

IEEE P802.11

Wireless Access Method and Physical Layer Specification

D2.0 Changes Referenced in Michael Fischer's Letter Ballot Response

Michael Fischer
 Digital Ocean, Inc.
 4242-3 Medical Drive
 San Antonio, TX 78229

Telephone: +1-210-614-4096
 Facsimile: +1-210-614-8192
 email: mfischer@CHILD.com

Summary

This document contains text updates that were too large, too scattered, and/or involved diagram updates, to conveniently fit into the letter ballot template form. The 11 clauses of this document are explicitly referenced in 11 of the technical comments in D2.0 letter ballot response. Note that the clause numbers used as the headings of this document are exclusively for references from my D2.0 letter ballot response, and have nothing to do with the clause numbers within the draft standard. References to clauses of the D2.0 draft, as well as other editorial comments, appear below in *bracketed italics* where necessary.

CLAUSE 1 — Add MA_UNITDATA_STATUS.indication Service Primitive

{insert a new clause, 3.2.1.3, immediately following 3.2.1.2 — the definition of this primitive is based directly upon the generic definition in 2.3.2.3 of 802.2, 1994 edition}

3.2.1.3. MA_UNITDATA_STATUS.indication

Function

This primitive provides the Local LLC sublayer entity with status concerning the immediately preceding MA_UNITDATA.request primitive.

Semantics of the Service Primitive

The semantics of the primitive are as follows:

MA_UNITDATA_STATUS.indication (
 source address,
 destination address,
 transmission status,
 provided priority.

provided service class
)

The source address parameter (SA) shall specify the individual MAC sublayer entity address as specified in the associated MA_UNITDATA.request primitive. The destination address parameter (DA) shall specify either the individual or group MAC sublayer entity address as specified in the associated MA_UNITDATA.request primitive. The transmission status parameter shall specify the success or failure of the transmission requested in the associated MA_UNITDATA.request primitive. Possible values for transmission status are:

- a) successful,
- b) undeliverable (for unacknowledged directed MSDUs when the aRetry Max is reached),
- c) excessive data length,
- d) non null source routing,
- e) unsupported priority (for priorities other than contention or contention free),
- f) unsupported service class (for service classes other than asynchronous, asynchronous with encapsulated information, time bounded, or time bounded, or time bounded with encapsulated information),
- g) unavailable priority (for contention free when no point coordinator is available, in which case the MSDU is transmitted with a provided priority of contention),
- h) unavailable service class (for time bounded or time bounded with encapsulated information under the current MAC definition).

The provided priority parameter specifies the priority that was used for the associated data unit transfer (contention or contention free). The provided service class parameter specifies the class of service used for the associated data unit transfer (asynchronous or asynchronous with encapsulated information).

When Generated

The MA_UNITDATA_STATUS.indication primitive is passed from the MAC sublayer entity to the LLC sublayer entity or entities to indicate the status of service provided for the previous associated MA_UNITDATA.request primitive.

Effect of Receipt

The effect of receipt of this primitive by the LLC sublayer is dependent on the reported transmission status of the frame.

CLAUSE 2 — Add Mechanism to Encapsulate Ancillary MSDU Information

{modifications to clause 4.1.2.1.2}

The Type field shall be two bits and the Subtype field four bits in length. The Type and Subtype fields shall together identify the function of the frame. There are three frame types: control, data and management. Each of the frame types have several defined subtypes. The table below defines the valid combinations of Type and Subtype.

Type Value	Type Description	Subtype Value	Subtype Description
00	Management	0000	Association Request
00	Management	0001	Association Response
00	Management	0010	Reassociation Request

00	Management	0011	Reassociation Response
00	Management	0100	Probe Request
00	Management	0101	Probe Response
00	Management	0110-0111	Reserved
00	Management	1000	Beacon
00	Management	1001	Reserved
00	Management	1010	Disassociation
00	Management	1011	Authentication
00	Management	1100	Deauthentication
00	Management	1101	Connection Request
00	Management	1110	Grant Connection
00	Management	1111	End Connection
01	Control	0000-1001	Reserved
01	Control	1010	PS-Poll
01	Control	1011	RTS
01	Control	1100	CTS
01	Control	1101	ACK
01	Control	1110	CF End
01	Control	1111	CF End + CF-ACK
10	Data	e0000	Data
10	Data	e0001	Data + CF-Ack
10	Data	e0010	Data + CF-Poll
10	Data	e0011	Data + CF-Ack + CF-Poll
10	Data	e0100	Null Function (no data)
10	Data	e0101	CF-Ack (no data)
10	Data	e0110	CF-Poll (no data)
10	Data	e0111	CF-Ack + CF-Poll (no data)
10	Data	1000-1111	Reserved
11	Reserved	0000-1111	Reserved

Table 4-1: Valid Type/Subtype Combinations

The most-significant bit of the Subtype value for Data Type frames is designated 'e' in Table 4-1, and is used to indicate the presence of encapsulated LLC information in the MSDU. This bit shall be set to '1' if an encapsulated information element is present in the frame body, and shall be set to '0' in all other cases. The encapsulation mechanism is defined in 4.2.2.1. The format of the encapsulated information element is defined in 4.3.2.7.

{modifications to clause 4.2.2.1}

The frame format for a Data frame is independent of subtype and shall be as defined in Figure 4-11.

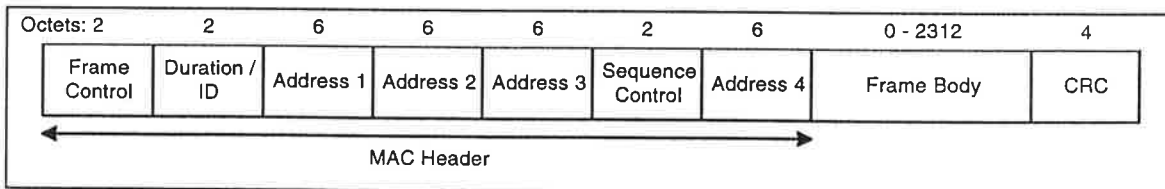


Figure 4-11: DATA Frame

The contents of the Address fields of the Data frame shall be dependent upon the values of the To DS and From DS bits and are defined in table 4-4, below. Where the content of a field is shown as N/A, the field shall be omitted.

To DS	From DS	Address 1	Address 2	Address 3	Address 4
0	0	DA	SA	BSSID	N/A
0	1	DA	BSSID	SA	N/A
1	0	BSSID	SA	DA	N/A
1	1	RA	TA	DA	SA

Table 4-5: Address Field Contents

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

A station shall use the contents of the Address 2 field to direct the ~~acknowledgment~~acknowledgement if an ~~acknowledgment~~acknowledgement is necessary.

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

The SA shall be the address of the MAC entity initiating the transmission of the MSDU (or fragment thereof) in the frame body field.

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

The TA shall be the address of the STA contained in the AP in the wireless distribution system that is transmitting the frame.

The BSSID of the Data frame shall be determined as follows:

- a) If the station is an AP or is associated with an AP, the BSS Identifier shall be the address of the STA contained in the AP.
- b) If the station is a member of an ad hoc LAN, the BSS Identifier shall be the BSS ID of the ad hoc LAN.

The Frame Body shall consist of the MSDU or a fragment thereof, ~~and a WEP IV and ICV for frames with~~ ~~the WEP subfield in the frame control field is set to '1'~~, and an encapsulated information element for frames with the 'e' bit in the Subtype field set to '1'. The frame body is null (zero octets length) in Data frames of Subtype 01xx.

Data frames sent during the contention period shall use the Data Subtypes $\text{e}0000$, or $\text{e}0100$. Data frames sent by, or in response to polling by, the PCF during the contention free period shall use the appropriate ones of the Data Subtypes $\text{e}0000$ – $\text{e}0111$ based upon the usage rules:

Data Subtypes $\text{e}0010$, $\text{e}0011$, $\text{e}0110$, and $\text{e}0111$ shall only be sent by a PCF.

Data Subtypes $\text{e}0000$, $\text{e}0001$, $\text{e}0100$, and $\text{e}0101$ may be sent by any CF-aware station.

Stations receiving Data frames shall only process the Data frame body, and shall only consider the frame body as the basis of a possible indication to LLC, if the Data Subtype is of the form $\text{e}00xx$. Stations capable of transmitting in response to polling by a PCF shall interpret all Subtype bits of received Data frames for CF purposes, but shall only inspect the frame body if the Subtype is of the form $\text{e}00xx$.

If the Last Frag subfield is set to '1' in the Frame Control field of this frame, the Duration value shall be set to the time, in microseconds, required to transmit one ACK frame, plus one SIFS interval. If the Last Frag subfield is set to '0' in the Frame Control field of this frame, and the Address 1 field contains a unicast address, the Duration value shall be the time,

in microseconds, required to transmit the next fragment of this Data frame, plus two ACK frames, plus three SIFS intervals. If the Last Frag subfield is set to '0' in the Frame Control field of the frame, and the Address 1 field contains a multicast address, the Duration value shall be the time, in microseconds, required to transmit the next fragment of this Data frame, plus one SIFS interval. If the calculated duration includes a fractional microsecond, that value shall be rounded up to the next higher integer. All stations shall process the duration field contents of valid data frames to update their NAV settings as appropriate under the coordination function rules.

If an encapsulated information element is present in the MSDU, the 'e' bit in the Subtype field shall be set to '1'. The encapsulated information element shall be located at the beginning of the frame body, immediately following the MAC header, when the WEP bit in the Frame Control field is set to '0', or immediately following the IV field, when the WEP bit in the Frame Control field is set to '1'. If no encapsulated information element is present in the MSDU, the 'e' bit in the Subtype field shall be set to '0'. The value of the 'e' bit is only interpreted by MAC data service entities at stations where the MSDU is passed to or from an LLC entity, and by distribution service entities at locations where the MSDU is transmitted on or received from a segment of wired distribution system medium. All other frame handling within 802.11 MAC and PHY entities transfer the MSDU payload, and corresponding 'e' bit setting, without modification.

{insert a new clause, 4.3.2.7, immediately following 4.3.2.6}

4.3.2.#. Encapsulated Information

Encapsulated information elements shall be used to convey ancillary, LLC-visible information for integrated LANs. This is necessary when integrating certain, non-802 LANs which place LLC-visible information, such as protocol type identifier, in their MAC headers. Encapsulated information elements shall not be used for integrating other 802 LANs.

The general format of the encapsulated information element, and the specific layout and values for use with type 2 Ethernet, are shown below in Figure 4-xx. The first octet shall contain a type code indicating the type of encapsulated information. The type value of 20 shall indicate a protocol type code. All other type values are reserved. The second octet shall indicate the element length, as the number of octets in the remainder of the element. The element length shall always be an even number. If necessary, a pad octet shall be added at the end of the encapsulated information to maintain even octet alignment for the remainder of the MSDU payload. For type value '20', the information length shall be '2'.

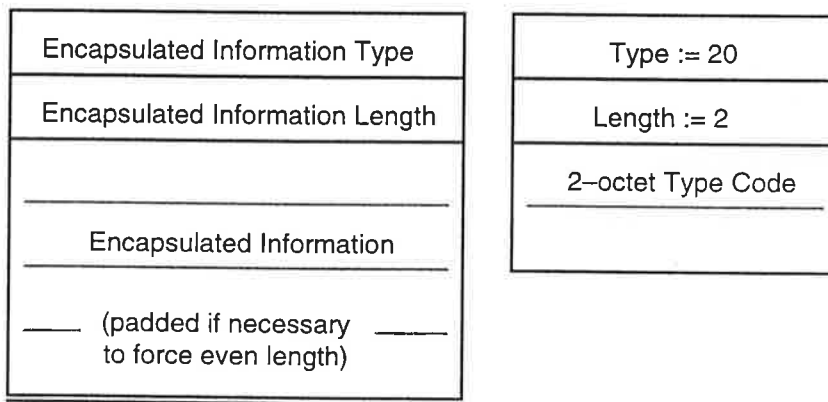


Figure 4-xx. Encapsulated Information Element Format and Values for Type 2 Ethernet

The total number of octets in the MSDU, including both the encapsulated information element and the MAC frame body of the Integrated LAN, shall not exceed the value of aMax Frame Length.

{insert information on the use of the encapsulated information element — this could be an extension of the item directly above, but some people feel that clause 4 of the draft should contain only the formats, not the rules for using those formats, in which case this material needs to be added to a new clause — most logically a new main clause, but to maintain current numbering, the new clause is designated 6.8, to go at the end of the MAC description, immediately following 6.7}

6.8. Integration Of Wired LANs

A portal, upon receiving a frame from the integrated LAN with destination address information designating one or more potential recipient stations in the ESS, shall transmit the MSDU from the received frame onto the DSM, appropriately framed for the MAC protocol used on the DSM. If the received frame includes service class, priority, or other delivery-related information which cannot be provided on the DSM of the ESS, the portal discards the frame without transmission onto the DSM. If the integrated LAN uses a (non-802) MAC protocol which places LLC-visible information in the MAC header (e.g. Type 2 Ethernet) the portal shall place that information into an encapsulated information element as defined in 4.2.2.1, prior to transmitting the frame onto the DSM.

A portal, upon receiving a frame from the DSM with destination address information designating one or more potential recipient stations on the integrated LAN, shall transmit the MSDU from the received frame onto the integrated LAN, appropriately framed for the MAC protocol used on the integrated LAN. If the received frame includes an encapsulated information element with an information type relevant to the MAC protocol of the integrated LAN, the portal shall use the encapsulated information from that element to set the appropriate fields in the MAC header of the frame transmitted onto the integrated LAN. If the received frame includes any other type of encapsulated information element, that element is discarded prior to transmitting the frame onto the integrated LAN.

{modifications to clause 3.2.1.1 — note that the choice of the service_class parameter to indicate the presence of encapsulated information is based on the definitions of “service” (1.4.2.38 of 802.2), “service class” (1.4.2.39 of 802.2), “N-layer” (1.4.2.19 of 802.2), and “N-user” (1.4.2.20 of 802.2)}

Function

This primitive defines the transfer of a MSDU from a Local LLC sublayer entity to a single peer LLC sublayer entity, or multiple peer LLC sublayer entities in the case of group addresses.

Semantics of the Service Primitive

The semantics of the primitive are as follows:

```

MA_UNITDATA.request (
    source_address,
    destination_address,
    routing_information,
    data,
    priority,
    service_class
)

```

The source_address parameter (SA) shall specify an individual MAC sublayer entity address, this SA shall be replaced in the MPDUs resulting from this request with the individual MAC sublayer address of the MAC entity to which the request is made. The destination_address parameter (DA) shall specify either an individual or a group MAC sublayer entity address. The routing_information parameter specifies the route desired for the data transfer (a null value indicates source routing is not to be used). The data parameter specifies the MAC service data unit (MSDU) to be transmitted by the MAC sublayer entity. The length of the MSDU shall be less than or equal to 2304 octets. The priority parameter specifies the priority desired for the data unit transfer (contention or contention-free). The service_class parameter specifies the service_class desired for the data unit transfer (asynchronous or time-bounded), and also indicates whether an encapsulated information element is present at the beginning of the MSDU.

When Generated

This primitive is generated by the LLC sublayer entity whenever a MSDU must be transferred to a peer LLC sublayer entity or entities. This can be as a result of a request from higher layers of protocol, or from a MSDU generated internally to the LLC sublayer, such as required by Type 2 operation.

Effect of Receipt

The receipt of this primitive shall cause the MAC sublayer entity to append all MAC specified fields, including DA, SA, and any fields that are unique to the particular media access method, and pass the properly formatted frame to the lower layers for transfer to peer MAC sublayer entity or entities. If the service_class indicates the presence of an encapsulated information element, this shall be indicated in the manner specified in 4.

{modifications to clause 3.2.1.2 — note that the choice of the service_class parameter to indicate the presence of encapsulated information is based on the definitions of “service” (1.4.2.38 of 802.2), “service class” (1.4.2.39 of 802.2), “N-layer” (1.4.2.19 of 802.2), and “N-user” (1.4.2.20 of 802.2)}

Function

This primitive defines the transfer of a MSDU from the MAC sublayer entity to the LLC sublayer entity, or entities in the case of group addresses. In the absence of error, the contents of the data parameter are logically complete and unchanged relative to the data parameter in the associated MA_UNITDATA_MA_UNIT_DATA_rRequest primitive.

Semantics of the Service Primitive

The semantics of the primitive are as follows:

```

MA_UNITDATA.indication(
    source_address,
    destination_address,
    routing_information,
    data,
    reception_status,
    priority,
    service_class
)

```

The source_address parameter must be an individual address as specified by the SA field of the incoming frame. The destination_address parameter shall be either an individual or a group address as specified by the DA field of the incoming frame. The routing_information parameter specifies the route desired for the data transfer (null for 802.11

MACs). The data parameter specifies the MAC service data unit (MSDU) as received by the local MAC entity, with any encapsulated information element removed, and shall be less than or equal to 2304 octets in length. The reception_status parameter indicates the success or failure of the incoming frame, and if an encapsulated information element is present in the incoming frame, contains the encapsulated information extracted from that element prior to its removal. The priority parameter specifies the priority desired for the data unit transfer (contention or contention-free). The service_class parameter specifies the service_class desired for the data unit transfer (asynchronous or time-bounded), and also indicates whether an encapsulated information element is present at the beginning of the incoming MSDU.

When Generated

The MA_UNITDATAMA_UNIT_DATA indication primitive is passed from the MAC sublayer entity to the LLC sublayer entity or entities to indicate the arrival of a frame at the local MAC sublayer entity. Frames are reported only if at the MAC sublayer they are validly formatted, received without error, received with valid (or null) privacy encryption, and their destination address designates the local MAC sublayer entity as either an individual or group member. When the receiving MAC sublayer entity is operating with a null privacy function, frames that are received in error may be reported, at the option of LLC; however, when operating with WEP enabled, erroneous reception (e.g. CRC failure) precludes validation of the ICV, so to report such frames when operating with WEP enabled could constitute a breach of security.

Effect of Receipt

The effect of receipt of this primitive by the LLC sublayer is dependent on the validity and content of the frame.

CLAUSE 3 — Allow Combined Authentication and (Re)Association Functions

{modifications to clause 4.2.3.9}

The Frame Body of a Management frame of Subtype Authentication shall contain the following information:

Order	Information	Notes
1	Authentication Algorithm Number	
2	Authentication Transaction Sequence Number	
3	Status Code	1
4	Challenge Text	2
5	Capability Information	3
6	Listen Interval / Station ID (SID)	3, 4
7	Current AP Address	5
8	ESSID	6
9	Supported Rates	3

Notes:

- 1 The Status Code information shall be ~~reserved and~~ set to '0' in the Authentication frames for which the Status Code is defined as 'reserved' in the table below.
- 2 The Challenge Text ~~information~~ shall only be present in the Authentication frames as defined in the table below.

3. The Capability Information and Listen Interval/Station ID fields, and the Supported Rates element shall only be present in the Authentication + (Re)Association frames, as defined in the table below.
4. This 2-octet field shall be used for Listen Interval in frames defined in the table below to contain (Re)Association request fields. This field shall be used for Station ID (SID) in frames defined in the table below to contain (Re)Association response fields.
5. When used in the request frame of an Authentication + Reassociation transaction, as defined in the table below, the Current AP Address field shall contain the MAC address of the access point with which the requesting station is currently associated. When used in the request frame of an Authentication + Association transaction, as defined in the table below, all six octets of the Current AP Address field shall be set to '0'. The Current AP Address field is not present in response frames of Authentication + (Re)Association transactions, nor is defined to have no (Re)Association fields present.
6. The ESSID element shall only be present in Authentication + (Re)Association request frames, as defined in the table below.

<u>Authentication Algorithm TypeNumber and Operation</u>	<u>Authentication Algorithm Number</u>	<u>Authentication Transaction-Sequence Number</u>	<u>Status Code</u>	<u>Challenge Text</u>	<u>Association or Reassociation Fields</u>
Open System	0	1	reserved	not present	not present
Open System	0	2	status	not present	not present
<u>Open System + (Re)Association</u>	1	1	<u>reserved</u>	<u>not present</u>	<u>request</u>
<u>Open System + (Re)Association</u>	1	2	<u>status</u>	<u>not present</u>	<u>response</u>
Shared Key	2	1	reserved	not present	not present
Shared Key	2	2	reserved	present	not present
Shared Key	2	3	reserved	present	not present
Shared Key	2	4	status	not present	not present
<u>Shared Key + (Re)Association</u>	3	1	<u>reserved</u>	<u>not present</u>	<u>request</u>
<u>Shared Key + (Re)Association</u>	3	2	<u>reserved</u>	<u>present</u>	<u>not present</u>
<u>Shared Key + (Re)Association</u>	3	3	<u>reserved</u>	<u>present</u>	<u>not present</u>
<u>Shared Key + (Re)Association</u>	3	4	<u>status</u>	<u>not present</u>	<u>response</u>

{modifications to clause 5.1}

The 802.11 authentication service supports defines two subtypes of authentication algorithms service; "Open System" and "Shared Key". The authentication algorithm type subtype invoked is indicated indicated in the Authentication Algorithm Number field in the body of authentication management frames. Thus authentication frames are self identifying identifying with respect with respect to authentication algorithm.

Authentication algorithms are identified using even algorithm numbers. Odd algorithm numbers refer to the same authentication algorithm as the next lower even number, and also indicate that an Association or Reassociation function is being requested in conjunction with this authentication transaction. For any authentication algorithm, the information for the (Re)Association request is appended to the authentication information in the first frame of the authentication transaction sequence, and the information for the (Re)Association response is appended to the authentication information in the last frame of the authentication transaction sequence. The (Re)Association function of these combined transactions is never successful unless the Authentication function is successful.

CLAUSE 4 — Change “Status” to “Reason” in Disassoc. & Deauth. Frames*{modifications to clause 4.2.3.2}*

The Frame Body of a Management frame of Subtype Disassociation shall contain the following information:

Order	Information	Note
1	<u>Reason</u> Status Code	

{modifications to clause 4.2.3.10}

The Frame Body of a Management frame of Subtype Deauthentication shall contain the following information:

Order	Information	Note
1	<u>Reason</u> Status Code	

{modifications to clause 4.3.1.9 — includes the recommendations in 95/213 plus additional causes}

This Status Code shall be used to indicate the success or failure of an operation. The length of the status code field is one octet. If an operation is successful then the Status Code shall be set to 0. If an operation results in failure the Status Code shall indicate a failure cause.

The following failure cause codes are defined:

Status Code	Meaning
0	Successful
1	Unspecified Failure
<u>2-9</u>	<u>Reserved</u>
<u>10</u>	<u>Cannot support all requested capabilities in the Capability Information Field</u>
<u>11</u>	<u>Station requesting (Re)Association is not Authenticated with responding station</u>
<u>12</u>	<u>Reassociation denied due to inability to confirm that Association exists</u>
<u>13</u>	<u>Association denied due to not recognizing the validity of requesting station</u>
<u>14</u>	<u>Open System Authentication not acceptable to the responding station</u>
<u>15</u>	<u>Responding station does not support the specified Authentication Algorithm</u>

<u>16</u>	<u>Received an Authentication Frame with Authentication Transaction Sequence Number out of expected sequence</u>
<u>17</u>	<u>Authentication rejected because of challenge failure</u>
<u>18</u>	<u>Authentication rejected due to timeout waiting for next frame in sequence</u>
<u>19</u>	<u>Association denied because AP is unable to handle additional associated stations</u>
<u>202 - 255</u>	<u>Reserved</u>

{insert new clause between 4.3.1.9 & 4.3.1.10 — details of issue mentioned but undefined in 95/213}

4.3.1.#. Reason Code

This Reason Code shall be used to indicate the reason that a notification management frame of Type Disassociation or Deauthentication was generated. The length of the reason code field is one octet.

The following reason codes are defined:

Reason Code	Meaning
<u>0</u>	<u>Reserved</u>
<u>1</u>	<u>Unspecified Reason</u>
<u>2</u>	<u>Previous Authentication no longer valid</u>
<u>3</u>	<u>Deauthenticated because sending station is leaving (has left) IBSS or ESS</u>
<u>4</u>	<u>Disassociated due to inactivity</u>
<u>5</u>	<u>Disassociated because AP is unable to handle all currently associated stations</u>
<u>6</u>	<u>Class 3 frame received from non-Associated station</u>
<u>7</u>	<u>Disassociated because sending station is leaving (has left) BSS</u>
<u>8 - 255</u>	<u>Reserved</u>

CLAUSE 5 — Improve Details of Allowable Frame Sequences

{modifications to clause 4.4}

The following frame sequences are valid:

- a) — DATA
- b) — DATA DATA (fragmented broadcast MSDU)

- e) ~~DATA ACK~~
- d) ~~RTS CTS DATA ACK~~
- e) ~~DATA ACK DATA ACK (fragmented MSDU)~~
- f) ~~RTS CTS DATA ACK DATA ACK (fragmented MSDU)~~
- g) ~~PS POLL DATA ACK~~
- h) ~~PS POLL DATA ACK DATA ACK (fragmented MSDU)~~
- i) ~~PS POLL ACK~~
- j) ~~REQUEST ACK~~
- k) ~~RESPONSE ACK~~
- l) ~~BEACON DATA/END*~~
- m) ~~DATA* ACK DATA/END*~~
- n) ~~DATA* *CF ACK DATA/END*~~
- o) ~~DATA+CF POLL DATA+CF ACK DATA/END*~~
- p) ~~DATA+CF POLL RTS CTS DATA ACK DATA/END*~~
- q) ~~DATA+CF POLL NULL DATA/END*~~

Sequence	Frames in Sequence	Usage
[Data(bc/mc) -] Data(bc/mc)	1 - 10	broadcast or multicast MSDU
[Mgmt(bc) -] Mgmt(bc)	1 - 10	broadcast management frame
{ RTS - CTS - } [Data(dir) - ACK -] Data(dir) - ACK	2 - 22	directed MSDU
{ RTS - CTS - } [Mgmt(dir) - ACK -] Mgmt(dir) - ACK	2 - 22	directed management frame
PS-Poll - ACK	2	deferred PS-POLL response
PS-Poll - [Data(dir) - ACK -] Data(dir) - ACK	3 - 21	immediate PS-POLL response
Beacon(CF) - [<CF-Sequence> -] CF-End*	³ 2	start of CF period
[<CF-Sequence> -] <CF-Sequence>	³ 1	continuation of CF period
[<CF-Sequence> -] <CF-Sequence> - CF-End*	³ 1	end of CF period

Where "DATA*" can be any of the DATA sub-types, "DATA/END*" can be any of the DATA or CF-END sub-types, and "*CF ACK" can be DATA+CF ACK or CF ACK(no data):

Where:

Items enclosed in brackets "[...]" may occur zero or more times in the sequence.

Items enclosed in braces "{...}" may occur zero or one time in the sequence.

An isolated hyphen "-" represents an SIFS gap separating the pair of frames.

"Data(BC/Mac)" represents any frame of type Data with a broadcast or multicast address in the Address1 field.

"Data(dir)" represents any frame of type Data with an individual address in the Address1 field.

"Mgmt(bc)" represents any Management type frame with a broadcast address in the DA field.

"Mgmt(dir)" represents any Management type frame with an individual address in the DA field.

"Beacon(CF)" represents a management frame of type Beacon with a non-zero value in the CF Dur Remaining field of its CF Parameter Set element.

"CF-End*" represents a control frame of type CF-End, or (if the final frame of the preceding <CF-Sequence> was a directed data or management frame requiring acknowledgment by the AP) of type CF-End+Ack.

<CF-Sequence> represents a sequence of one or more frames sent during a contention free period. A valid <CF-Sequence> consists of any of the CF frame sequences shown in the table below. These CF frame sequences may occur in any order.

CF Frame Sequence	Frames in Sequence	Usage
[Data(bc/mc) -] Data(bc/mc)	1 - 10	broadcast or multicast MSDU
{ CF-Ack(no data) - } [Mgmt(bc) -] Mgmt(bc)	1 - 11	broadcast management frame

Data(dir)+CF-Poll{+CF-Ack} – Data(dir)+CF-Ack	2	poll and ack sent with MSDUs
Data(dir)+CF-Poll{+CF-Ack} – CF-Ack(no data)	2	poll of station with empty queue
Data(dir)+CF-Poll{+CF-Ack} – ACK	2	alternate ack if station queue empty
Data(dir)+CF-Poll{+CF-Ack} – Data(dir)+CF-Ack – ACK	3	polled station sends to station in BSS
CF-Poll(no data){+CF-Ack} – Data(dir)	2	separate poll, ack sent with MSDU
CF-Poll(no data){+CF-Ack} – Data(dir) – ACK	3	polled station sends to station in BSS
CF-Poll(no data){+CF-Ack} – Null(no data)	2	separate poll, station queue empty
Data(dir){+CF-Ack} – ACK	2	ack if not CF-aware or not polled

Individual frames within each of these sequences are ~~separated~~ separated by a SIFS.

CLAUSE 6 — Updates to MAC Architecture & General Description

{modifications to clause 6}

Here, the MAC functional description is presented. -6.1 introduces the architecture of the MAC sublayer, including the distributed coordination function, the point coordination function and their coexistence in an 802.11 LAN. 6.2 and 6.3 expand on this introduction and provide a complete functional description of each. 6.4 ~~describes the security mechanisms within the MAC layer.~~ 6.4~~5~~ and 6.5~~6~~ cover fragmentation and reassembly. Multirate support is addressed in 6.6~~7~~. 6.7~~8~~ reiterates the functional descriptions in the form of state machines.

{modifications to clause 6.1}

The MAC is composed of several functional blocks: the MAC Data Service Interface (between MAC and -LLC)-Service Interface, the MAC Control State Machines, the MAC Management Service Interface (between MAC and sublayer or station management entities), the MAC Management State Machines and (at access points) the Distribution Services Interface (between MAC and the distribution system). The MAC Management Information Base (MIB) is maintained by the MAC Management function. The MAC-LLC Service Interface comprises the MAC Data Service and the MAC Management Service. These blocks perform the functions required to provide higher layer access to contention and contention-free frame transfers-access control on a variety of physical layers. These frame transfer functions are provided without reliance upon particular data rates or physical layer characteristics. The MAC provides both distributed and point coordination functions and is able to support both asynchronous and connection-based services. Under certain circumstances, the connection-based services in conjunction with the point coordination function may be able to provide a time bounded service classeselases. Figure 6-1 illustrates the MAC architecture.

The MAC-LLC Service Interface shall accept MAC service requests from higher layer entities, as well as from station management entities, and shall distribute those requests to either the MAC Data Service or the MAC Management Service as appropriate. The MAC Data and MAC Management Services shall interpret the service requests and shall cause the appropriate signals to be generated to initiate actions in the state machines. The MAC-LLC Service Interface shall also accept indications from the state machines and provide those indications to higher layer entities. The particular service requests and indications are described in -3.2.

At access points there is an additional functional block, Distribution Services, which provides an interface between the MAC and the distribution system. Distribution Services shall accept requests from the distribution system, and shall provide relevant ones of those requests to the local MAC Control State Machines. Distribution Services shall also accept

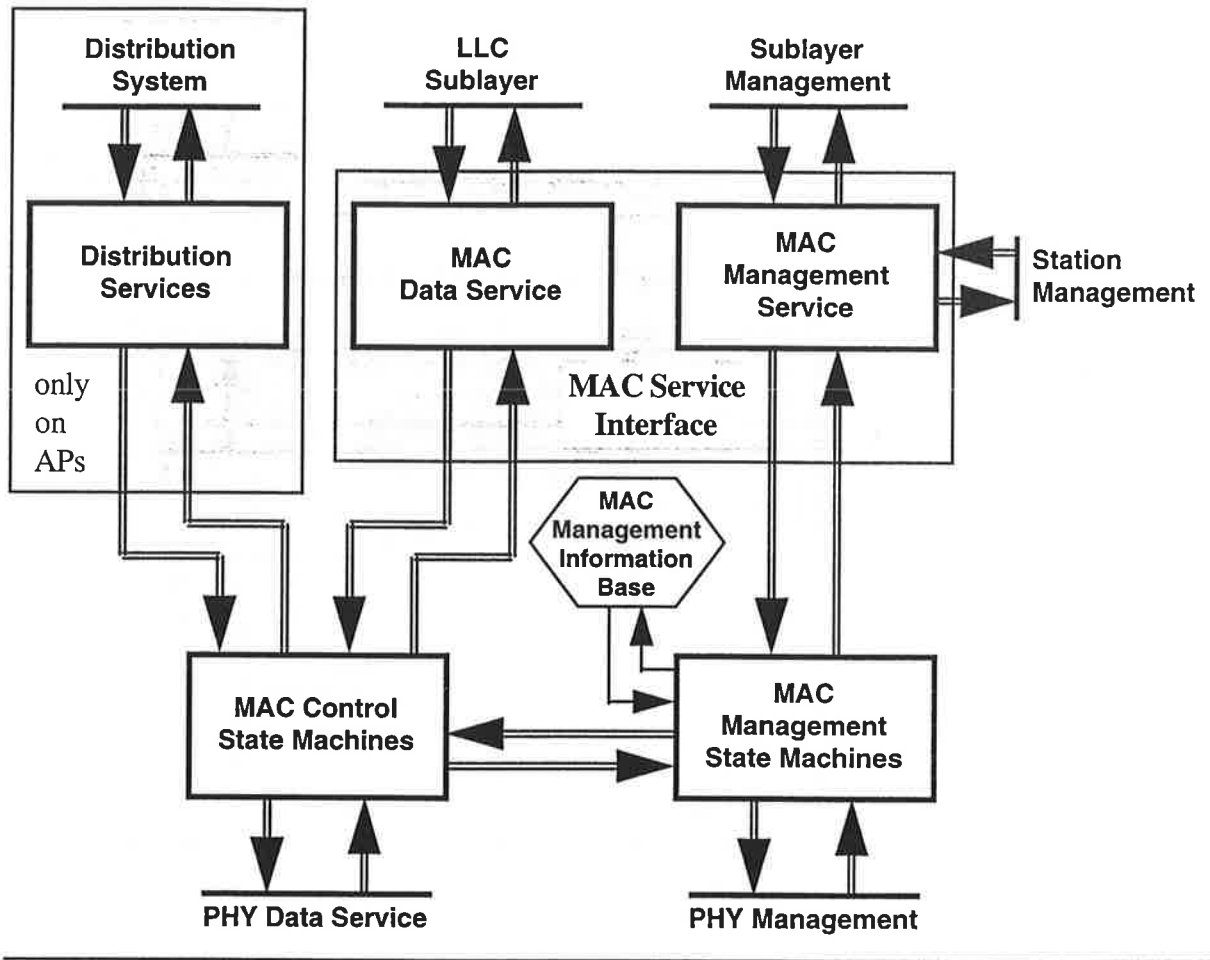
indications from the local MAC Control State Machines and shall provide relevant ones of those indications to the distribution system.

The MAC Control State Machines shall provide the sequencing required to provide the distributed coordination function. The MAC Control State Machines shall provide the protocol sequencing necessary to provide asynchronous communication service. The MAC Control State Machines shall provide the sequencing required to provide the point coordination function and the associated ~~time-bounded and contention-free frame transfers, communication services.~~ The implementation of the PCF portions of the MAC Control State Machines, ~~(and the associated Time-bounded and contention-free transfer support services.)~~ is optional. The MAC Control State Machines shall not interfere with ~~connection-based time-bounded~~ nor contention-free communications even if the optional point coordination function is not implemented.

The MAC Management State Machines shall provide the protocol sequencing required to provide the following services:

- a) Association and re-association
- b) Access to the MAC MIB
- c) Timing synchronization
- d) Power management
- e) Authentication

The MAC MIB shall provide storage of and access to all of the information required to properly manage the MAC.



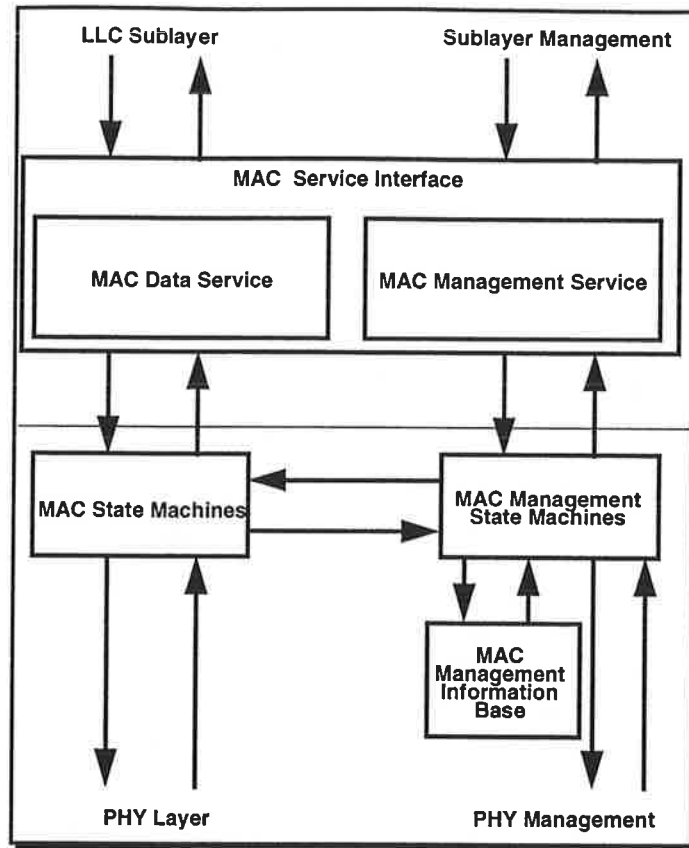


Figure 6-1: MAC Architecture Block Diagram

Viewed along a different axis, the MAC architecture can be described as shown in Figure 6-2 below as providing the point coordination function through the services of the distributed coordination function.

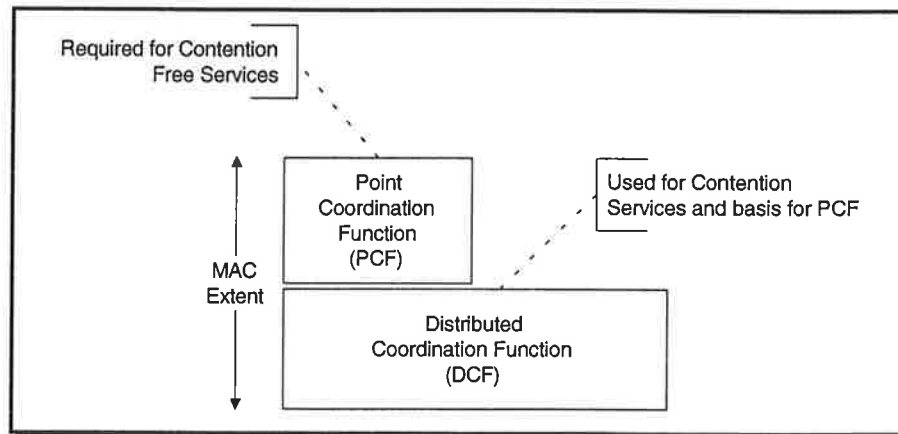


Figure 6-2: Alternative view of MAC architecture.

{modifications to clause 6.1.1}

The fundamental access method of the 802.11 MAC is a distributed coordination function known as carrier sense multiple access with collision avoidance, or CSMA/CA. The distributed coordination function shall be implemented in all stations, for use. ~~It is used~~ within both ad hoc and infrastructure network configurations.

A station wishing to transmit shall sense the medium to determine if another station is transmitting. If the medium is not busy, 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 station shall ensure that the medium is idle for this required duration before attempting to transmit. If the medium is sensed busy the station shall defer until the end of the current transmission. After deferral, or prior to attempting to transmit again immediately after a successful transmission, the station shall select a random backoff interval and shall decrement the backoff interval counter while the medium is free. A refinement of the method may be used under various circumstances to further minimize collisions - here the transmitting and receiving station exchange short control frames (**RTS** and **CTS** frames) after sensing the medium to be free and any deferrals or backoffs and prior to the data transmission. The details of CSMA/CA, deferrals, and backoffs are described in 6.2. RTS/CTS exchanges are also presented in 6.2.

{modifications to clause 6.1.2}

The 802.11 MAC may also incorporate an optional access method described as a point coordination function, which is only usable on infrastructure networks. This optional access method shall be implemented on top of the distributed coordination function. This access method uses a point coordinator, which must operate at the access point of the BSS, to determine which station currently has the right to transmit. The operation is essentially that of polling with the point coordinator playing the role of the polling master. The operation of the Point Coordination Function may require additional coordination, not ~~specified~~ specified in this standard, to permit efficient ~~efficient~~ operation in cases where multiple Point-Coordinated BSSs are operating on the same channel in overlapping physical space.

The point-coordination function shall be built up from the distributed coordination function through the use of an access priority mechanism, aided by the virtual carrier sense mechanism. Different classes of traffic can be defined through the use of different values for IFS, thereby creating prioritized access to the medium for those classes with a shorter IFS. The point coordination function shall use an IFS that is smaller than the IFS for data frames transmitted via the distributed coordination function. The use of a smaller IFS implies that point-coordinated traffic shall have priority access to the medium.

The access priority provided by point-coordinated traffic may be utilized to create a **contention-free** access method. The priority access of the PIFS allows the point coordinator to "seize control" of the medium, at a time when the medium is free, by starting its transmission before the other stations are ~~stations are~~ allowed to begin their transmissions under the DCF access method. The point coordinator can then control the frame transmissions of the stations so as to eliminate contention ~~contention~~ for a limited period of time.

{modifications to clause 6.1.4}

The process of partitioning a MAC Service Data Unit (MSDU) into smaller MAC level frames, MAC Protocol Data Units (MPDUs), is defined as fragmentation. Fragmentation creates MPDUs smaller than the MSDU size to increase reliability ~~reliability~~ of successful transmission of the MSDU over a given PHY. Fragmentation is accomplished at each immediate transmitter. The process of recombining MPDUs into a single MSDU is defined as reassembly. Reassembly is accomplished at each immediate recipient.

When a frame is received from the LLC with a MSDU size greater than a Fragmentation_Threshold, the frame must be fragmented. The MSDU is divided into MPDUs. Each MPDU is a fragment with a frame body no larger than a Fragmentation_Threshold. It is possible that the final fragment may contain a frame body smaller than a Fragmentation_Threshold Payload. An illustration of fragmentation is shown in Figure 6-3.

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

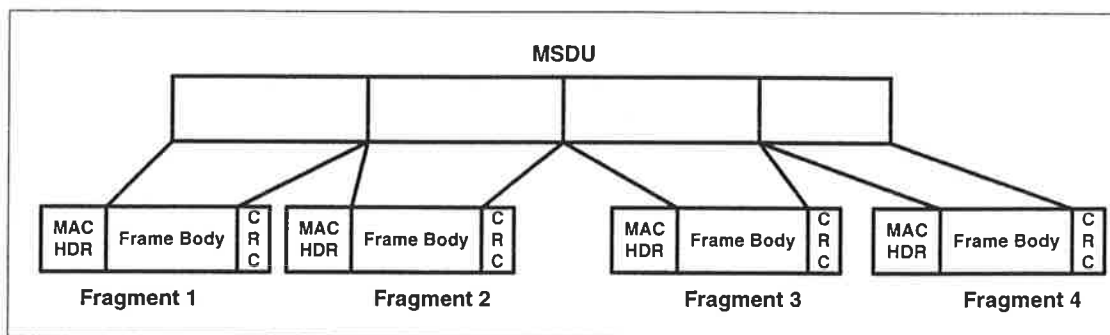


Figure 6-3: Fragmentation

(modifications to clause 6.1.5)

The MAC Data Service shall translate MAC service requests from LLC into input signals utilized by the MAC Control State Machines. 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 6.7.3.2 below.

~~The MA_DATA request from LLC shall initiate one of the transmit cycles in the MAC State Machine. The pseudo-code below shall be used to translate this request into inputs to the MAC State Machine.~~

```

Tx_data_req = { requested_service_class = async & length(MSDU) > RTS_threshold
               & destination_address <> (broadcast + multicast) }
Tx_multicast_req = { requested_service_class = async & destination_address = multicast }
Tx_unifdata_req = { requested_service_class = async & length(MSDU) < RTS_threshold }
DA = { destination_address }
Length = { Rate_factor * (length(MSDU) + Overhead) }
Connection ID = integer. Note a value of zero is reserved for all asynchronous data requests

```

~~The MAC Data Service shall translate outputs from the MAC State Machine to MA_DATA indication as shown in the following pseudo-code:~~

```

control = { type, control }
destination_address = { DA }
source_address = { SA }
MSDU = { info_field }
reception_status = { !(CRC_error + Format_error) }
Connection ID = integer. Note a value of zero is used when there is no connection.

```

CLAUSE 7 — Complete the Definition of the Random Backoff Mechanism

{modifications to clause 6.2.5}

STA desiring to initiate transfer of asynchronous MPDUs shall utilize the carrier sense function to determine the state of the mediummedia. If the mediummedia is busy, the STA shall defer until after a DIFS interval with idle mediumgap is detected, and then generate a random backoff period for an additional deferral time before transmitting. This process resolves contention between multiple STA that have been deferring to the same busy medium conditionMPDU occupying the medium.

Backoff Time = INT(CW * Random()) * Slot time

where:

CW = An integer between aCW_min_min and aCW_max_max

Random() = Pseudo random number, from a uniform distribution between 0 and 1

Slot Time = The value of PHY MIB attribute aSlot TimeTransmitter turn-on delay + medium propagation delay + medium busy detect response time (including MAC delay) and is PHY dependent.

The Contention Window (CW) parameter shall ~~take on~~contain an initial value of aCW_min_min for every MPDU queued for transmission. The CW shall take the next value in the series~~double~~ at every retry until it reaches the value of aCW_max_max. The CW ~~shall~~will remain at the value of aCW_max_max for the remaining ~~of the~~retries. This is done to improve the stability of the access protocol under high load conditions. See Figure 6-5.

The set of CW values which shall be used by all stations is: 7 (aCW_min), 15, 31, 63, 127, 255 (aCW_max)~~Suggested values are for: CWmin=31, CWmax = 255.~~

FIGURE 6-5 NEEDS TO BE CORRECTED BY SOMEONE WHO CAN EDIT THE VISIO DRAWING

Figure 6-5: Exponential Increase of CW

~~CWmin and CWmax are MAC constants that should be fixed for all MAC implementations, because they effect the access fairness between stations.~~

CLAUSE 8 — Point Coordination Function Details Cleanup

{modifications to clause 6.3}

The Point Coordination Function (PCF) provides Contention Free frame transfer. It is an option for a stationSTA to be able to become the Point Coordinator(PC). All stationsSTA inherently obey the medium access rules of the PCF, because these rules are based on the DCF, with the Point Coordinator gaining priority access to the medium using a PCF IFS (PIFS) which is smaller than the DCF IFS (DIFS) used by~~used by~~ the DCF to access the medium. The operating characteristics of the PCF are such that all stations are able to operate properly in the presence of a BSS in which a Point Coordinator is operating, and, if associated with a point-coordinated BSS, are able to receive data and management frames sent under PCF control.- It is also an option for a station to be able to respond to a contention-free poll (CF-poll)

received from a Point Coordinator. A station which is able to respond to CF-polls is referred to as being CF-Aware, and may request to be polled by an active Point Coordinator. When polled by the Point Coordinator, a CF-Aware station may transmit one frame to any destination (not just to the Point Coordinator), and may ~~“piggyback”~~ the ~~acknowledgment~~ ~~acknowledgement~~ of a frame received from the Point Coordinator using particular data frame subtypes for this transmission. If the addressed recipient of a CF transmission is not CF-Aware, that station acknowledges the transmission using the DCF ~~acknowledgment~~ ~~acknowledgement~~ rules, and the Point Coordinator retains control of the medium by waiting the PIFS duration before resuming CF transfers. It is also permissible for a Point Coordinator to use Contention Free frame transfer solely for delivery of frames to stations, and never to poll those stations. The presence of a point coordinator at the AP of a BSS, and whether that Point Coordinator polls CF-Aware stations (“maintains a polling list”) may be determined from bits in the Capability Information fields of Beacon, Probe Response, Association Response, and Reassociation Response management frames sent by that AP.

When more than one point-coordinated BSS is operating on the same PHY channel in overlapping space, the potential exists for collisions between PCF transfer activities by the independent point coordinators. The rules under which multiple, overlapping point-coordinated BSSs can coexist are presented in ~~section 6.3.3.3.~~ As shown in Figure 6-2, the PCF is built on top of the CSMA/CA based DCF, by utilizing the access priority provisions provided by this scheme. An active Point Coordinator must be located at an AP, which restricts PCF operation to infrastructure networks. However, there is no requirement that a distribution system be attached to this AP, which permits a station capable of AP and PC functionality to be designated as the ~~“AP”~~ ~~in what would otherwise be an isolated BSS.~~ PCF is activated at a PC—capable AP by setting the aCFP_Max_Duration attribute in the MAC MIB ~~managed object~~ to a non-zero value.

{modifications to clause 6.3.1}

The PCF controls frame transfers during a Contention Free Period (CFP). The CFP alternates with a Contention Period (CP), when the DCF controls frame ~~transfers, as~~ ~~transfers,~~ as shown in Figure 6-14. Each CFP begins with a Beacon frame that contains a DTIM Element (hereafter referred to as a ~~“DTIM”~~ ~~“DTIM”~~). The CFPs occur at a defined repetition rate, which is synchronized with the beacon interval as specified below.

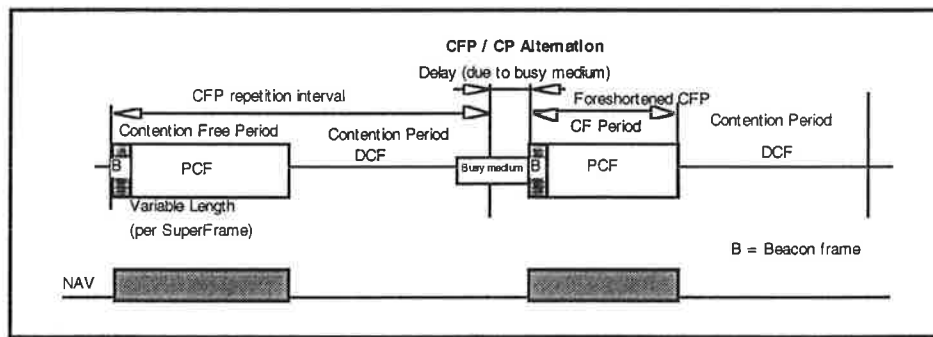


Figure 6-14: CFP / CP Alternation

The PC generates CFPs at the **Contention-Free Repetition Rate (CFPRate)**, which is defined as a number of beacon intervals, but shall always be an integral number of DTIM intervals. The PC determines the CFP-Rate (depicted as a repetition interval in the illustrations below) to use from the aCFP_Rate attribute in the MAC MIB ~~managed object~~. This value, in units of beacon intervals, is communicated to other stations in the BSS in the CFP_Rate field of the PCF ~~Parameter Set Element~~ of Beacon frames. The PCF ~~Parameter Set Element~~ is only present in Beacon frames transmitted by stations containing an active Point Coordinator.

The length of the CFP is controlled by the PC, with maximum duration specified by the value of the aCFP_Max_Duration attribute in the MAC MIB ~~managed object~~ at the PC. Neither the maximum duration nor the actual duration (~~signaled~~ ~~signalled~~ by transmission of a control frame of Subtype CF-End or CF-End+Ack ~~frame~~ by the PC) are

constrained to be a multiple of the beacon interval. If the CFP-Rate is greater than the beacon interval, the PC shall transmit beacons at the appropriate times during the CFP (subject to delay due to traffic at the nominal times, as with all beacons). The PCF Parameter Set Element in all beacons at the start of, or within, a CFP contain a non-zero value in the CFP_Dur_Remaining field. This value, in units of ~~microseconds~~ ~~milliseconds~~, specifies the maximum time from the transmission of this beacon to the end of this CFP. The value of the CFP_Dur_Remaining field is zero in beacons sent during the contention period. An example of these relationships is illustrated in figure 6-15, which shows a case where the CFP-Rate is 2 DTIM intervals, the DTIM interval is 3 beacon intervals, and the aCFP_Max_Duration value is approximately 2.5 beacon intervals.

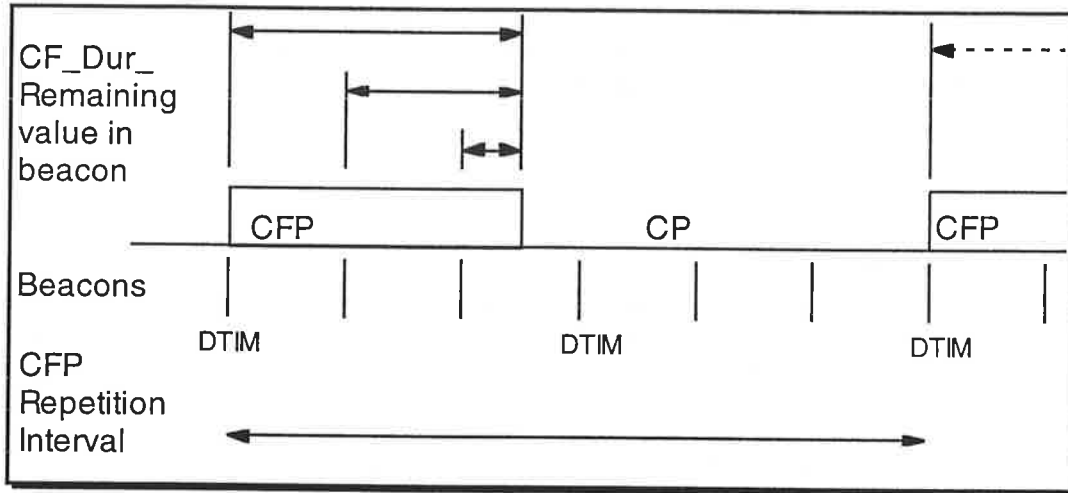


Figure 6-15: Beacons & Contention Free Periods

The PC may terminate any CFP at or before the CFP_Max_Duration, based on available traffic and size of the polling list. Because the transmission of any beacon may be delayed due to a medium busy condition at the ~~TBTT_{nominal}~~ ~~beacon transmission time~~, a CFP may be foreshortened by the amount of the ~~beacon transmission~~ delay. In the case of a busy medium due to DCF traffic, the upper bound on this delay is the maximum RTS + CTS + max_MPDU + Ack duration. In cases where the beacon transmission is delayed, the CFP_Dur_Remaining value in the beacon at the beginning of the CFP shall specify a time that causes the CFP to end no later than the ~~TBTT_{nominal}~~ ~~beacon transmission time~~ plus the value of aCFP_Max_Duration. This is illustrated in figure 6-16.

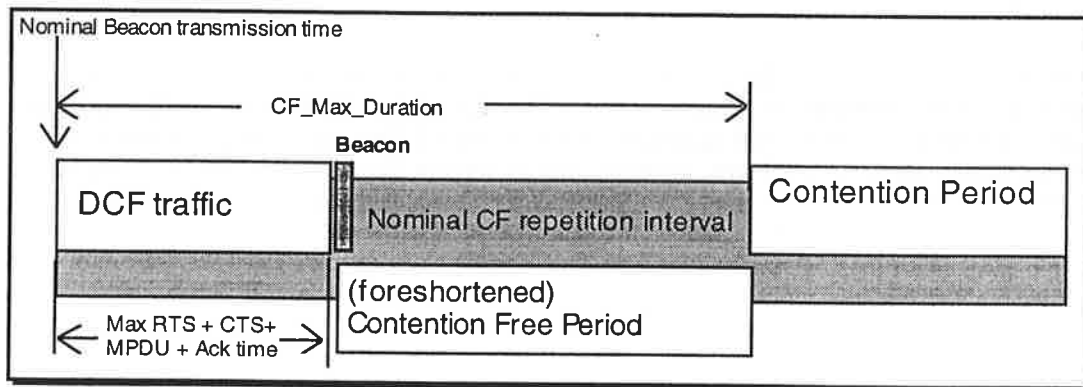


Figure 6-16: Example of Delayed Beacon and Foreshortened CFP

{modifications to clause 6.3.2}

The contention free transfer protocol is based on a polling scheme controlled by a Point Coordinator operating at the AP of the BSS. The PC gains control of the medium at the beginning of the CFP and attempts to maintain control for the entire CFP by waiting a shorter time between transmissions than the stations using the DCF access procedure. At the nominal start time of each CFP (TBTT of the DTIM), all stations in the BSS (other than the PC) set their NAVs to the value most recently received in a CFP Max Duration field of the CF Parameter Set Element of a beacon sent by this PC. This prevents most contention by preventing non-pollled transmissions by stations which received the beacon, whether or not they are CF-aware. Acknowledgment/Acknowledgement of frames sent during the Contention Free Period may be accomplished using Data+CF-Ack, CF-Ack, Data+CF-Poll+CF-Ack (only on frames transmitted by the PC), or CF-Ack+CF-Poll (only on frames transmitted by the PC) frames in cases where a data (or null) frame immediately follows the frame being acknowledged, thereby avoiding the overhead of separate Ack frames. Stations may also acknowledge frames during the Contention Free Period using the DCF Ack mechanism.

{modifications to clause 6.3.2.1}

At the nominal beginning of each CFP, the PC shall sense the medium. When the medium is free (~~both CCA and NAV~~) for one PIFS interval, the PC shall transmit a beacon frame containing a PCF Parameter Set Element with CFP_Rate, CFP_Max_Duration, and CFP_Dur_Remaining fields set as specified above. A DTIM element is also required in this beacon frame.

After the initial beacon frame, the PC waits for ~~the medium to be free (CCA only, not NAV)~~ for one SIFS interval then transmits either a Data frame, a CF-Poll frame, a Data+CF-Poll frame, or a CF-End frame. If a null CFP is desired, a CF-End frame shall be transmitted immediately after the initial beacon.

Stations receiving directed, error-free frames from the PC are expected to respond after an SIFS interval, in accordance with the transfer procedures defined in Section 6.3.3. If the recipient station is not CF-Aware, the response to receipt of an error-free Data frame is always an ACKAck frame.

{modifications to clause 6.3.2.2}

Each station, except the station with the PC, shall preset its NAV to the CFP_Max_Duration CF_Dur_Remaining value (obtained from the CF Parameter Set Element in beacons from this PC) at each TBTT (see 8.1.2.1) at which a Contention Free Period is scheduled to start (based on the CFP_Rate in the CF Parameter Set Element of the beacons from this PC). Each non-PC station shall update its NAV using the CF_Dur_Remaining value in the PCF Parameter Set Element of any error-free ~~the beacon frame containing such an element that the station receives.~~ This includes CF_Dur_Remaining values in CF Parameter Set Elements from beacons received from other (overlapping) BSSes. ~~at the beginning of every CFP.~~ This prevents stations from taking control of the medium during the CFP, which is especially important in cases where the CFP spans multiple medium-occupancy intervals, such as dwell periods of an FH PHY. This setting of the NAV also minimizes eliminates the risk of hidden stations sensing a DIFS gap during the CFP and possibly interfering with ~~corrupting~~ a transmission in progress.

The PC shall transmit a CF-End or CF-End+Ack frame at the end of each CF-Period. Receipt of either of these frames shall reset the NAV of all stations in the BSS.

{modifications to clause 6.3.3}

Frame transfers under the PCF typically consists of alternating between frames sent from the AP/PC and frames sent to the AP/PC. During the CFP, the ordering of these transmissions, and the station allowed to transmit frames to the PC at any given point in time, is controlled by the PC. Figure 6-17 depicts a frame transfer during a typical CFP. The rules under which this frame transfer takes place are detailed in the following paragraphs.

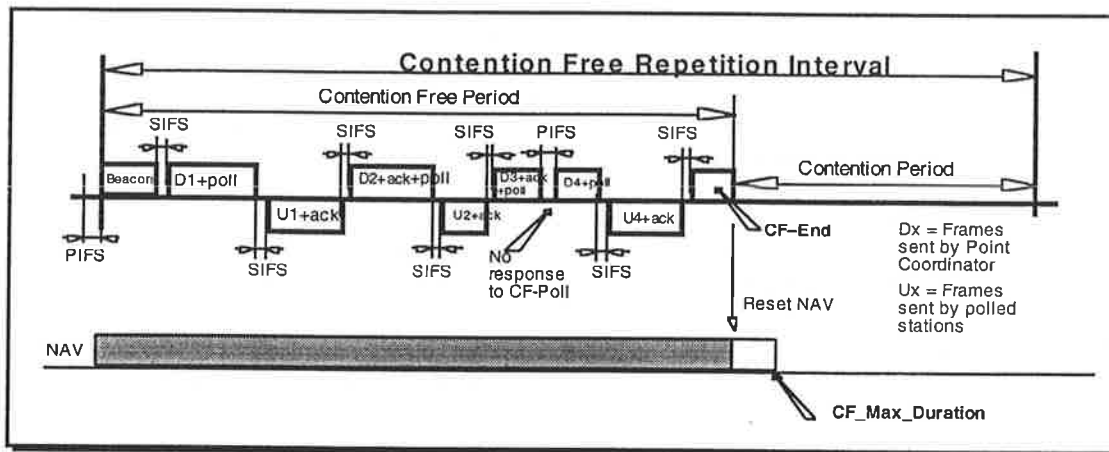


Figure 6-17: Example of PCF Frame Transfer

{modifications to clause 6.3.3.1}

The PC shall transmit frames between the beacon which starts of the CFP and the CF-End using the SIFS gap (CCA only, not NAV) except in cases where a transmission by another station is expected by the PC and a SIFS gap elapses without the receipt of the expected transmission. In such cases the PC may send its next pending transmission as soon as a PIFS gap after the end of its last transmission. This permits the PC to retain control of the medium in cases where an expected response or acknowledgment does not occur. The PC may transmit any of the following frame types to CF-Aware stations:

Data, used when the addressed recipient is not being polled and there is nothing to acknowledge;

Data+CF-Ack, used when the addressed recipient is not being polled and the PC needs to acknowledge the receipt of a frame received from a CF-Aware station an SIFS interval before starting this transmission;

Data+CF-Poll, used when the addressed recipient is the next station to be permitted to transmit during this CFP and there is nothing to acknowledge;

Data+CF-Ack+CF-Poll, used when the addressed recipient is the next station to be permitted to transmit during this CFP and the PC needs to acknowledge the receipt of a frame received from a CF-Aware station an SIFS interval before starting this transmission;

CF-Poll (no data), used when the addressed recipient has no pending frames buffered at the AP, but is the next station to be permitted to transmit during this CFP and there is nothing to acknowledge;

CF-Ack+CF-Poll (no data), used when the addressed recipient has no pending frames buffered at the AP but is the next station to be permitted to transmit during this CFP and the PC needs to acknowledge the receipt of a frame from a CF-Aware station an SIFS interval before starting this transmission;

CF-Ack (no data), used when the addressed recipient has no pending frames buffered at the AP or insufficient time remains in the CFP to send the next pending frame, but the PC needs to acknowledge receipt of a frame from a CF-Aware station an SIFS interval before starting this transmission (useful when the next transmission by the PC is a management frame, such as a beacon); or

any management frame that is appropriate for the AP to send under the rules for that frame type.

The PC may transmit Data or management frames to non-CF-Aware, non-Power Save stations during the CFP. These stations acknowledge receipt with ACKAek frames after an SIFS gap, as with the DCF. The PC may also transmit broadcast or multicast frames during the CFP. Because the Beacon frame that initiates the CFP contains a DTIM Element, if there are associated stations using Power Save Mode, the broadcasts and multicasts buffered for such stations shall be sent immediately after the initial Beacon.

A CF-Poll bit in the Subtype field of these frames will allow the stations to send their ~~(CF-Up)~~ data frames, if any. Stations shall respond to the CF-Poll immediately when a frame is queued, by sending this frame after an SIFS gap. This results in a burst of Contention Free traffic, the CF-Burst.

A CF-Aware station that receives a directed frame with any of data subtypes that include CF-Poll may transmit one data frame ~~when the medium is free (CCA only)~~ an SIFS gap after receiving the CF-Poll. CF-Aware stations ignore, but do not reset, their NAV when performing transmissions in response to a CF-Poll.

For frames that require MAC level acknowledgment, CF-Aware stations that received a CF-Poll (of any type) may perform this acknowledgment using the Data+CF-Ack subtype in the response to the CF-Poll. For example, the U1 frame in Figure 6-18 contains the ~~acknowledgment~~ acknowledgment to the preceding D1 frame. Also the D2 frame contains the ~~acknowledgment~~ acknowledgment to the preceding U1 frame. The PC may use the CF-Ack subtypes to acknowledge a received frame even if the Data frame sent with the CF-Ack subtype is addressed to a different station than the one being acknowledged. CF-Aware stations that are expecting an ~~acknowledgment~~ acknowledgment shall interpret the subtype of the frame (if any) sent by the PC an SIFS gap after that station's transmission to the PC. If a frame that requires MAC level ~~acknowledgment~~ acknowledgment is received by a non-CF-Aware station, that station does not interpret the CF-Poll indication (if any), and acknowledges the frame by sending an ACKAek control frame after an SIFS gap.

~~If a frame, transmitted during the CFP, requires MAC level acknowledgment and is not acknowledged, that frame is not retransmitted during the same CFP. The frame may be retried once, during a subsequent CFP, at the discretion of the PC or CF-Aware station.~~

The sizes of the frames may be variable, only bounded by the frame and/or fragment size limitations that apply for the BSS. If a CF-Aware station does not respond to a CF-Poll (of any type) within the SIFS gap following a transmission from the PC, or a non-CF-Aware station does not return the ACKAek frame within an SIFS gap following a transmission from the PC that requires acknowledgment, then the PC shall resume control and may transmit its next frame after a PIFS gap from the end of the PCF's last transmission. ~~or a non-CF-Aware station does not return the Aek frame within an SIFS gap following a transmission from the PC that requires acknowledgment,~~

A CF-Aware station must respond to a CF-Poll. If the station has no frame to send when polled, the response shall be a Null frame. If the station has no frame to send when polled, but an acknowledgment is required for the frame that conveyed the CF-Poll, the response shall be either a CF-Ack (no data) or an ACKAek control frame. The null response is required to permit a 'no-traffic' situation to be distinguished from a collision between overlapping PCFs.

~~The~~ CFP ends when the CFP_Max_Duration time has elapsed since the last Beacon or when the PC has no further frames to transmit nor stations to poll. In either case, the end of the CFP is ~~signaled~~ signalled by the transmission of a CF-End by the PC. If there is a received frame which requires ~~acknowledgment~~ acknowledgment at the time the CF-End is to be transmitted, the PC transmits a CF-End+Ack frame instead. All stations of the BSS receiving a CF-End or CF-End+Ack reset their NAVs so they may attempt to transmit during the contention period.

{modifications to clause 6.3.3.2}

A CF-Aware station, when transmitting in response to a CF-Poll (any type), may send a Data frame to any station in the BSS an SIFS gap after receiving the CF-Poll. If the addressed recipient of this transmission is not the AP, the Data frame is received and acknowledged according to the DCF rules for Data frames. However, RTS and CTS control frames are never used during the CFP, even if the frame size exceeds aRTS Threshold, because the NAV at all stations in the BSS is already set at least long enough to protect the data frame and its acknowledgment. This is illustrated in Figure 6-18. The PC may resume transmitting as soon as an SIFS gap after the Ack frame, if the PC hears the Ack, or a PIFS gap after the expected time for the ACKAck frame (the PC cannot resume after an SIFS gap because the station-to-station frame may be fragmented), if the PC does not hear the Ack.

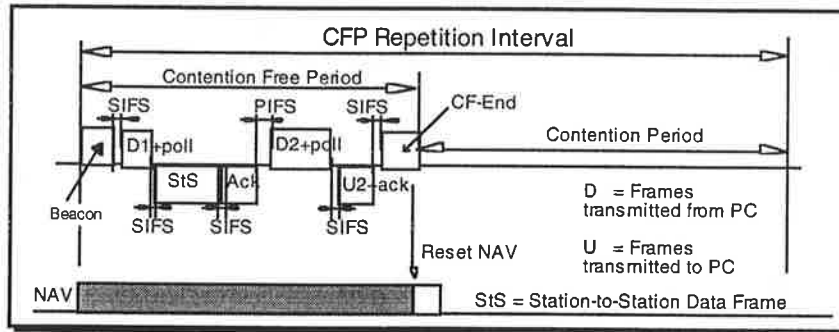


Figure 6-18: Station-to-Station Contention Free Transfer

{modifications to clause 6.3.3.3}

Because the PCF operates without the CSMA/CA contention window randomization and backoff of the DCF, there is a risk of repeated collisions if multiple, overlapping BSSs are operating with PCF on the same PHY channel, and their CFP-Rates and beacon intervals are approximately equal. To minimize the risk of significant frame loss due to CF collisions, the PC shall use a random backoff delay (over the range of 1 to aCW_min slot times) to start a CF period when the initial beacon is delayed because of deferral due to a busy medium. The PC may also use this backoff during the CFP prior to retransmitting an unacknowledged, directed data or management frame. ~~undetected collisions during contention free operation, transmissions of data or management frames during the CFP are only initiated when the medium is free (CCA only, NAV ignored) for the SIFS interval. This is in contrast to Ack frames, which are transmitted (under DCF or PCF) after the SIFS interval without regard to the state of the medium. In addition, whenever the PC has a Data and/or CF-Poll transmission go unacknowledged, the PC shall sense medium-free (CCA only) for the PIFS interval, rather than the SIFS interval prior to its next transmission.~~

To further reduce the susceptibility to inter-PCF collisions, the PC shall require the medium be free for a random (over range of 1 to CW_min) number of slot times once every aMedium_Occupancy_Limit ~~Kmicroseconds~~ milliseconds during the CFP. This can only result in loss of control of the medium to overlapping BSS or hidden station traffic, because the stations in this BSS are prevented from transmitting by their NAV_setting to CFP_Max_Duration or CFP_Dur_Remaining. For operation of the PCF in conjunction with an FH PHY, aMedium_Occupancy_Limit shall be set equal to the dwell time. For operation in conjunction with other PHY types, ~~when using a short CFP_Max_Duration that does not require this extra protection against inter-PCF collisions, aMedium_Occupancy_Limit may~~ be set equal to aCFP_Max_Duration, unless extra protection against PCF collisions is desired. (The Medium_Occupancy_Limit is also useful for compliance in regulatory domains that impose limits on continuous transmission time by a single station as part of a spectrum etiquette.)

{modifications to clause 6.3.3.4}

The value of aCFP_Max_Duration shall be limited to allow coexistence between Contention and Contention Free traffic.

The minimum value for aCFP_Max_Duration, if the PCF is going to be used, is two times aMax_MPDU plus the time required to send the initial Beacon frame and the CF-End frame of the CFP. This allows sufficient time for the AP to send one Data frame to a station, while polling that station, and for the polled station to respond with one Data frame.

The maximum value for aCFP_Max_Duration is the duration of aCFP_Rate minus aMax_MPDU plus the time required for the RTS_/CTS and ~~ACK~~Ack frames associated with this MSDU when operating with default size contention window. This allows sufficient time to send at least one contention-based Data frame.

{modifications to clause 6.3.3.5}

A PC may send broadcast or multicast frames, and directed Data or management frames to any active station, as well as to CF-Aware Power Save stations. During the CFP, CF-aware stations shall acknowledge receipt of each Data+CF-Poll frame-, Data+CF-Ack+CF-Poll frame, CF-Poll (no data) frame, or CF-Ack+CF-Poll frame using Data+CF-Ack or CF-Ack (no data) frames, sent after an SIFS_-interval; ~~(CCA only, NAV ignored);~~ and shall acknowledge the receipt of all other Data and management frames using ACK Control frames sent after an SIFS_-interval (CCA and NAV ignored, as with all ACK frames). Non-CF-aware stations shall acknowledge receipt of (all) Data and management frames using ACK Control frames sent after an SIFS_-interval (CCA and NAV ignored, as will all ACK frames). This non-CF-Aware operation is the same as these stations already do for DCF operation.

When polled by the PCF (Data+CF-Poll, Data+CF-Ack+CF-Poll, CF-Poll, or CF-Ack+CF-Poll) a CF-aware station may send one Data or ~~management~~management frame to any destination. Such a frame directed to or through the PC station shall be acknowledged by the PC, using the CF-Ack indication (Data+CF-Ack, Data+CF-Ack+CF-Poll, CF-Ack, CF-Ack+CF-Poll, or CF-End+Ack) sent after an SIFS_-interval. Such a frame directed to non-PCF stations shall be acknowledged using an ACK Control frame sent after an SIFS_-interval. (This is the same as these stations already do.) A polled CF-aware station with neither a Data frame nor ~~acknowledgment~~acknowledgement to send shall respond by transmitting a Null frame after an SIFS-interval.

The PC shall not issue CF-Polls if insufficient time remains in the current CFP to permit the polled station to transmit a Data frame containing a maximum-length MPDU.

{modifications to clause 6.3.4}

The PCF provides a frame transfer mechanism, not a service class. This transfer mechanism may be used for delivery of asynchronous traffic (data and management frames) that would otherwise be sent in the contention period, ~~and connection-based~~oriented traffic, which may include Time-Bounded Services (TBS), if such connection based functionality is defined elsewhere in this standard. ~~as defined elsewhere in this standard.~~

{modifications to clause 6.3.5}

If the PC supports use of the contention free period for in-bound frame transfer as well as for frame delivery, the PC shall maintain a "polling list" for use in selecting stations that are eligible to receive CF-Polls during contention free periods. The polling list functional characteristics are defined below. If the PC supports the use of the contention free period solely for frame delivery, the PC does not require a polling list, and never generates data frames with a sub-type that includes CF-Poll. The form of contention free support provided by the PC is identified in the Capability Information field of Beacon, Association Response, Reassociation Response, and Probe Response management frames (which are sent from APs, any such frames sent in an Ad-Hoc network always have these bits set to zero). ~~The PC maintains a "polling list" for use in selecting stations that are eligible to receive CF-Polls during contention free periods.~~

Bit 2 ("CF-Aware"):	=1 if a PC is operating at this station
	=0 if no PC is operating at this station
Bit 3 ("CF Polling Request")	=1 if the PC at this station maintains a polling list
	=0 if the PC at this station does not maintain a polling list and only supports CF frame delivery
	(never =1 unless bit 2 is also =1)

The meaning of these bits in the Capability Information field of Association Request, Reassociation Request, and Probe Request management frames are as follows:

Bit 2 ("CF-Aware"):	=1 if the sender can interpret CF sub-types
	=0 if the sender cannot interpret CF sub-types
Bit 3 ("CF Polling Request")	=1 if sender wants to be placed on the polling list
	=0 if the sender does not want to be on the polling list
	(bit 3 ignored when bit 2 is =0)

The polling list is used to force the polling of CF-Aware stations, whether or not the PC has ~~no~~ pending traffic to transmit to those stations. The polling list may be used to control the use of Data+CF-Poll and Data+CF-Ack+CF-Poll types for transmission of Data frames being sent to CF-Aware stations by the PC. The polling list is a *logical* construct, which is not exposed outside of the PCF. A minimum set of polling list maintenance techniques are required to ensure interoperability of arbitrary CF-Aware stations in BSSs controlled by arbitrary CF-Capable access points. APs may also implement additional polling list maintenance techniques which are outside the scope of this standard.

{modifications to clause 6.3.5.1}

The PC shall send a CF-Poll to at least one station during each CFP ~~that station~~ begins when there are entries in the polling list. The PCF shall issue polls to stations whose entries on the polling list are for reasons other than time-bounded service connections in order by ascending SID value. If there is insufficient time to send CF-Polls to all such entries on the polling list during a particular CFP, the polling commences with the next such entry during the next CFP. ~~The issuance of polls to stations whose entries on the polling list are for time-bounded service connections shall follow the rules applicable to the service class.~~ If the DTIM at the beginning of a CFP indicated traffic for any CF-Aware stations using power save mode, that buffered traffic, and polling of those stations occurs, in order by ascending SID, prior to polling of or frame delivery to non-power-save stations on the polling list.

While time remains in the CFP, the PC may generate one or more CF-Polls to *any* stations on the polling list. While time remains in the CFP, the PC *may* send Data or Management frames to *any* stations.

In order to gain maximum efficiency from the contention free period, and the ability to piggyback ~~acknowledgments~~ acknowledgements on successor Data frames in the opposite direction, the PC should generally use

Data+CF-Poll and Data+CF-Ack+CF-Poll types for each data frame transmitted while sufficient time for the potential response to the CF-Poll remains in the CFP. The PC may send multiple frames (with or without CF-Polls) to the same station during a single CFP, and may send multiple CF-Polls to a station in cases where time is available and the station indicates that More frames are available in the frame control field of a transmission in response to a CF-Poll.

{modifications to clause 6.3.5.2}

6.3.5.2. Polling List Update Procedure

A station indicates its CF-Awareness during the Association process. If a station desires to change the PCF's record of CF-Awareness, that station must perform a Reassociation. During Association, a CF-Aware station may also request to be placed on the polling list for the duration of its association, or to never be placed on the polling list. The later is useful for CF-Aware stations that normally use Power Save Mode, permitting them to receive buffered traffic during the CFP (since they have to be awake to receive the DTIM that initiated the CFP), but not requiring them to stay awake to receive CF-Polls when they have no traffic to send.

Stations that establish connections are automatically placed on the polling list for the duration of each connection. Note that any CF-Aware stations may establish connections, and that connection-based services are only available when a PC is operating in the BSS.

CF-Aware stations that are not on the polling list due to a static request during Association, and are not excluded from the polling list due to a static request during Association, may be dynamically placed on the polling list by the PC to handle bursts of frame transfer activity by that station. The PC may monitors CF-aware station activity during both the Contention Free period and the contention period. When a CF-aware station placed on the polling list dynamically has not transmitted a Data frame in response to the number of successive CF-Polls indicated in a Poll_Inactivity, then the PCF may delete that station from the polling list. When a CF-aware station not on the polling list, but not excluded from the polling list, has transmitted any Data frames during the previous contention period, then the PC may add that station to the polling list. This is illustrated in Figure 6-19.

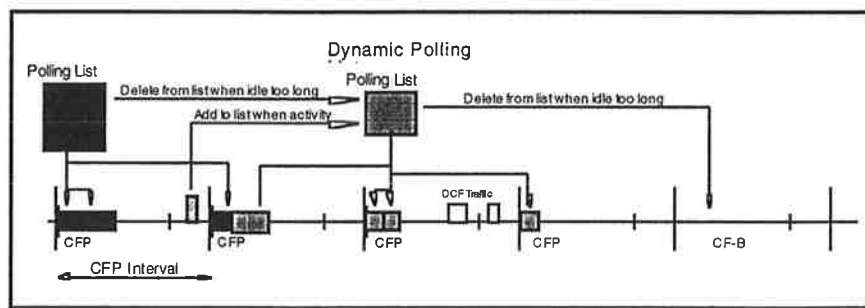


Figure 6-19: Dynamic Polling List Update Technique

{modifications to clause 6.3.6}

6.3.6. Connection Management Frame Usage

Note: The incomplete definition of the connection service specification and the incomplete specification of the connection management frames prevents this section from being complete. These updates reflect letter ballot comments, and do not constitute an attempt to complete definition of the connection management frames nor their usage.

The contention free management frames are used in the following way.

6.3.6.1. STA Start Connection Request

Generated if the MAC user (of a station) makes a "Start Connection Request" when there is no outstanding request.

A station initiates a request for a connection to be established. The Payload must be included in this frame.

Receipt of this management frame will generate a "Start Connection Indication".

6.3.6.2. AP Start Connection Request

Generated if the MAC user (of an AP) makes a "Start Connection Request" when there is no outstanding request.

An AP initiates a request for a connection to be established within the contention free period. The Payload and Connection ID must be included in this frame. The connection ID is the proposed connection ID that of the connection that will be established if this request is granted.

6.3.6.3. Grant Connection

After a Start Connection Request frame has been received the MAC shall reply with a "Grant Connection" frame which indicates the success or failure of the connection request.

If the requested connection is granted, the PC places an entry corresponding to that connection onto the polling list. If a station has multiple connections active, that station appears on the polling list multiple times. Only an access point may assign MAC connection numbers; so if a station is to grant a connection it must return the connection ID that was proposed by the access point. The MAC Connection ID must be included in this frame.

Transmitting or receiving this frame causes a Connection Granted Indication or a Connection Denied Indication.

6.3.6.4. End Connection

Either a station or an access point may initiate the end of a connection. When a node receives an End Connection frame it should stop using that connection, since the sending node will no longer maintain it. The MAC Connection ID must be included in this frame. When the connection is ended, the PC removes the entry corresponding to that station from the polling list.

{modifications to clause 4.3.2.5}

The CF Parameter Set element shall contain the set of parameters necessary to support the PCF. The information field shall contain the CFP_Rate, CFP_Max_Duration and CFP_Dur_Remaining fields. The total length of the information field shall be six octets.

THIS FIGURE NEEDS TO BE CORRECTED BY SOMEONE WHO CAN EDIT THE VISIO DRAWING

Element ID	1 octet
Length	1 octet
CFP_Rate	n octets
CFP_Max_Duration (Kµs)	n octets
CFP_Dur_Remaining (Kµs)	n octets

CFP_Rate shall be two octets in length and shall indicate the number of beacon intervals between the start of CFPs. The value shall be an integral number of DTIM intervals.

CFP_Max_Duration shall be two octets in length and shall indicate the maximum duration, in Kmicroseconds, of the CFP that may be generated by this PCF. This value is used by STAs to set their NAV at the TBTT of beacons that begin CFPs.

CFP_Dur_Remaining shall be two octets in length and shall indicate the maximum time, in Kmicroseconds, remaining in the present CFP, and is set to zero in CFP Parameter elements of beacons transmitted during the contention period. This value is used by all STAs to update their NAVs during CFPs.

CLAUSE 9 — Power Save Mode Details Cleanup

{modifications to clause 8.2.1.1}

Stations changing power management mode shall inform the AP of this fact (~~via~~using the Power Management bits within the Frame Control field of transmitted frames). The AP shall not arbitrarily transmit frames to station operating in a power saving mode, but shall buffer frames and only transmit them at designated times.

The stations which currently have buffered frames within the AP are identified in a **Traffic Indication Map (TIM)**, which shall be included as an element within all Beacons generated by the AP. A station shall determine that a frame is buffered for it by receiving and interpreting a TIM.

Stations operating in power save modes shall periodically listen for Beacons, as determined by the Station's **Listen Interval** parameter.

In a BSS operating under the DCF, or during the contention period of a BSS using the PCF: Upon determining that a frame is currently buffered in the AP, a Station operating in the **Power Save Mode (PSM)** shall transmit a ~~short-PS-Poll control~~ frame to the AP, which will respond with the corresponding buffered frame. If the TIM indicating the buffered frame is sent during a contention free period, a CF-Aware station operating in the PSM does not send a PS-Poll frame, but remains active until the buffered frame is received (or the CFP ends). If any station in its BSS is in power saving mode, the AP shall buffer all broadcast and multicast frames and deliver them to all stations immediately after following the next Beacon frame that contains a Delivery TIM (DTIM) count equal to zero transmission.

A station shall remain in its current power management mode until it informs the AP of a power management mode change via a successful frame exchange. Power management mode shall not change during any single frame exchange sequence, as described in 4.43.

{modifications to clause 8.2.1.2}

A station can be in one of two different power states:

Awake: Station is fully powered.

Doze: Station is not able to transmit or receive and consumes very low power. Some circuitry (such as timers) may still be active.

The manner in which a station transitions between these two power states shall be determined by the station's Power Management Mode (aPower_Management_Mode). These modes are summarized in the table below.

Active Mode or AM

Station may receive frames at any time, ~~so the, no~~ AP does not buffering of directed frames addressed to these stations. In Active Mode, a station shall be in the Awake state. ~~A station on the polling list of a PCF shall be in Active Mode for the duration of the contention free period.~~

Power Save Mode or PSM

Station listens to selected Beacons TIMs (based upon its aListen_Interval) and sends PS-Poll frames to polls the AP if the TIM element in one of those Beacons indicates a directed frame is buffered for that station ~~(except for broadcasts).~~ The AP shall transmit buffered directed unicast frames to a PS station only in response to a PS-Poll from that station, or during the contention free period in the case of a CF-Aware PS station. In PS ~~M~~mode, a station shall be in the Doze state and shall enter the Awake state to receivelisten for selected Beacons TIMs, to received broadcast and multicast transmissions following certain received Beacons, and to transmit, and to await responses to transmitted PS-Poll frames or (for CF-Aware stations) to receive contention free transmissions of buffered frames.

To change power management modes, a station shall inform the AP through a successful frame exchange initiated by the station. The Power Management bits in the Frame Control field of the frame sent by the station in this exchange indicate the power management mode that the station shall adopt upon successful completion of the entire frame exchange.

{modifications to clause 8.2.1.3}

The TIM ~~shall~~^{will} identify the stations for which traffic is pending and buffered in the AP. This information is coded in a ~~compressed~~^{virtual} ~~bitmap~~, as described in 4.3.2.1. In addition the TIM contains an indication whether ~~any b~~^Broadcast or ~~/m~~^Multicast frames are buffered at the AP ~~traffic is pending~~. Every station is assigned a Station ID code (SID) by the AP as part of the association process (see 7.3). SID 0 (zero) shall be reserved to indicate the presence of buffered broadcast or ~~/m~~^Multicast frames. The AP shall identify those stations for which directed frames are buffered by setting bits in the TIM's ~~compressed~~^{virtual} bitmap that correspond to the appropriate SIDs.

{modifications to clause 8.2.1.4}

Two different TIM types are distinguished: TIM and DTIM. After a DTIM, the AP shall send out the buffered~~stored~~ ~~b~~^Broadcast and ~~/m~~^Multicast frames using normal frame transmission rules.

The AP shall transmit TIMs as an element in~~with~~ every Beacon frame. Every ~~a~~^aDTIM_Interval, a TIM of type "DTIM" is transmitted within a Beacon rather than an ordinary TIM. DTIMs are distinguished by the DTIM_Count value in the TIM element being equal to zero.

The following figure illustrates the AP and station activity under the assumption that a DTIM is transmitted once every three TIMs. The top line in the figure represents the time axis, with the Beacon Interval shown together with a DTIM Interval of three Beacon Intervals. The second line depicts AP activity. The AP schedules Beacons for transmission every Beacon Interval, but the Beacons may be delayed if there is traffic at the target beacon transmission times. This is indicated as "busy medium" on the second line. For the purposes of this figure, the important fact about Beacons is that they contain TIMs, some of which may be DTIMs.

The third and fourth lines in the figure depict the activity of two stations operating with different power management requirements. Both stations power on their receivers whenever they need to listen for a TIM. This is indicated in the figure as a ramp-up of the receiver power prior to the target beacon transmission time. The first station, for example, powers up its receiver and receives a TIM in the first beacon which indicates the presence of a buffered frame for it. It generates a subsequent PS-Poll frame, which elicits the transmission of the buffered Data frame from the AP. Broadcast frames are sent by the AP subsequent to the transmission of a Beacon containing a DTIM.

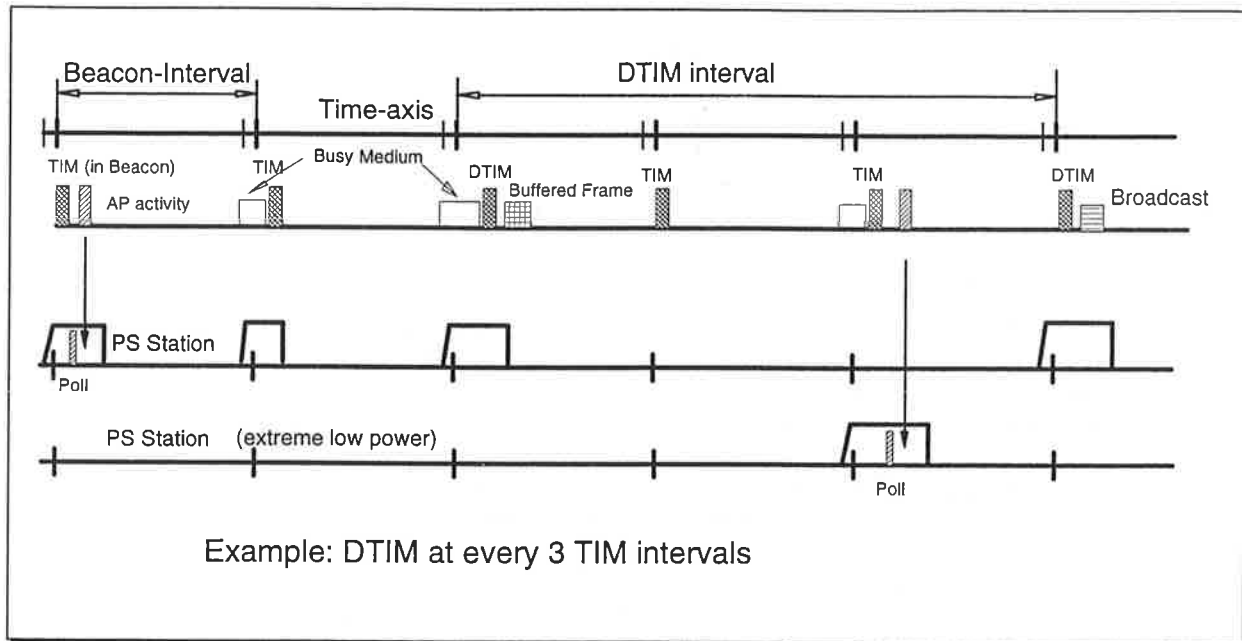


Figure 8-4: Infrastructure Power Management Operation (No PCF Operating)

{modifications to clause 8.2.1.5}

Access Points shall maintain a Power Management status for each currently associated station that indicates in which Power Management mode the station is currently operating. An AP shall, for stations in the Power Save Mode, depending on the Power Management mode of the station, buffer the frames addressed destined to those stations temporarily. The power management support function at APs does not buffer No frames addressed received to for stations operating in the Active Mmode shall be buffered.

- a) Frames addressed destined to for PSM stations shall be temporarily-buffered in the AP.
- b) Frames addressed destined to stations in the Active Mmode shall be directly queued for immediate transmission.
- c) At every Beacon Interval, the AP shall assemble the compressed virtual bitmap containing the buffer status per assigned SID value destination for stations in the PS Mmode, and shall transmit send this bitmap out in the TIM element field of the Beacon frame. The bit for SID 0 (zero) shall be set whenever broadcast or multicast traffic is buffered at the AP. The bit for SID 0 is set in all TIMs, whether or not the DTIM Count value is zero; however, the buffered broadcast and multicast frames are only transmitted following a Beacon frame in which the DTIM Count is zero.
- d) All bBroadcast and MMulticast frames shall be buffered if any associated stations are in the PS Mmode.
- e) Immediately aAfter every DTIM (Beacon frame with DTIM Count equal to zero), the AP shall transmit all buffered broadcast and /multicast frames.
- f) Buffered frames addressed to afor stations in the PS Mmode shall only be transmitted forwarded to that station after a PS-Poll has been received from that station. The AP shall attempt to transmit the buffered data frame within an interval shorter than aResponse Wait following the receipt and acknowledgment of the PS-Poll frame. One buffered data frame is transmitted by the AP after each reception of a PS-Poll frame. The PSM station can determine whether there are additional buffered frames using the "more" indication in the Frame Control field of the data frame transmitted by the AP in response to that station's PS-Poll, and may transmit an additional PS-Poll if the AP indicates the existence of more buffered frames.

- g) An AP shall have an aging function to delete ~~buffered pending frame traffic which remain undelivered when it was buffered~~ for an excessive time period.
- h) Whenever an AP detects ~~that is informed that~~ a station has changed from the Power Save Mode changes to the Active Mode, then the AP shall queue send any buffered frames addressed (if any exist) to that station for immediately transmission.

{modifications to clause 8.2.1.6}

Access Points shall maintain a Power Management status for each currently associated CF-Aware station that indicates in which Power Management mode the station is currently operating. An AP shall, for stations in Power Save Mode, buffer the frames addressed destined to those stations temporarily. The power management support function at APs does not buffer frames addressed to stations operating in the Active Mode.

- a) Frames ~~addressed destined to for~~ PSM CF-Aware stations shall be temporarily buffered in the AP.
- b) Frames ~~addressed destined to~~ stations in the Active ~~M~~mode shall be queued for transmission as defined in 6.3-5.
- c) At the beginning of ~~Prior to~~ every Contention Free Period, and at each Beacon Interval within the Contention Free Period, the AP shall assemble the compressed virtual ~~compressed virtual~~ bitmap containing the buffer status per assigned SID value destination for CF-Aware stations in the PS ~~M~~mode, and shall also set the bits in the compressed virtual bitmap for CF-Aware stations which the Point Coordinator is intending to poll during ~~in~~ this Contention Free Period, and shall transmit send this bitmap out in the TIM element field of the Beacon frame DTIM. The bit for SID 0 (zero) shall be set whenever broadcast or multicast traffic is buffered at the AP. The bit for SID 0 is set in all TIMs, whether or not the DTIM Count value is zero, and whether or not there are any CF-Aware stations operating in the PSM; however, the buffered broadcast and multicast frames are only transmitted following a Beacon frame in which the DTIM Count is zero.
- d) All broadcast and multicast frames shall be buffered if any associated stations are in the PS Mode, whether or not those stations are CF-Aware.
- e) Immediately after every DTIM (Beacon frame with DTIM Count equal to zero), the AP shall transmit all buffered broadcast and multicast frames.
- f) Buffered frames addressed to for stations in the PS ~~M~~mode shall be transmitted forwarded to the CF-Aware stations under control of the Point Coordinator. Transmission of these buffered frames shall begin immediately after transmission of buffered broadcast and multicast frames (if any), and shall occur in order by increasing SID of CF-Aware stations. A CF-Aware station for which the TIM element of the most recent Beacon indicated buffered traffic must be in the Awake state at least until the receipt of a directed data frame from the AP in which the Frame Control field does not indicate the existence of more buffered frames. After acknowledging the last of the buffered, directed frames, the CF-Aware station operating in the PSM may enter the Doze state until the next DTIM is expected.
- g) An AP shall have an aging function to delete ~~buffered pending frame traffic which remain undelivered when it was buffered~~ for an excessive time period.
- h) Whenever an AP detects that a CF-Aware station has changed from the Power Save Mode to the Active Mode, then the AP shall queue any buffered frames addressed to that station for transmission to that CF-Aware station under control of the Point Coordinator.

{modifications to clause 8.2.1.7}

Stations in PS ~~M~~mode shall operate as follows to receive buffered, directed ~~directed~~ frames from the AP when no Point Coordinator is operating and during the contention period when a Point Coordinator is operating, not participating in the contention-free period:

- a) Stations shall enter Awake state~~wake-up~~ so as to receive the next scheduled Beacon frame after a Listen Interval from the last TBTT.
- b) When a station detects that the bit corresponding to its SID is set in the TIM element of a Beacon frame, the station shall transmit~~issue~~ a PS-Poll to retrieve the buffered frame. If more than one bit is set in the TIM element, the station shall wait a random number of slot times (over the range of 1 to aCW_min) prior to initiating the transmission a PS-Poll frame to the AP (using the DCF medium access method)~~shall be transmitted after a random delay~~. Once a station has transmitted a PS-Poll frame, that station shall remain in Awake state at least until the directed data frame sent by the AP in response to the PS-Poll has been received and acknowledged, or until an interval of a Response Wait has elapsed since the AP acknowledged the PS-Poll without receipt of a directed data frame from the AP.
- c) If the Power Management bits in the Frame Control field of a frame received in response to a PS-Poll frame indicate that more traffic for that station is buffered, the station shall transmit another PS-Poll to retrieve the next buffered frame. This polling shall be repeated -until no more frames are buffered for that station.
- d) To receive broadcast and multicast frames, the station shall enter Awake state~~wake-up~~ so as to receive every DTIM, and to remain in the Awake state after any DTIM which indicates frames buffered for SID 0 at least until receipt of a broadcast or multicast frame without the "more" indication in its Frame Control field.

{modifications to clause 8.2.1.8}

Stations in PS Mmode that are associated as CF-Aware in a BSS with an active Point Coordinator shall operate as follows to receive buffered, directed~~a~~ frames from the AP during the contention free period:

- a) Stations shall enter Awake state~~wake-up~~ so as to receive the Beacon frame (which contains a DTIM) at the start of each contention free period, and shall remain in Awake state if the DTIM in the Beacon the next scheduled DTIM.
- b) When a station detects that the bit corresponding to its SID is set in the DTIM at the start of the contention free period (or in a subsequent TIM during the contention free period), the station shall remain in Awake state for at least that portion~~the duration~~ of the contention free period through the time that station receives a directed data frame~~the frame(s) buffered for it in from~~ the AP or until a frame is received with the Power Management bits in the Frame Control field indicating no further traffic is buffered.
- c) If the Power Management bits in the Frame Control field of the last frame received from the AP~~frame~~ indicate that more traffic for that station is buffered when~~and~~ the contention free period ends, the station may remain in Awake state, and transmit~~send~~ a PS-Poll frames during the contention period to the AP to request the delivery of additional buffered frames, or may enter Doze state during the contention period (except when DTIMs are expected during the contention period), awaiting the start of the next contention free period.

{modifications to clause 8.2.1.9}

Stations operating in Active~~this~~ Mmode shall have their transceivers activated continuously. These stations, so they do not need to interpret the TIM element~~traffic announcement~~ part of the Beacon frames.

{new entry for MAC MIB, clause 8.4.##.##}

aResponse Wait ATTRIBUTE
WITH APPROPRIATE SYNTAX

integer;

BEHAVIOR DEFINED AS

"This s attribute is the minimum amount of time, in Kmicroseconds, that a station shall wait, after receiving the acknowledgment for a management request frame to receive the corresponding management response frame, or after receiving an acknowledgment for a PS-Poll frame to receive the corresponding directed data frame, before taking alternate actions due to non-receipt of the expected response.";

REGISTERED AS

{ iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(1) attribute(7) response wait(#) };

CLAUSE 10 — Scanning and Reassociation Details Cleanup

{modifications to clause 8.3.1}

A station shall associate with an access point via the following procedure:

- a) The station shall transmit an Association Request frame to an access point with which that station is authenticated.
- b) If the Association Request frame transmission fails (no acknowledgement), or if the Association Request frame is acknowledged but no corresponding Association Response frame is received within an interval of aResponse Wait, then after the appropriate number of retries, the station shall scan for a different access point with which to attempt association.
- c) If an Association Response frame is received with status value of "successful", the station is now associated with the access point.
- d) If an Association Response frame is received with any status value other than "successful", the station shall scan for a different access point with which to attempt association.

{modifications to clause 8.3.2}

An access point shall operate as follows in order to support the association of stations.

- a) Whenever an Association Request frame is received from a station, the access point shall attempt to transmit a Association Response frame within aResponse Wait of the time at which the AP acknowledges receipt of the Association Request frame. The Association Response frame shall have with a status value of "successful" or one of the failure codes defined in 4.3.1.9 "failed". If the status value is "successful", the assigned Station ID assigned to the newly associated station is included in the response.
- b) When the Association Response with a status value of "successful" frame is acknowledged by the station, the station is considered to be associated with this access point.
- c) The AP shall inform the Distribution System of the association.

{modifications to clause 8.3.3}

A station shall reassociate with an access point via the following procedure:

- a) The station shall transmit a Reassociation Request frame to an access point with which that station is authenticated.
- b) If the Reassociation Request frame transmission fails, (no acknowledgment), or if the Reassociation Request frame is acknowledged but no corresponding Reassociation Response frame is received within an interval of aResponse Wait, then after the appropriate number of retries, the station shall scan for a different access point with which to attempt reassociation.
- c) If an Reassociation Response frame is received with status value of "successful", the station is now associated with the access point.
- d) If an Reassociation Response frame is received with any status value other than of "~~successful~~failed", the station shall scan for a different access point with which to attempt reassociation.

{modifications to clause 8.3.4}

An access point shall operate as follows in order to support the reassociation of stations.

- a) Whenever an Reassociation Request frame is received from a station, the access point shall attempt to transmit a Reassociation Rresponse within aResponse Wait of the time at which the AP acknowledges the receipt of the Reassociation Response frame. The Reassociation Response frame shall have with a status value of "successful" or one of the failure codes defined in 4.3.1.9"failed". If the status value is "successful", the assigned Station ID assigned to the reassociated station is included in the response..
- b) When the Reassociation Response with a status value of "successful" frame is acknowledged by the station, the station is considered to be associated with this access point.
- c) The AP shall inform the Distribution~~Distribution~~ System- of the reassociation.

{modifications to clause 8.1.3.1}

If a Station's aScan_Mode variable is PASSIVE, the station shall listen for Beacon or Probe Response frames on to each channel scanned for a maximum duration aPassive_Scan_Duration.

{modifications to clause 8.1.3.2.1}

Stations receiving a Pprobes frames shall respond with a Pprobe Rresponse frame only if the ESSID is the broadcast ESSID or if the ESSID matches the specific ESSID of the station. Probe Rresponse frames shall be sent as directed frames messages to the source address of the station that generated the Pprobe frame. The Pprobe Rresponse frame shall be sent using normal frame transmission rules. An access point shall respond to all probes meeting the criteria above. In an ad hoc network, the station which that transmitted generated the last Beacon frame shall respond to a Pprobe frames.

In each BSSa network there shall be at least one stationnode that is in Aawake state at any given time to respond to Pprobe frames. The station that sent the most recently transmitted a Beacon frame shall remain in Aawake state, and shall be the only station in the BSS to respond to Probe frames until that station received a Beacon frame from another station in the BSSis received. If the station which sent the Beacon frame is an access point, that station shall always remain in Awake state and shall always respond to Pprobe frames for the BSS.

{modifications to clause 8.1.5 — this is part of the removal of PHY-type-specific operations from the MAC specification, since they belong in the appropriate PHY specification}

NOTE: This only pertains to stations using a Frequency Hopped PHY.

The TSF described here provides a mechanism for synchronization of stations using PHYs, such as frequency hopping PHYs, that require coordinated switching of their use of the physical medium.

in a frequency hopping system to synchronize their transitions from one channel to another (their hops). Every station shall maintain a table of all of the hopping sequences that are used in the system. All of the stations in a BSS shall use the same hopping sequence. Each Beacon and probe response includes the channel synchronization information necessary to determine the hop pattern and timing for the BSS.

The value of the sStation's shall use their TSFTIMER shall be available to the PHY to time the aDwell intervalwell Interval. The dwell interval (of the duration specified by the aDwell_Interval attribute) is the length of time that FH stations will stay on each frequency in their hopping sequence. Once stations are synchronized, they have the same TSFTIMER value, which permits; the PHYs of Sstations in the BSS to shall tune simultaneously (with the uncertainty tolerance of the TSFTIMER value) to the next frequency in the hopping sequence whenever:

$$\text{—————}[\text{TSFTIMER} + \text{aDwell_Offset}] \text{ MOD } \text{aDwell_Interval} = 0$$

During the time this channel switching is in progress, the FH PHY shall generate PHY_CCA.indicate(BUSY) to inform the MAC that the medium is unavailable for the transfer of MPDUs. If an FH PHY receives a PHY_TXSTART.request with a LENGTH parameter in the TXVECTOR that requires a transmission longer than the time remaining in the current dwell interval, the PHY shall not perform the requested transmission, and shall reject the request with an appropriate TXERROR value in the PHY_TXSTART.confirm.

{new entry for the MAC MIB, aResponse_Wait, is used in 8.3 as well as in 8.2, the definition appears at the end of Clause 10 of this document }

CLAUSE 11 — Add “Exclude Unencrypted” Indication to Capabilities Field

{modifications to clause 4.3.1.4; also clarifies the usage of 2 preexisting capability bits }

The Capability Information field contains a number of subfields that are used to indicate requested or advertised capabilitiescapabilities. The length of the Capability Information octet is one octet. The following subfields are defined:

- Bit 0: Infrastructure BSS
- Bit 1: Ad-hoc BSS
- Bit 2: CF-Aware (in frames sent by AP indicates that a point coordinator is present)
- Bit 3: CF Polling Request (in frames sent by AP indicates that the point coordinator maintains a polling list)
- Bit 4: Exclude unencrypted MSDUs
- Bits 5 - 7: Reserved