityInformation	As defined in Frame Format	As defined in Frame Format	The advertised capabilities of the BSS.
BSSBasicRateSet	set of integers	1 through 127 inclusive (for each integer in the set)	The set of data rates (in units of 500kbit/s) that shall be supported by all STAs that desire to join this BSS. The STAs shall be able to receive at each of the data rates listed in the set.
QBSSLoad (QoS only)	As defined in Frame Format	As defined in Frame Format	The values from the QBSS Load information element if such an element was present in the probe response or beacon, else null.
ErrorStatistics (QoS only)	As defined in Frame Format	As defined in Frame Format	Reserved for future use. The values from the Error Statistics information element if such an element was present in the probe response or beacon, else null.
ExtendedCapabilities (QoS only)	As defined in Frame Format	As defined in Frame Format	The values from the Extended Capabilites information element if such an element was present in the probe response or beacon, else null.

10.3.2.2.3 When Generated

This primitive is generated by the MLME as a result of an MLME-SCAN.request to ascertain the operating environment of the STA.

10.3.2.2.4 Effect of Receipt

The SME is notified of the results of the scan procedure.

Change 10.3.6.1 as shwon below:

10.3.6.1 MLME-ASSOCIATE.request

10.3.6.1.1 Function

This primitive requests association with a specified peer MAC entity that is acting as an AP.

10.3.6.1.2 Semantics of the Service Primitive

The primitive parameters are as follows:

MLME-ASSOCIATE.request (
PeerSTAAddress,
AssociateFailureTimeout,
CapabilityInformation,
ListenInterval,
ExtendedCapabilities
)

Name	Type	Valid Range	Description
PeerSTAAddress	MACAddress	Any valid individual MAC address	Specifies the address of the peer MAC entity with which to perform the association process.
AssociateFailureTimeout	integer	Greater than or equal to 1	Specifies a time limit (in TU) after which the associate procedure will be terminated.
CapabilityInformation	As defined in Frame Format	As defined in Frame Format	The operational capability definitions to be used by the MAC entity.
ListenInterval	Integer	Greater than or equal to 0	Specifies the number of Beacon intervals which may pass before the station awakens and listens for the next beacon.
ExtendedCapabilities (QoS only)	As defined in Frame Format	As defined in Frame Format	The extended operational capability definitions to be used by the QSTA.

10.3.6.1.3 When Generated

This primitive is generated by the SME when a (Q)STA wishes to establish association with an (Q)AP.

10.3.6.1.4 Effect of Receipt

This primitive initiates an association procedure. The MLME subsequently issues a MLME-ASSOCIATE.confirm that reflects the results.

Change 10.3.7.1 as shown below:

10.3.7.1 MLME-REASSOCIATE.request

10.3.7.1.1 Function

This primitive requests a change in association to a specified new peer MAC entity that is acting as an AP.

10.3.7.1.2 Semantics of the Service Primitive

The primitive parameters are as follows:

MLME-REASSOCIATE.request (
NewAPAddress,
ReassociateFailureTimeout,
CapabilityInformation,

ListenInterval,
ExtendedCapabilities
)

Name	Type	Valid Range	Description
NewAPAddress	MACAddress	any valid individual MAC address	Specifies the address of the peer MAC entity with which to perform the reassociation process.
ReassociateFailureTimeout	integer	greater than or equal to 1	Specifies a time limit (in TU) after which the reassociate procedure will be terminated.
CapabilityInformation	As defined in Frame Format	As defined in Frame Format	The operational capability definitions to be used by the MAC entity.
ListenInterval	Integer	Greater than or equal to 0	Specifies the number of Beacon intervals which may pass before the station awakens and listens for the next beacon.
ExtendedCapabilities (QoS only)	As defined in Frame Format	As defined in Frame Format	The extended operational capability definitions to be used by the QSTA.

10.3.7.1.3 When Generated

This primitive is generated by the SME when a (Q)STA wishes to change association to a specified new peer MAC entity that is acting as an (Q)AP.

10.3.7.1.4 Effect of Receipt

This primitive initiates a reassociation procedure. The MLME subsequently issues a MLME-REASSOCIATE.confirm that reflects the results.

Replace 10.3.10.1 with the updated subclause below:

10.3.10.1 MLME-START.request

10.3.10.1.1 Function

This primitive requests that the MAC entity start a new BSS.

10.3.10.1.2 Semantics of the Service Primitive

The primitive parameters are as follows:

MLME-START.request (
SSID,
BSSType,
BeaconPeriod,
DTIMPeriod,
CF parameter set,
PHY parameter set,
IBSS parameter set,

ProbeDelay.
CapabilityInformation,
BBSBasicRateSet,
OperationalRateSet,
ExtendedCapabilities,
QoS parameter set,
QAPC-STA enabled,
QAPC-STA parameter set element
)

Name	Type	Valid Range	Description
SSID	octet string	1 - 32 octets	The SSID of the BSS.
BSSType	Enumeration	INFRA-STRUCTURE, INDEPEN-DENT	The type of the BSS.
Beacon Period	integer	Greater than or equal to 1	The Beacon period of the BSS (in TU).
DTIM Period	integer	As defined in Frame Format	The DTIM Period of the BSS (in Beacon Periods)
CF parameter set	As defined in Frame Format	As defined in Frame Format	The parameter set for CF periods, if the BSS supports CF mode. aCFPPeriod is modified as a side effect of the issuance of a MLME-START.request primitive.
PHY parameter set	As defined in Frame Format	As defined in Frame Format	The parameter set relevant to the PHY.
IBSS parameter set	As defined in Frame Format	As defined in Frame Format	The parameter set for the IBSS, if BSS is an IBSS.
ProbeDelay	integer	N/A	Delay (in µs) to be used prior to transmitting a Probe frame during active scanning
CapabilityInformation	As defined in Frame Format	As defined in Frame Format	The capabilities to be advertised for the BSS.
BSSBasicRateSet	set of integers	1 through 127 inclusive (for each integer in the set)	The set of data rates (in units of 500 kbit/s) that shall be supported by all STAs that desire to join this BSS. The STA that is creating the BSS shall be able to receive at each of the data rates listed in the set.
OperationalRateSet	set of integers	1 through 127 inclusive (for each integer in the set)	The set of data rates (in units of 500 kbit/s) that the STA desires to use for communication within the BSS. The STA shall be able to receive at each of the data rates listed in the set. The OperationalRateSet is a superset of the BSSBasicRateSet advertised by the BSS.
ExtendedCapabilities	As defined in Frame Format	As defined in Frame Format	The extended operational capability definitions to be used by the QSTA.
QoS parameter set (QoS only)	As defined in Frame Format	As defined in Frame Format	The initial QoS parameter set values to be used in the QBSS.
QAPC-STA enable	Enumeration	“Enabled” and	Whether the QSTA should operate as a

state (QAPC-STA only)		"Disabled"	QAPC-STA (enabled) or not (disabled).
QAPC-STA parameter set element (QAPC-STA only)	As defined in Frame Format	As defined in Frame Format	When the QAPC-STA enable state is set to "enabled", contains the QAPC-STA parameter set element (except for the *Inhibit QAP Mobility* field, which is initially set to 0). Otherwise, the contents of this parameter are undefined and have no effect.

10.3.10.1.3 When Generated

This primitive is generated by the SME to start either an infrastructure BSS (with the MAC entity acting as an AP), or start an Independent BSS (with the MAC entity acting as the first STA in the IBSS).

The MLME-START.request primitive shall be generated after a MLME-RESET.request primitive has been used to reset the MAC entity and before an MLME-JOIN.request primitive has been used to successfully join an existing infrastructure BSS or Independent BSS.

The MLME-START.request primitive shall not be used after successful use of the MLME-START.request primitive or successful use of the MLME-JOIN.request without generating an intervening MLME-RESET.request primitive.

10.3.10.1.4 Effect of Receipt

This primitive initiates the BSS initialization procedure once the current frame exchange sequence is complete. The MLME subsequently issues a MLME-START.confirm that reflects the results of the creation procedure.

Insert after 10.3.10.2.4 the following subclauses:

10.3.10.3 MLME-QAPCS-STATUS.indication

10.3.10.3.1 Function

This primitive is emitted when the QAPC-STA function transitions between active and inactive states as described in 11.4.

10.3.10.3.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-QAPCS-STATUS.indication        (
                                    QAPC-STA active
                                    )
```

Name	Type	Valid Range	Description
QAPCS active	Enumeration	"Active" and "Inactive"	Whether the QAPCS function is the active AP in the BSS or not.

10.3.10.3.3 When generated

This service primitive is generated by the MLME to inform the SME of a change in state of the QAPC-STA function. It will be generated with "Active" each time the QAPC-STA function becomes an active QAPC-STA, and with "Inactive" each time it becomes an inactive QAPC-STA.

An initial indication containing either "Active" or "Inactive" will also be generated after the MLME-START.confirm.

10.3.10.3.4 Effect of Receipt

This is not specified.

The SME may use this indication to modify the state of its association with or connection to a DS.

10.3.11 QoS management action

This mechanism supports the process of adding, modifying, or deleting a traffic stream in a QBSS using the procedures defined in 11.6.

The primitives used for this mechanism are called QoS Management primitives, which include MLME-ADDTS.xxx and MLME-DELTS.xxx primitives, where xxx denotes request, confirm, indication, or response. They each contain the frame body, starting from the Dialog Token field, of the corresponding QoS Management Action frame, i.e., Add TS QoS Action frame or Del TS QoS Action frame, as their parameters.

Table 22.1 - Supported QoS Management Primitives

Primitive	Request	Confirm	Indication	Response
ADDTS	WSTA	WSTA	HC	HC
DELTS	WSTA & HC	WSTA & HC	WSTA & HC	-

10.3.11.1 MLME-ADDTS.request

10.3.11.1.1 Function

This primitive requests addition (or modification) of a traffic stream with a specified peer MAC entity or entities capable of supporting parameterized QoS traffic transfer.

10.3.11.1.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-ADDTS.request    (
                      DialogToken,
                       TrafficSpecification,
                       TrafficClassification
                      )
```

Name	Type	Valid Range	Description

DialogToken	Integer	0-255	Specifies a number unique to the QoS management action primitives and frames used in adding (or modifying) the traffic stream of concern
TrafficSpecification	As defined in frame format	As defined in frame format	Specifies the source address, destination address, TSID, traffic characteristics and QoS requirements of the traffic stream of concern
TrafficClassification	As defined in frame format	As defined in frame format	Specifies the the search order, classifier type, and classifier for classifying incoming MSDUs of the traffic stream of concern

10.

This primitive supports the creation of or modification of a traffic stream. The stream is defined by the parameters in the TSPEC and optional TClas parameters and identified by the TSID and Direction fields within the TSPEC, selected by the WSTA SME.

This primitive results in an ADDTS QoS Action request frame being sent from the WSTA to the HC. The MLME-ADDTS.confirm contains the HC's response.

NOTE: When the WSTA SME is intending to create a new TS, it is recommended that the SME allocate new TSIDs from among those unused in a circular fashion, thus avoiding any recently used TSIDs.10.3.11.1.3 When generated

This primitive is generated by the SME at a WSTA to request the addition of a new (or modification of an existing) traffic stream in order to support parameterized QoS transport of the MSDUs belonging to this traffic stream when a higher-layer protocol or mechanism signals the QSTA to initiate such an addition (or modification).

10.3.11.1.4 Effect of receipt

The WSTA operates the procedures defined in 11.6.

10.3.11.2 MLME-ADDTS.confirm

10.3.11.2.1 Function

This primitive reports the results of a traffic stream addition (or modification) attempt.

10.3.11.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-ADDTS.confirm (
                    ResultCode,
                    DialogToken,
                    TrafficSpecification,
                    TrafficClassification
                    )
```

Name	Type	Valid Range	Description
ResultCode	Enumeration	SUCCESS, INVALID-PARAMETERS, ALTERNATIVE, TIMEOUT	Indicates the results of the corresponding MLME-ADDTS.request
DialogToken	Integer	As defined in the corresponding MLME-ADDTS.request	Specifies a number unique to the QoS management action primitives and frames used in adding (or modifying) the traffic stream of concern
TrafficSpecification	As defined in frame format	As defined in frame format	Specifies the source address, destination address, TSInfo, traffic characteristics and QoS requirements of the traffic stream of concern
TrafficClassification (optional)	As defined in frame format	As defined in the corresponding MLME-ADDTS.request	Specifies the the search order, classifier type, and classifier for classifying incoming MSDUs of the traffic stream of concern

For ResultCode values of SUCCESS and ALTERNATIVE, the TSPEC and optional TClas parameters describe the characteristics of the traffic stream that has been created (or modified). In the case of SUCCESS, these parameters exactly match those of the matching MLME-ADDTS.request.

In the case of ALTERNATIVE, they represent an alternative proposal by the HC. A TS is created with this definition. If the alternative is not acceptable to the WSTA, it is the responsibility of the WSTA to delete the unwanted TS.

For the other ResultCodes, no TS has been created. If this is the result of a modification of an existing TS, the status of that TS is undefined and the TS shall not be used by the WSTA. The WSTA should attempt to delete the TS and recreate it if necessary.

10.3.11.2.3When generated

This primitive is generated by the MLME as a result of an MLME-ADDTS.request to indicating the results of that request.

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

10.3.11.2.4Effect of receipt

The SME is notified of the results of the traffic stream addition (or modification) procedure.

The SME should operate the procedures defined in 11.6.

In the case of and ALTERNATIVE ResultCode, if the alternative is not acceptable to the SME, it is the responsibility of the SME to delete the unwanted TS.

In the case of other failure ResultCode values, if this is the result of a modification of an existing TS, the status of that TS is undefined and the TS shall not be used by the WSTA. The SME should attempt to delete the TS and recreate it if necessary.

10.3.11.3 MLME-ADDTS.indication

10.3.11.3.1 Function

This primitive reports the initiation of adding (or modifying) a traffic stream to the HC SME.

10.3.11.3.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-ADDTS.indication    (
                         DialogToken,
                         WSTA Address
                         TrafficSpecification,
                         TrafficClassification
                         )
```

Name	Type	Valid Range	Description
DialogToken	Integer	As defined in the received Add TS QoS Action frame	Specifies a number unique to the QoS management action primitives and frames used in adding (or modifying) the traffic stream of concern
WSTA Address	MAC Address		Contains the MAC address of the WSTA that initiated the MLME-ADDTS.request
TrafficSpecification	As defined in frame format	As defined in the received Add TS QoS Action frame	Specifies the source address, destination address, TSID, traffic characteristics and QoS requirements of the traffic stream of concern
TrafficClassification (optional)	As defined in frame format	As defined in the received Add TS QoS Action frame	Specifies the the search order, classifier type, and classifier for classifying incoming MSDUs of the traffic stream of concern

The TrafficSpecification and optional TrafficClassification define the QoS parameters of the requested TS. The TS is identified in the HC by a combination of the TSID and Direction fields within the TSPEC.

The TrafficClassification is optional at the discretion of the WSTA that originated the request. An HC shall be capable of receiving an ADDTS QoS Action frame that contains a TrafficClassification element and generating an indication that contains this parameter.

10.3.11.3.3 When generated

This primitive is generated by the MLME as a result of receipt of an initiation to add (or modify) a traffic stream by a specified peer MAC entity in the form of an Add TS QoS Action frame.

10.3.11.3.4 Effect of receipt

The SME is notified of the initiation of a traffic stream addition (or modification) by a specified peer MAC entity.

This primitive solicits a MLME-ADDTS.response from the SME that reflects the and admission control at the HC on the traffic stream requested to be added (or modified).

The SME should operate the procedures defined in 11.6.

The SME shall generate an MLME-ADDTS.response within a dot11ADDTSResponseTimeout.

10.3.11.4 MLME-ADDTS.response

10.3.11.4.1 Function

This primitive responds to the initiation of a traffic stream addition (or modification) by a specified WSTA MAC entity.

10.3.11.4.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-ADDTS.response (
                        ResultCode,
                        DialogToken,
                        WSTAAddress
                        TrafficSpecification,
                        TrafficClassification
                        )
```

Name	Type	Valid Range	Description
ResultCode	Enumeration	SUCCESS, INVALID-PARAMETERS, ALTERNATE, TIMEOUT	Indicates the results of the corresponding MLME-ADDTS.indication
DialogToken	Integer	As defined in the corresponding MLME-ADDTS.indication	DialogToken of the matching MLME-ADDTS.indication
WSTA Address	MAC Address		WSTA Address of the matching MLME-ADDTS.indication
TrafficSpecification	As defined in frame	As defined in frame	Specifies QoS parameters of the TS.

	format	format	
TrafficClassification	As defined in frame format	As defined in the corresponding MLME-ADDTS.indication	Specifies the the search order, classifier type, and classifier for classifying incoming MSDUs of the traffic stream of concern

The DialogToken and WSTA Address parameters shall be as in the matching MLME-ADDTS.indication.

If the ResultCode is SUCCESS, the TrafficSpecification and (optional) TrafficClassifiation parameters shall be as in the matching MLME-ADDTS-indication.

If the ResultCode is ALTERNATIVE, the TrafficSpecification and TrafficClassification parameters represent an alternative proposed TS. The TSID and Direction within the TSPEC shall be as in the matching indication. The difference may lie in the and QoS (e.g., minimum data rate, mean data rate, delay bound, and jitter bound) values, as a result of admission control performed at the SME of the HC on the traffic stream requested to be added (or modified) by the WSTA. If no adequate bandwidth is available, the QoS values may be reduced—in one extreme, the minimum data rate, mean data rate, delay bound, and jitter bound may be all set to zero, indicating no QoS is to be provided to this traffic stream.

10.3.11.4.3When generated

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

10.3.11.4.4Effect of receipt

This primitive approves addition (or modification) of a traffic stream requested by a specified WSTA MAC entity, with or without altering the traffic specification.

This primitive causes the MAC entity at the HC to send an ADDTS QoS Action Response frame to the requesting WSTA containing the specified parameters.

10.3.11.5 MLME-DELTS.request

10.3.11.5.1Function

This primitive requests deletion of a traffic stream with a specified peer MAC.

10.3.11.5.2Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DELTS.request        (
                          DialogToken,
                          WSTAAddress
                          TrafficSpecification
                          )
```

Name	Type	Valid Range	Description

DialogToken	Integer	0-255	Specifies a number unique to the QoS management action primitives and frames used in deleting the traffic stream of concern
WSTA Address (HC only)	MAC Address		(At the HC only) Specifies the MAC address of the WSTA that initiated this TS.
TrafficSpecification	As defined in frame format	As defined in frame format	The TSID and Duration fields within the traffic specification specify the TS to be deleted. All other fields are undefined.

This primitive may be generated at the WSTA or HC specifying a f the traffic stream to be deleted, as determined by the higher-layer signaling policy.

10.3.11.5.3 When generated

This primitive is generated by the SME at a QSTA to initiate deletion of a traffic stream TAs when a higher-layer protocol or mechanism signals the QSTA to initiate such a deletion.

10.3.11.5.4 Effect of receipt

This primitive initiates a traffic stream deletion procedure. The MLME subsequently issues a MLME-DELTS.confirm that reflects the results.

This primitive causes the local MAC entity to send out a DELTS QoS Action frame containing the specified parameters. If this primitive was generated at the HC, the frame is sent to the specified WSTA MAC addres. If this primitive was generated at the WSTA, the frame is sent to its HC. In either case, sent the DELTS QoS Action frame does not solicit a response from the receipient frame other than an acknowledgment to receipt of the frame (if applicable).

10.3.11.6 MLME-DELTS.confirm

10.3.11.6.1 Function

This primitive reports the results of a traffic stream deletion attempt with a specified peer MAC entity or entities.

10.3.11.6.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DELTS.confirm      (
                        ResultCode,
                        DialogToken,
                        WSTAAddress,
                        TrafficSpecification
                        )
```

Name	Type	Valid Range	Description
ResultCode	Enumeration	SUCCESS, INVALID-PARAMETERS, FAILURE	Indicates the results of the corresponding MLME-DELTS.request
DialogToken	Integer	As defined in the corresponding MLME-DELTS.request	Contains the DialogToken of the matching request
WSTA Address (HC only)	MAC address		(HC only) contains the WSTA MAC address of the matching request.
TrafficSpecification	As defined in frame format	As defined in the corresponding MLME-DELTS.request	Contains the traffic specification of the matching request

10.3.11.6.3When generated

This primitive is generated by the MLME as a result of an MLME-DELTS.request after the DELTS QoS Action frame has been sent (or attempts to send it have failed) and any internal state regarding the use of the TS has been destroye.

10.3.11.6.4Effect of receipt

The SME is notified of the results of the traffic stream deletion procedure.

10.3.11.7 MLME-DELTS.indication

10.3.11.7.1Function

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

10.3.11.7.2Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DELTS.indication(
                      DialogToken,
                      WSTAAddress
                      TrafficSpecification
                      )
```

Name	Type	Valid Range	Description
DialogToken	Integer	As defined in the received Add TS QoS Action frame	Specifies a number unique to the QoS management action primitives and frames used deleting the traffic stream of concern

Reason	Enumeration	Requested and Timeout values	Indicates the reason why the traffic stream is being deleted.
WSTA Address (HC only)	MAC address		(HC only) The MAC address of the WSTA for which the TSPEC is being deleted.
TrafficSpecification	As defined in frame format	As defined in the received Del TS QoS Action frame	Specifies the source address, destination address, TSInfo, traffic characteristics and QoS requirements of the traffic stream of concern

10.3.11.7.3When generated

This primitive is generated by the MLME as a result of receipt of an initiation to delete a traffic stream by a specified peer MAC entity.

This primitive may also be generated by the MLME at the HC as a result of inactivity of a particular traffic stream. Inactivity results when a period equal to the Inactivity Interval in the Traffic Specification for the traffic stream elapses without arrival of an MSDU belonging to that traffic stream at the MAC entity of the HC via an MA-UNITDATA.request primitive in the case where the HC is the source station of that traffic stream, or without reception of an MSDU belonging to that traffic stream by the MAC entity of the HC in the case where a WSTA is the source station of that traffic stream.

This primitive is generated after any other state concerning the TSID/Direction within the MAC has been destroyed.

10.3.11.7.4Effect of receipt

The SME is notified of the initiation of a traffic stream deletion by a specified peer MAC entity.

10.3.11.9 MLME-SET-INHIBIT-QAP-MOBILITY.request

10.3.11.9.1 Function

This function allows the SME to control the setting of the "Inhibit QAP Mobility" field in the QAPC-STA parameter set element transmitted by a QAPC-STA when it is operating as an active QAPC-STA.

10.3.11.9.2 Semantics of the Service Primitive

The primitive parameters are as follows:

```
MLME-SET-INHIBIT-QAP-MOBILITY.request    (
                                         Inhibit QAP Mobility
                                         )
```

Name	Type	Valid Range	Description
Inhibit QAP Mobility	integer	0-1	Contains the value for the Inhibit QAP Mobility field of the QAPC-STA parameter set element to be transmitted in any subsequent QAPC-STA parameter set

			element transmitted by the QAPC-STA.

10.3.11.9.3 When generated

This service primitive is generated by the SME when it needs to specify a value for the “Inhibit QAP Mobility” field. See 11.4.1.3.

10.3.11.9.4 Effect of Receipt

This primitive specifies the value to be transmitted in the “Inhibit QAP Mobility” field of any subsequent QAPC-STA parameter set element transmitted by the QAPC-STA.

10.3.12.1 MLME-WMSTATUS.request

10.3.12.1.1 Function

This primitive requests information on the state of the wireless medium.

10.3.12.1.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-WMSTATUS.request      ( )
```

10.3.12.1.3 When generated

This primitive is generated by the SME at a QSTA when a higher-layer QoS management entity wishes to obtain information on the state of the wireless medium.

10.3.12.1.4 Effect of receipt

This primitive causes generation of a MLME-WMSTATUS.confirm that reports on the state of the wireless medium.

10.3.12.2 MLME-WMSTATUS.confirm

10.3.12.2.1 Function

This primitive reports the results of the preceding MLME-WMSTATUS.request.

10.3.12.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-WMSTATUS.confirm      (
                             ResultCode,
                             << additional parameter values >>
                             )
```

Name	Type	Valid Range	Description
ResultCode	enumeration	SUCCESS, NOT_AVAILABLE	Indicates the result of the MLME-WMSTATUS.request.

10.3.12.2.3 When generated

This primitive is generated by the MLME as a result of an MLME-WMSTATUS.request to report on the state of the wireless medium.

10.3.12.2.4 Effect of receipt

The SME is notified of the state of the wireless medium.

10.3.13 Direct WSTA-WSTA Communication

This mechanism supports the determination of direct WSTA to WSTA.

The primitives used for this mechanism are called Direct WSTA-WSTA communication primitives, which include MLME-CONNECTIVITY.request and MLME-CONNECTIVITY.response.

10.3.13.1 MLME-CONNECTIVITY.request

10.3.13.1.1 Function

This primitive requests that the MAC entity determine the connectivity with another WSTA.

10.3.13.1.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-CONNECTIVITY.request        (
                                 WSTA MAC Address
                                 )
```

Name	Type	Valid range	Description
WSTA MAC Address	MAC Address	N/A	The MAC address of the WSTA for which the connectivity results are generated.

10.3.13.1.3 When generated

This primitive is generated by the SME at a WSTA to determine the connectivity to another WSTA in order for the initiating WSTA determine how the data frames generated will be handled by the MAC.

10.3.13.1.4 Effect of receipt

This primitive initiates a connectivity determination procedure at the MAC. The MAC will examine its own cache and if there is an entry corresponding to the target WSTA MAC address. If there is no entry, it shall use the WARP to determine the connectivity status and update its own cache.

10.3.13.2 MLME-CONNECTIVITY.response

10.3.13.2.1 Function

This primitive returns the connectivity with a WSTA for which a MLME-CONNECTIVITY.request has been made by the SME.

10.3.13.2.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-CONNECTIVITY.response    (
                              WSTA MAC Address
                              Connection Type
                              Capability Information
                              PHY Rates
                              )
```

Name	Type	Valid range	Description
WSTA MAC Address	MAC Address	N/A	The MAC address of the WSTA for which the connectivity results are generated.
Connection Type	Enumeration	DIRECT, DISTRIBUTION	Indicates the result of the MLME-CONNECTIVITY.response
Capability Information	As defined in frame format	As defined in frame format	This field is used only when the Connection Type is "DIRECT" and shall have a NULL otherwise. The advertised capabilities of the WSTA with the WSTA MAC address.
PHY Rates	Set of Integers	2-127 inclusive (for each integer in the set	This field is used only when the Connection Type is "DIRECT" and shall have a NULL otherwise. The set of data rates (in units of 500 kb/s) that can be used for a direct transfer of data to the WSTA with the WSTA MAC address.

10.3.13.1.3 When generated

This primitive is generated by the MLME as a result of an MLME-CONNECTIVITY.request to ascertain the connectivity with a specific WSTA.

10.3.13.1.4 Effect of receipt

The SME is notified of the results of the connectivity determination procedure.

10.3.15.3 MLME-HL-SYNC.indication

10.3.15.3.1 Function

This primitive indicates the last symbol on air of a higher layer synchronization frame, whether transmitted or received by the MAC.

10.3.15.3.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-HL-SYNC.indication (
SourceAddress
SequenceNumber
)

Name	Type	Valid Range	Description
SourceAddress	MACAddress	Any valid individual MAC address	Specifies the Source Address of the STA that transmitted the higher layer synchronization frame.
SequenceNumber	Integer	As defined in the frame format	Specifies the sequence number of the higher layer synchronization frame received or transmitted.

10.3.15.3.3 When generated

This primitive is generated by the MLME when the successful reception or transmission of a higher layer synchronization frame is detected, as indicated by the PHY_RXEND.indication or PHY_TXEND.confirm primitives generated by the PHY layer. The higher layer synchronization frame is identified by the multicast MAC address registered by an earlier MLME-HL-SYNC.request primitive, in Address 1 field of a data type frame.

10.3.15.3.4 Effect of Receipt

The SME is notified of the reception or transmission of a higher layer synchronization frame.

Insert the following sections after section 11.3.4 and renumber 11.4 to 11.5:

11.4 Description of QAPC-STA behavior

11.4.1 and 11.4.2 define rules followed by a QSTA that supports the QAPC-STA behavior following an MLME-START.request with the QAPC-STA enable state parameter set to “enabled”. Otherwise, the QSTA shall not support the behavior defined in these subclauses. It shall not transmit any QAPC-STA parameter set elements.

11.4.3 defines rules that may be followed by all QSTAs in support of QAPC-STA behavior regardless of whether they are QAPC-STA or not.

On receipt of a legal MLME-START.request primitive, the QAPC-STA function shall perform a scan for matching SSID. The operation then proceeds according to the result of the scan as shown in table 23.1.

Condition	Action
No matching SSID found	Start operating as an active QAPC-STA. Emit an MLME-START.confirm containing *success* status and emit an MLME-QAPCS-STATUS.indication containing *active* status.

Matching SSID found with lower rank	Perform the active takeover procedure in section 11.4.2.1. If this succeeds, start operating as an active QAPC-STA, emit an MLME-START.confirm containing *success* status and emit an MLME-QAPCS-STATUS.indication containing *active* status. Otherwise start operating as an inactive QAPC-STA, emit an MLME-START.confirm containing *success* status and emit an MLME-QAPCS-STATUS.indication containing *inactive* status.
Matching SSID found with higher rank	Start operating as an inactive QAPC-STA. Emit an MLME-START.confirm containing *success* status and emit an MLME-QAPCS-STATUS.indication containing *inactive* status.

Table 23.1 - QAPC-STA Initialization actions

11.4.1 Behavior supported by the active QAPC-STA

An active QAPC-STA shall broadcast a QAPC-STA parameter set element in every beacon.

An active QAPC-STA that receives a beacon containing a lower ranked (as defined in 11.4.4) QAPC-STA parameter set shall send a QAPC-STA assertion action request to that QAPC-STA. This should cause the lower ranked QAPC-STA to stop operation as a QAP and to start operation as an WSTA.

An active QAPC-STA that knows it is going to stop operating for any local reason (for example, before powering-down) should, if it has time, disassociate its associated stations. During this process, the QAPC-STA shall send no further beacons and shall not respond to probe requests with a broadcast RA.

NOTE: this explicit disassociation can reduce the delay before these stations start to look for an alternative AP. Successful operation of this protocol does not depend on this disassociation.

An active QAPC-STA that is not signalling *Inhibit QAP mobility* set to 1 shall periodically scan all channels for APs with higher QAPC-STA priority using the procedure defined in 11.4.1.2. An active QAPC-STA that receives a beacon from a (Q)AP with higher QAPC-STA rank shall:

- send no further beacons
- not respond to probe requests with a broadcast RA
- disassociate all its stations using reason code "Active QAPC-STA about to become inactive"
- stop operating as an active QAPC-STA.

NOTE: scanning for APs ensures that a non-QAPC-STA AP that stops operation and then re-starts can regain control of the STAs associated with the SSID.

An active QAPC-STA that receives a QAPC-STA assertion action request shall respond with a QAPC-STA assertion action response. If the request is from a higher ranked QAPC-STA, the QAPC-STA can deassociate its stations, shall send a response with "success" status and shall become an inactive QAPC-STA. If the request is from a lower ranked QAPC-STA, the QAPC-STA shall send a response containing a "refused" status and continue operation as the active QAPC-STA.

11.4.1.1 Scanning by the active QAPC-STA

The active QAPC-STA passively scans for a duration that equals dot11APMobilityScanRate percent of a beacon interval every dot11APMobilityScanInterval beacon intervals. It shall listen on a single channel per scan.

If the QAPC-STA has set the Spectrum Management subfield [Reference 802.11h when it is released here] of the Capability Information Field in its beacons and probe responses, then it may make use of the Channel Measurement Request facility as an alternative to performing the scan itself.

NOTE: 802.11h may need to be modified to return additional parameters in the BSS report, including the SSID and QAPC-STA parameter set.

11.4.1.2 Inhibit QAP Mobility field setting

An active QAPC-STA may indicate its unwillingness to become inactive using the *Inhibit QAP Mobility* field of the QAPC-STA parameter set.

NOTE: this means that an active QAPC-STA can prevent a new QAPC-STA coming online from attempting an active takeover procedure while the active QAPC-STA is aware of current activity (e.g. a current TSPEC).

An active QAPC-STA that has no STAs associated with it shall not set the *Inhibit QAP Mobility* field.

An active QAPC-STA should consider setting the *Inhibit QAP Mobility* field if it has active TSPECs.

11.4.2 Behavior supported by the inactive QAPC-STA

An inactive QAPC-STA shall not broadcast beacons.

An inactive QAPC-STA that receives a beacon with a matching SSID shall evaluate the relative rank of the active QAPC-STA and itself using 11.4.4. If the inactive QAPC-STA has higher rank, it shall perform the active takeover procedure defined in 11.4.2.1.

An inactive QAPC-STA shall determine that the active AP for the BSS has failed if it receives no valid beacon frames from it in a period equal to the product of dot11MissedBeaconThreshold and the Beacon Interval from the last valid beacon frame. If the inactive QAPC-STA has never received a valid beacon frame (for example after initialisation) it shall use the value of the beacon period from MLME-START.request primitive instead. An inactive QAPC-STA that determines failure of itsthe active AP shall perform the passive takeover procedure defined in 11.4.2.2.

An inactive QAPC-STA that becomes active shall operate using its own BSSID and an unchanged SSID. It shall use the BSS configuration parameters specified to it in the MLME-START.request primitive, and may, for example, start operation on the same or a different channel.

An inactive QAPC-STA that is deauthenticated and/or disassociated by the active AP shall remain an inactive QAPC-STA.

An inactive QAPC-STA that receives a QAPC-STA assertion request shall send a QAPC-STA assertion response with status *refused*.

11.4.2.1 Active Takeover

This section defines procedures performed by an inactive QAPC-STA to request an active QAPC-STA to become inactive.

The inactive QAPC-STA sends a QAPC-STA assertion action request MMPDU to the active QAPC-STA. If the transmission fails (after re-transmission attempts), the inactive QAPC-STA shall become an active QAPC-STA.

Otherwise, the inactive QAPC-STA waits for a QAPC-STA assertion action response.

If no response is received within 2 beacon intervals, the inactive QAPC-STA shall become an active QAPC-STA. If the response status is *success*, the inactive QAPC-STA shall become an active QAPC-STA. If the response status is *refused*, the inactive QAPC-STA shall remain an inactive QAPC-STA.

11.4.2.2 Passive Takeover

This procedure is performed by an inactive QAPC-STA that detects loss of its AP.

The QAPC-STA shall delay for a period of time based on its own score (see 11.4.4) given by:

delay = (max-score – score) * dot11SlotTime

NOTE: the purpose of this delay is to make it likely that the highest ranking QAPC-STA is detected by any lower ranking QAPC-STAs before they have a chance to start operating as active QAPC-STAs.

The QAPC-STA shall set its TSF timer so that the end of this delay coincides with a TBTT of its own BSS.

If this delay expires without receiving a beacon from a QAPC-STA with higher rank, the QAPC-STA shall then transmit its first beacon using this TBTT and shall become an active QAPC-STA.

Otherwise, on receiving a beacon from a QAPC-STA with higher rank, the QAPC-STA ends the delay and remains an inactive QAPC-STA.

11.4.3 Behavior at the QSTA (Informative)

This section describes procedures that a QSTA may carry out to minimise the disruption caused to it by changes of the active QAPC-STA. It is informative, as the procedures are not required for the QAPC-STA function to work.

When a passive or an active takeover occurs, A STA in the BSS may or may not receive a disassociation from its AP depending on the reason for the takeover.

The STA will see that its (Q)AP stops transmitting beacons. The STA may search for an AP with the same SSID. Assuming that there is at least one QAPC-STA present, the STA will discover a new active (Q)AP, not necessarily on the same channel as the old one.

A QSTA that needs to select between multiple AP or QAPC-STA devices may do so on the basis of highest QAPC-STA rank.

11.4.4 QAPC-STA ranking

This section defines how to compare the ranking of two QAPC-STAs or a QAPC-STA and a non-QAPC-STA (Q)AP sharing the same SSID.

A non-QAPC-STA (Q)AP (identified by having no QAPC-STA parameters element in the beacon) is considered to be the highest rank of all.

NOTE: This means that a QAPC-STA will always remain inactive while a non-QAPC-STA (Q)AP is operational. This section does not address how to select between multiple non-QAPC-STA (Q)APs.

When an inactive QAPC-STA device is ranking itself against an active QAPC-STA, it shall set its own *Inhibit QAP Mobility* field to 0.

The ranking score is determined by interpreting the QAPC-STA Control Field as a 16 bit unsigned integer. The higher score indicates the higher rank.

NOTE: the reserved fields of received QAPC-STA Control Fields are not zeroed before this comparison.

Ties between two equal scores are resolved in favor of the QAPC-STA with the numerically higher MAC address (treating the MAC address as a 48-bit unsigned integer with the I/G bit in the least significant position).

For the purposes of 11.4.3.2, the maximum score "max-score" is defined to be:

max-score = 2**16 – 1 = 65535

11.6 Traffic Stream Operation

Introduction (Informative)

A TSPEC describes the QoS characteristics of a traffic stream. The main purpose of the TSPEC is to reserve resources within the HC and modify the HCs scheduling behavior. It also allows other parameters to be specified that are associated with the traffic stream, such as ACK policy and use of FEC.

A TSPEC is transported on the air by the ADDTS and DELTS QoS Action frames and across the MLME SAP by the MLME-ADDTS and MLME-DELTS primitives.

Following a successful negotiation, a traffic stream is created, identified within the WSTA by its TSID and Direction, and identified within the HC by a combination of TSID, Direction and WSTA address.

It is always the responsibility of the WSTA to initiate the creation of a TS for the uplink and downlink cases.

In the sidelink case, it is the responsibility of the WSTA that is going to send the DATA to create the TS. In this case, the WSTA negotiates with the HC to gain TXOPs that it will use to send the DATA. There is no negotiation between the originator and recipient WSTAs concerning the TS – the originator can discover the capabilities of the recipient (rates, FEC, BurstAck) using the WARP protocol in section ??. It does not negotiate the use of these on a per-TS basis with the intended recipient.

11.6.1 TS Lifecycle

Figure 11.6.1 summarises the TS lifecycle. (Using the HMSC syntax defined in ITU Z.120).

Initially a TS is inactive. No MPDUs may be transmitted by a QSTA using the TSID/Direction of an inactive TS.

Following a successful TS Setup initiated by the WSTA, the TS becomes active, and either the WSTA or HC may transmit MPDUs using this TSID (according to the Direction field).

While the TS is active, the parameters of the TSPEC characterising the TS can be re-negotiated, initiated by the WSTA. This negotiation can succeed – resulting in a change to the TSPEC, or can fail, resulting in no change to the TSPEC.

An active TS becomes inactive following a TS deletion process initiated at either WSTA or HC. It also becomes inactive following a TS timeout detected at the HC.

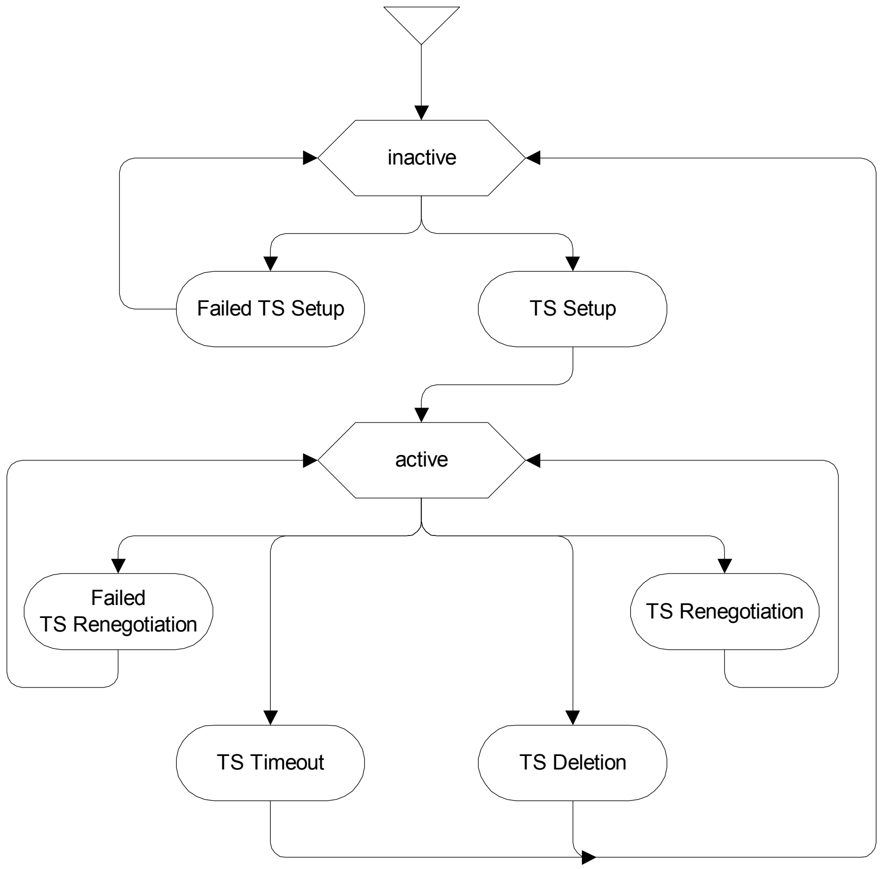


Figure 41.6.1 – TS Lifecycle

11.6.2 TS Setup

Figure 11.6.2 shows the sequence of messages occuring at a TS setup.

The WSTA SME decides that a TS needs to be created. How it does this, and how it selects the TSPEC parameters are beyond the scope of this specification. It generates an MLME-ADDTS.request containing a TSPEC.

The WSTA MAC transmits the TSPEC in an ADDTS QoS action request to the HC and starts a response timer called ADDTS timer of duration dot11ADDTSResponseTimout.

The HC MAC receives this MPDU and generates an MLME-ADDTS.indication primitive to its SME containing the TSPEC.

The SME in the HC decides whether to admit the TSPEC as specified, admit the TSPEC with a counter proposal or refuse the TSPEC and generates an MLME-ADDTS.response primitive containing the TSPEC and a status value. The contents of the TSPEC and status field contain values specified in table 11.6.1.

TABLE 11.6.1 – TSPEC and Status field contents in the MLME-ADDTS.response.

Condition	TSPEC Contents	Status
HC SME grants requested TXOP	Exactly as the requested TXOP	Success

HC SME grants an altered TXOP	TSID and Direction field the same as the requested TXOP. Other fields can be modified	ALTERNATIVE
HC SME refuses TXOP	Exactly as the requested TXOP	REFUSED

The HC MAC transmits an ADDTS QoS action response containing this TSPEC and status.

The WSTA MAC receives this MPDU and cancels its ADDTS timer. It generates an MLME-ADDTS.confirm to its SME containing the TSPEC and status.

The WSTA SME decides whether the response meets its needs or not. How it does this is beyond the scope of this specification. In the “OK” and “ALTERNATIVE_GRANT” Status cases, the TS is in the active state. If an alternative grant is acceptable, the setup procedure ends here. Otherwise, the whole process can be repeated using the same TSID and Direction and a modified TSPEC until the WSTA SME decides that the granted TXOP is adequate or inadequate and cannot be improved. If the WSTA SME decides to terminate and that an ALTERNATIVE is inadequate, it is the responsibility of the WSTA SME to destroy the TS using the TS Deletion procedure.

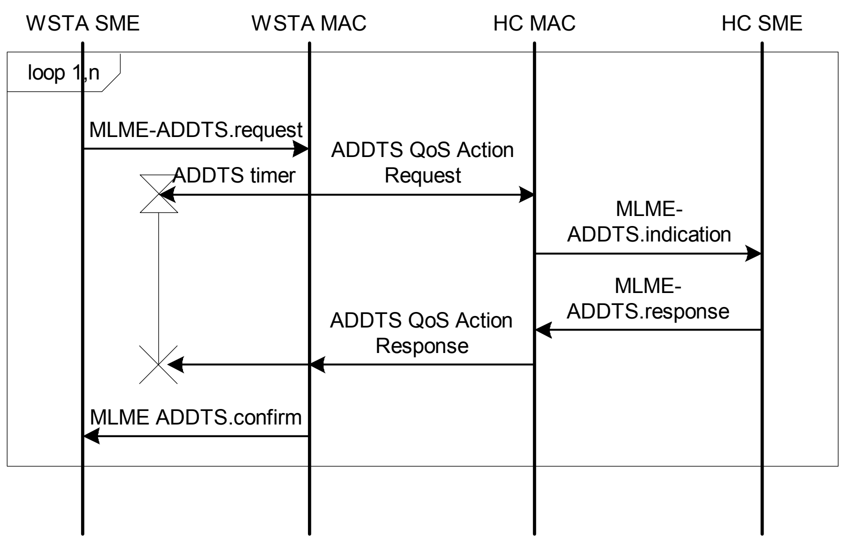


Figure 41.6.2 – TS Setup

11.6.3 Failed TS Setup

There are three possible types of Failed TS setup:

1. An alternative grant is not acceptable to the WSTA SME
2. The ADDTS MPDU transmission failed
3. No ADDTS MPDU response is received from the HC (for example because of delay due to congestion, or because the response frame cannot be transmitted)

The first case is indistinguishable from success within the MAC, and is not considered further here.

Cases 2 and 3 are considered to be the same as the WSTA cannot be sure that its transmission failed. Figure 11.6.3 summarises this case. The WSTA MAC shall send a DELTS QoS Action request to the HC specifying the TSID and Direction of the failed request just in case the HC had received the request and it was the response that was lost.

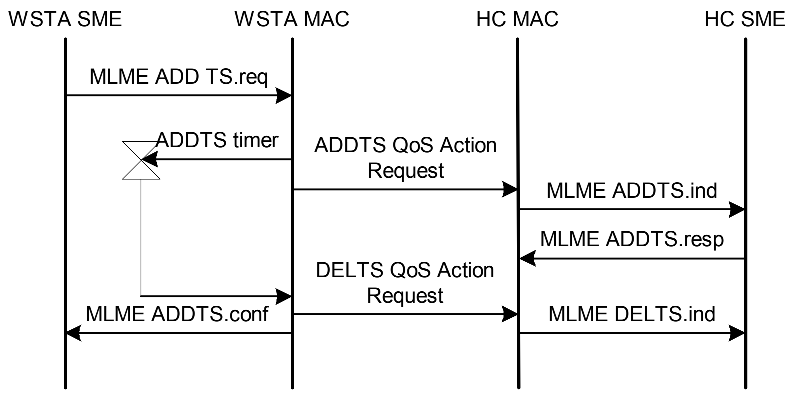


Figure 41.6.3 – Failed TS Setup detected within WSTA MAC

11.6.4 TS Deletion

There are two types of TS deletion: WSTA-initiated and HC-initiated. In both cases, the SME entity above the MAC generates an MLME-DELTS.request specifying the TSID and Direction of the TS to be deleted. This causes the MAC to send a DELTS management action frame.

The TS is considered inactive within the initiating MAC when the ACK MPDU to the manangement action frame is received. No management action frame response is generated.

Figure 11.6.4 shows the case of TS deletion initiated by the WSTA. The case of HC-initiated TS deletion is the same with the WSTA and HC labels swapped over.

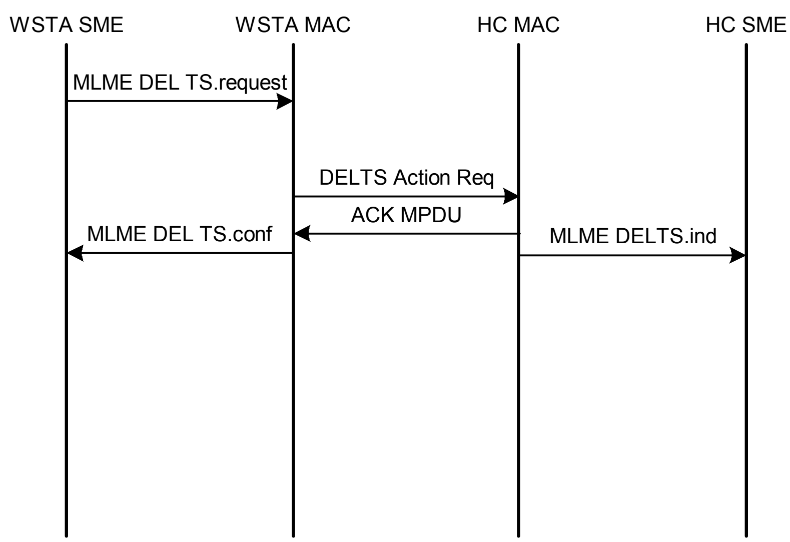


Figure 11.6.4 TS Deletion (WSTA-initiated)

11.6.5 TSTimeout

TS timeout is detected within the HC MAC when no traffic is detected on the TS within the inactivity timeout specified when the TS was created.

For an uplink TS, the timeout is based on the arrival of correctly received MSDUs within the MAC after any decryption and reassembly.

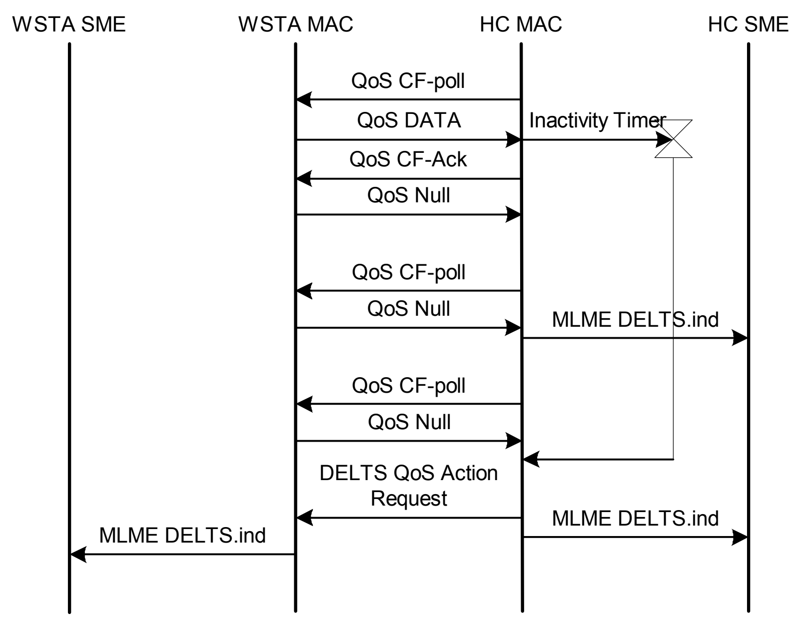
For a downlink TS, the timeout is based on the arrival of valid MAC-UNITDATA.request primitives using this TS at the MAC service interface.

For a sidelink TS, returning an immediate QoS NULL response that contains a zero queue size field in the QoS control field to a QoS CF-Poll or no QoS NULL termination of a TXOP are both considered to be inactivity. Any other use of a polled TXOP delivered to the WSTA is considered to be activity on all sidelink TS associated with that WSTA. Detection of inactivity of this type is optional.

In response to an inactivity timeout, the HC shall send a DELTS QoS Action request to the WSTA, and inform its SME using the MLME-DELTS.indication.

The case of uplink TS timeout is shown in figure 11.6.5.

FIGURE 11.6.5 – TS Timeout



Annex D

Editor's remark: The lists that appear below are the result of an initial attempt to list new MIB attributes which are needed for the QoS facility. These lists are provided as a resource to assist in the generation of the QoS MIB definition, not as an attempt to specify the QoS MIB. The QoS-related attributes are presented in three lists: The first list contains attributes that are mentioned by name in the text in this draft. The second list contains attributes whose names are not mentioned, but whose existence is implied by specific provisions in this draft. The third list contains attributes that are neither named nor implied in draft, but which the editor believes are likely to be necessary or useful. There is also a fourth section which identifies existing MIB attributes which need to be modified for use with QoS.

QoS MIB attributes mentioned by name in this draft

dot11CWmin[0..7] Integer (0..1023) read-write

dot11CWmax[0..7] Integer (0..65535) read-write

dot11AIFS[0..7] Integer (2..10) read-write

dot11PriorityMap[0..7] Integer (0..7) read-write

dot11CAPLimit Integer read-write

dot11EDCFCFBLimit[0..7] Integer (0..10000) read-write

Default values for some of the above MIBs

UP	**dot11AIFS[UP]**	**dot11CWmin[UP]**	**dot11CWmax[UP]**	**dot11EDCFCFBLimit[UP] Units: ms**
0 (best effort)	2	*aCWmin*	*aCWmax*	*0*
1 (excellent effort)	1	*aCWmin*	*aCWmax*	*1.5*
2 (interactive tcp)	1	*aCWmin*	*2*aCWmin+1*	*0*
3				
4 (video/interactive)	1	*floor (aCWmin/2)*	*aCWmin*	*3*
5 (voice)	1	*floor(aCWmin/4)*	*floor(aCWmin/2)*	*1.5*
6				
7				

Note – *aCWmin* and *aCWmax* are the values appropriate to the underlying PHY.
Note – there are no default values specified for UP 3,6,7
There is no dot11MSDULifetime specified for any UP.

dot11HCCWmin Integer read-write

dot11HCCWmax Integer read-write

dot11HCAIFS Integer read-write

dot11PeerLivenessTimeout Integer read-only

dot11MissedBeaconThreshold OBJECT-TYPE
SYNTAX INTEGER (0..255)
MAX-ACCESS read-write

STATUS current
DESCRIPTION
"This attribute shall indicate the number of successive missed beacons received by a QAPC-STA in order to detect that it must perform a passive QAP takeover procedure defined in 11.4.2.2. The default value of this attribute shall be 11."
::= (dot11MissedBeaconThreshold ***xxx***)

dot11APMobilityScanRate OBJECT-TYPE
SYNTAX INTEGER (0..100)
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This attribute shall indicate the percentage of a beacon interval that an active QAPC-STA spends scanning for beacons in a beacon interval in which a scan is required. The default value of this attribute shall be 10%."
::= (dot11APMobilityScanRate ***xxx***)

dot11APMobilityScanInterval OBJECT-TYPE
SYNTAX INTEGER (0..255)
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This attribute shall indicate the number of beacon intervals that shall elapse between scans for beacons by an active QAPC-STA. The default value of this attribute shall be 10."
::= (dot11APMobilityScanInterval ***xxx***)

QoS MIB attributes implied by text in this draft:

Editor's remark: Attribute names are suggestions by the editor.

dot11QosOptionImplemented	TruthValue	read-only
dot11AssociateAsQSTA (WSTA only)	TruthValue	read-write
dot11EDCFTXOPLimit	Integer	read-write
dot11QueuesAvailable	Integer (4..8)	read-only
dot11FECOptionImplemented	TruthValue	read-only
dot11FECFragmentsCorrectedCount	Counter32	read-only
dot11FECUncorrectableCount	Counter32	read-only
dot11QosDiscardedFragmentCount	Counter32	read-only
dot11QoSMPDUsReceivedCountTID[0..15]	Counter32	read-only
dot11QoSRetriesReceivedCountTID[0..15]	Counter32	read-only
dot11AssociatedStationCount (QAP only)	Integer	read-only
dot11ChannelUtilization (QAP only)	Integer	read-only

dot11FrameLossRate (QAP only)	Integer	read-only
dot11ADDTSResponseTimeout (QAP only)	Integer	read-write

Other QoS MIB attributes that editor believes might be useful

Editor's remark: Attribute names are suggestions by the editor.

dot11QueueSizeTC[0..7]	Integer (0..511)	read-only
dot11QueuePeakSizeTC[0..7]	Counter32	read-only
dot11QosDiscardedFrameCountTC[0..7]	Counter32	read-only
dot11QosCFPollsReceivedCount	Counter32	read-only
dot11QosCFPollsUnusedCount	Counter32	read-only
dot11QosCFPollsUnusableCount	Counter32	read-only
dot11QosTXOPRequestCount	Counter32	read-only
dot11QosTXOPRequestRetryCount	Counter32	read-only
dot11QosCCOPCount	Counter32	read-only
dot11QosCCOPUsedCount	Counter32	read-only
dot11QosCCOPCollisionCount	Counter32	read-only

Editor's remark: The next 10 entries are per-TC instances of the relevant subset of dot11Counters.

dot11QosTransmittedFragmentCountTC[0..7]	Counter32	read-only
dot11QosFailedCountTC[0..7]	Counter32	read-only
dot11QosRetryCountTC[0..7]	Counter32	read-only
dot11QosMutipleRetryCountTC[0..7]	Counter32	read-only
dot11QosFrameDuplicateCountTC[0..7]	Counter32	read-only
dot11QosRTSSuccessCountTC[0..7]	Counter32	read-only
dot11QosRTSFailureCountTC[0..7]	Counter32	read-only
dot11QosACKFailureCountTC[0..7]	Counter32	read-only
dot11QosReceivedFragmentCountTC[0..7]	Counter32	read-only
dot11QosTransmittedFrameCountTC[0..7]	Counter32	read-only

Existing MIB attributes that editor believes require modification

dot11DesiredBSSType	need to add an enumeration value: "QBSS (4)"

Annex H An Example of Encoding a Frame for FEC

H.1 Introduction

The purpose of this annex is to show an example encoding of a frame with the QoS FEC option, as described in Clause 7 of IEEE Standard 802.11e. The example frame is a QoS Data frame with no Address 4 field prior to encoding, and with a 206 byte MAC payload. After encoding, the last RS block consists of the last two bytes of FEC FCS plus 16 RS parity bytes.

H.2 Example Frame Prior to FEC Encoding

The example frame prior to FEC Encoding is shown in Table H.1. The example frame is show prior to padding of Address Field 4 and prior to cacluation and appending of FEC FCS. The bit ordering of bits within bytes is consistent with the way the MAC might buffer frame bytes prior to transmission; that is, least significant bit in each byte is shown to the right.

##	Val	Val	Val	Val	Val	Val	Val	Val	Val	Val
1..10	88	82	00	80	10	11	11	11	11	11
11..20	20	22	22	22	22	22	30	33	33	33
21..30	33	33	00	00	78	00	01	02	03	04
31..40	05	06	07	08	09	0a	0b	0c	0d	0e
41..50	0f	10	11	12	13	14	15	16	17	18
51..60	19	1a	1b	1c	1d	1e	1f	20	21	22
61..70	23	24	25	26	27	28	29	2a	2b	2c
71..80	2d	2e	2f	30	31	32	33	34	35	36
81..90	37	38	39	3a	3b	3c	3d	3e	3f	40
91..100	41	42	43	44	45	46	47	48	49	4a
101..110	4b	4c	4d	4e	4f	50	51	52	53	54
111..120	55	56	57	58	59	5a	5b	5c	5d	5e
121..130	5f	60	61	62	63	64	65	66	67	68
131..140	69	6a	6b	6c	6d	6e	6f	70	71	72
141..150	73	74	75	76	77	78	79	7a	7b	7c
151..160	7d	7e	7f	80	81	82	83	84	85	86
161..170	87	88	89	8a	8b	8c	8d	8e	8f	90
171..180	91	92	93	94	95	96	97	98	99	9a
181..190	9b	9c	9d	9e	9f	a0	a1	a2	a3	a4
191..200	a5	a6	a7	a8	a9	aa	ab	ac	ad	ae
201..210	af	b0	b1	b2	b3	b4	b5	b6	b7	b8
211..220	b9	ba	bb	bc	bd	be	bf	c0	c1	c2
221..230	c3	c4	c5	c6	c7	c8	c9	ca	cb	cc
231..240	cd	ce	---	---	---	---	---	---	---	---

H.3 Example Frame After FEC Encoding

The example frame after FEC encoding is shown in Table H2. The bit ordering of the bits with bytes is consistent with transmission order; that is, the least significant bit in each byte is shown to the left.

##	Val	Val	Val	Val	Val	Val	Val	Val	Val	Val
1..10	11	41	00	01	08	88	88	88	88	88
11..20	04	44	44	44	44	44	0c	cc	cc	cc
21..30	cc	cc	00	00	ff	ff	ff	ff	ff	ff
31..40	1e	00	c3	24	d6	48	9c	ae	a7	c7

41..50	df	d9	be	52	cc	a2	4a	92	80	40
51..60	c0	20	a0	60	e0	10	90	50	d0	30
61..70	b0	70	f0	08	88	48	c8	28	a8	68
71..80	e8	18	98	58	d8	38	b8	78	f8	04
81..90	84	44	c4	24	a4	64	e4	14	94	54
91..100	d4	34	b4	74	f4	0c	8c	4c	cc	2c
101..110	ac	6c	ec	1c	9c	5c	dc	3c	bc	7c
111..120	fc	02	82	42	c2	22	a2	62	e2	12
121..130	92	52	d2	32	b2	72	f2	0a	8a	4a
131..140	ca	2a	aa	6a	ea	1a	9a	5a	da	3a
141..150	ba	7a	fa	06	86	46	c6	26	a6	66
151..160	e6	16	96	56	d6	36	b6	76	f6	0e
161..170	8e	4e	ce	2e	ae	6e	ee	1e	9e	5e
171..180	de	3e	be	7e	fe	01	81	41	c1	21
181..190	a1	61	e1	11	91	51	d1	31	b1	71
191..200	f1	09	89	49	c9	29	a9	69	e9	19
201..210	99	59	d9	39	b9	79	f9	5	85	45
211..220	c5	25	a5	65	e5	15	95	55	d5	35
221..230	b5	75	f5	0d	8d	4d	cd	2d	ad	6d
231..240	ed	1d	9d	5d	dd	3d	bd	7d	fd	03
241..250	83	43	c3	23	a3	63	e3	13	93	53
251..260	d3	33	b3	73	b3	55	c1	25	11	35
261..270	6b	74	23	5a	6e	c8	af	95	b9	07
271..280	8c	3b	30	ca	d7	0b	ce	3c	5a	73
281..290	7d	ad	6e	5f	84	82	d3	9d	51	62
291..300	97	dc	05	1a	---	---	---	---	---	--

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