IEEE P802.11

Wireless Access Method and Physical Layer Specification

Corrections and Clarifications Concerning the PCF

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Abstract

This submission discusses issues relating to the PCF, and harmonization of the updated PCF description (now in section 6.3, formerly in section 5.3) with the rest of the D1.2 draft. Most of the proposed changes comprise a general cleanup, improving consistency, accuracy, and clarity. A few of the proposed changes constitute a simplification which is possible because, as several parts of the 802.11 MAC definition have advanced in parallel, there are more than one mechanism for achieving the same purpose.

Desired Outcome

Adoption of the modified text for inclusion in the D2 draft of the standard..

Consistency Improvements

This submissions contains replacement text for section 6.3 (formerly 5.3), which describes the PCF. These text changes are primarily the result of trying to achieve consistency with other sections updated in creating the D1.2 draft. Most of the changes pertain to eliminating references to CCA sensing after an SIFS interval, which is not possible under the D1.2 definition of CCA (and may never have been possible). Because SIFS is governed by the TX/RX turnaround time, and is defined to be the earliest time that reverse–direction transmission may be initiated, stations involved in this turnaround cannot yet have sensed the medium by the end of the SIFS, so all transmissions after SIFS (under DCF or PCF) are done without CCA sensing. There is also additional mention of the interaction between the DTIM's power save traffic advisory and the polling list processing, based on the changes to power save mode in section 8.2.

Elimination of Redundant Mechanisms

A substantial simplification is proposed to the concept of CFP integrity and retry mechanisms appropriate for use during the CFP. The original PCF definition had two, separate mechanisms for protecting the CFP from collisions: NAV setting in the stations to protect the entire CFP, and use of shorter IFS intervals during the CFP. In D1.1 the NAV setting was weakened in response to letter ballot comments questioning how the stations knew when to set their NAVs to protect the CFP. In the updated section 8.1 (formerly 7.1), the improved definition of TBTT provides a basis to answer that question without weakening the NAV setting mechanism. Therefore, NAV setting becomes the primary mechanism to protect the CFP integrity, and PIFS gaps within the CFP become a permissable mechanism that the PC may use, rather than a mandatory mechanism. This has the advantages of removing overspecification of PC retry rules (since the PC may use backoff within a CFP to recover from suspected collisions), and of improving the integrity of CFPs which span multiple dwell intervals\]

Modifications to D1.2 Text in Sections 4.3 and 6.3 for PCF cleanup

1. placeholder for section 1

2. placeholder for section 2

3. placeholder for section 3

4. placeholder for section 4

UPDATED TEXT FOR CF–RELATED PORTIONS OF SECTION 4

4.3.2.7 CF Parameter Set

The CF Parameter Set element shall contain the set of parameters necessary to support the PCF. The information field shall contain the following parameters. The total length of the information field shall be n octets.

CFP_Rate. This is the number of beacon intervals between the start of CFPs. The value shall be an integral number of DTIM intervals.

CFP_Max_Duration. This is the maximum duration, in milliseconds, of the CFP that may be generated by this PC. This value is used by stations to set their NAV at the TBTT of beacons that begin CFPs.

CFP_Dur_Remaining. This is the maximum time, in milliseconds, remaining in the present CFP, and is set to zero in CFP elements of beacons transmitted during the contention period. This value is used by all stations to update their NAVs during CFPs.

5. placeholder for section 5

6. placeholder for section 6

6.1. placeholder for section 6.1

6.2. placeholder for section 6.2

REPLACEMENT TEXT FOR SECTION 6.3

6.3. Point Coordination Function

The Point Coordination Function (PCF) provides Contention Free frame transfer. It is an option for a STA to be able to become the Point Coordinator(PC). All STA 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) usedby 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 "piggypack" the 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 acknowledgement rules, and the Point Coordinator retains control of the medium by waiting the PIFS duration before resuming CF transfers.

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 an isolated BSS. PCF is activated at a PC---capable AP by setting the aCFP_Max_Duration managed object to a non--zero value.

6.3.1. Contention Free Period Structure and Timing

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 shown in Figure 6-14. Each CFP begins with a Beacon frame that contains a DTIM Element (hereafter referred to as a "DTIM"). The CFPs occur at a defined repetition rate, which is synchronized with the beacon interval as specified below.

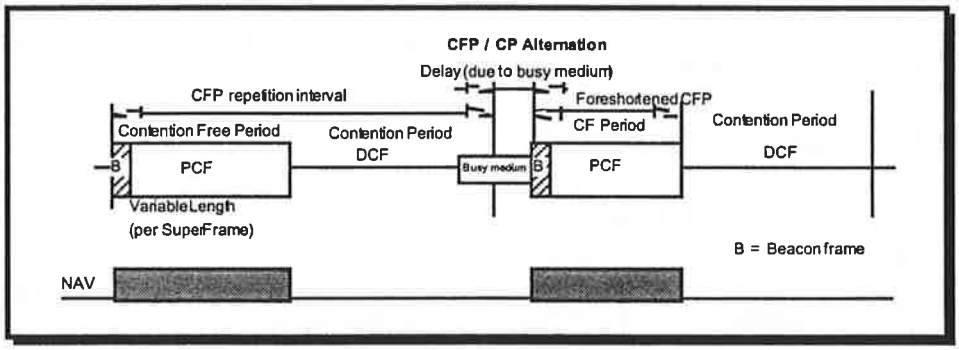

Figure 6-14: CFP / CP Alternation

The PC generates CFPs at the **Contention-Free Repetition Rate** (CFP_Rate), 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 managed object. This value, in units of beacon intervals, is communicated to other stations in the BSS in a field of the PCF Element of Beacon frames. The PCF 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 managed object at the PC. Neither the maximum duration nor the actual duration (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 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 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 CFP_Max_Duration is approximately 2.5 beacon intervals.

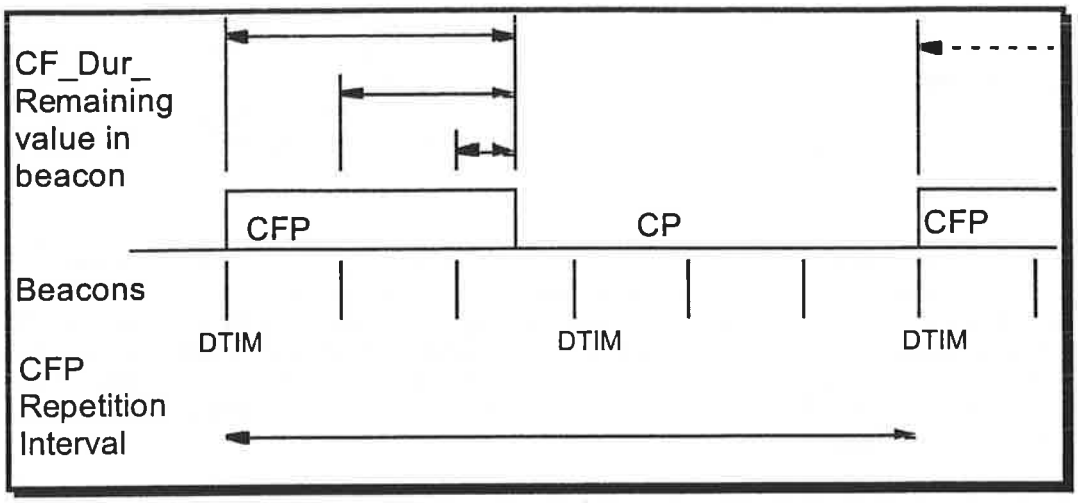

Figure 6-15: Beacons & Contention Free Periods

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 nominal beacon transmission time, a CFP may be foreshortened by the amount of the 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 nominal beacon transmission time plus the value of aCFP_Max_Duration. This is illustrated in figure 6-16.

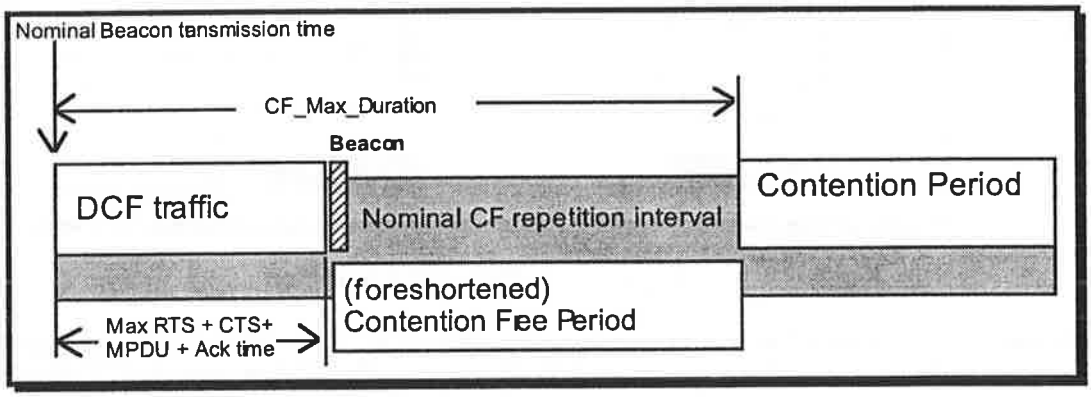

Figure 6-16: Example of Delayed Beacon and Foreshortened CFP

6.3.2. PCF Access Procedure

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. All stations in the BSS (other than the PC) set their NAVs to the CFP_Max_Duration value at the nominal start time of each CFP. This prevents most contention by preventing non–polled transmissions my stations which received the beacon, whether or not they are CF–aware. 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 acknowldege frames during the Contention Free Period using the DCF Ack mechanism.

6.3.2.1. Fundamental Access

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 Element with CFP-Rate 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 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 Ack frame.

6.3.2.2. NAV Operation During the Contention Free Period

Each station, except the station with the PC, shall preset it's NAV to the CFP_Max_Duration ~~CF_Dur_Remaining~~ value (obtained from the PCF element in beacons) at each TBTT (see section 8.1.2.1) at which a Contention Free Period is scheduled to start (based on the CFP_Rate in the PCF Element of the beacons from this PC). Each non–PC station shall update its NAV using the CF_Dur_Remaining value in the PCF Element of any error–free ~~the~~ beacon frame containing such an element that the station receives. This includes CF_Dur_Remaining values in PCF 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 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.

6.3.3. PCF Transfer Procedure

Frame transfer 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.

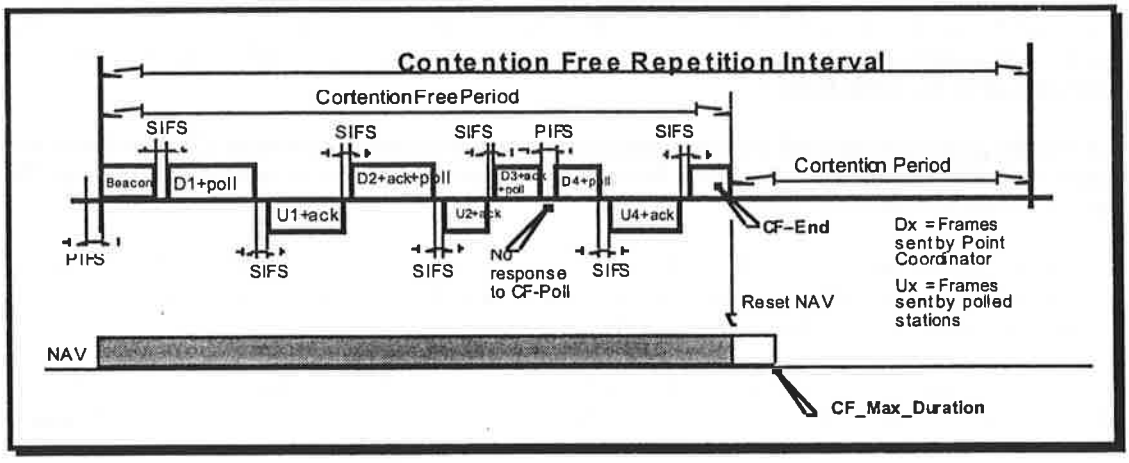

Figure 6-17: Example of PCF Frame Tranfser

6.3.3.1. PCF Transfers When the PCF Station is Transmitter or Recipient

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 an SIFS gap elapses without the receipt of the expected transmission. In such cases the PC mayshall 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 acknowledgement 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 Ack frames after and 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 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 acknowledgement to the preceding D1 frame. Also the D2 frame contains the acknowledgement 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 acknowledgement shall interpret the subtype of the frame (if any) sent by the PC an SIFS gap after that station'Õs transmission to the PC. If a frame that requires MAC level acknowledgement 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 Ack frame after an SIFS gap.

~~If a frame, transmitted during the CFP, requires MAC level acknowledgement 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 Ack 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 Ack 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 Ack frame. The null response is required to permit a 'no-traffic' situation to be distinguished from a collision between overlapping PCFs.

The 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 signalled by the transmission of a CF-End by the PC. If there is a received frame which requires acknowledgement 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.

6.3.3.2. PCF Transfers When the PCF Station is Neither Transmitter nor Recipient

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. This is illustrated in Figure 6-18. The PC may resume~~s~~ 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 Ack 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~~.

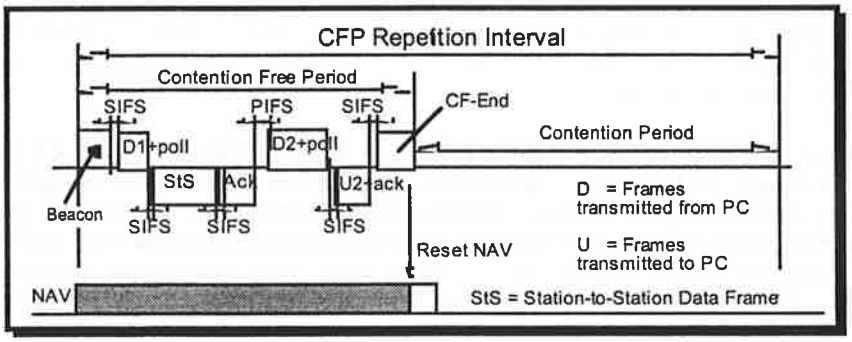

Figure 6-18: Station-to-Station Contention Free Transfer

6.3.3.3. Operation with Overlapping Point-Coordinated BSSs

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 CW_min) 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 an 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 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 NAVs. 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 can be set equal to aCFP_Max_Duration. (The Medium_Occupancy_Limit is also useful for compliance in regulatory domains that impose limits on continuous transmission time as part of a spectrum etiquette.)

6.3.3.4. CFP_Max_Duration Limit

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 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.

6.3.3.5. Contention Free Usage Rules

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 managment 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 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.

6.3.4. Contention Free Service Types

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-oriented traffic, which may include Time-Bounded Services (TBS) as defined elsewhere in this standard.

6.3.5. Contention Free Polling List

The PC maintains a "polling list" for use in selecting stations that are eligible to recive CF-Polls during contention free periods. 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.

6.3.5.1. Polling List Processing

The PC shall send a CF-Poll to at least one station during each 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 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.

6.3.5.2. Polling List Update~~ACFS~~ 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 ony 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 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 aPoll_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.

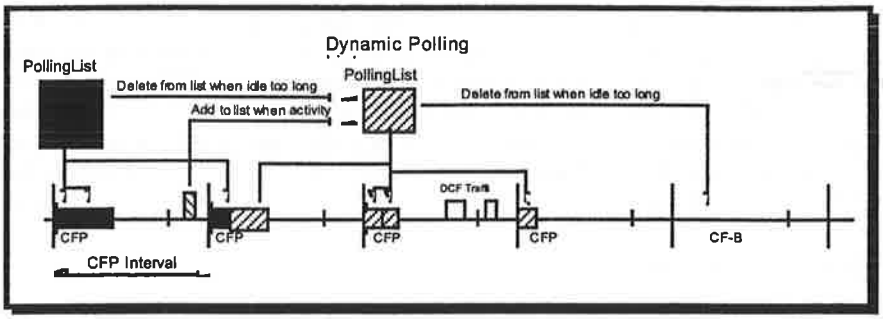

Figure 6-19: Dynamic Polling List Update Technique

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.