Proposed Text for Section 5.3
Based on responses to Draft D1 Letter Ballot processed at May, 1995 Meeting of IEEE P802.11

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Abstract: This paper presents the changes to section 5.3 in the Draft Standard P802.11/D1 as a result of the Response to Draft D1 Letter Ballot processed at the May, 1995 meeting of IEEE P802.11 as shown in the companion Documents P802.11-95/100. All Letter Ballot comments marked as pertaining to section 5.3 were processed at the May, 1995 meeting.

Action: Adopt the changes in this paper to replace the relevant portions of P802.11/D1.1.

5. MAC Sub-layer Functional Description

<placeholder to maintain section numbering>

5.1. MAC Architecture

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5.1.1. Distributed Coordination Function

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5.1.2.Point Coordination Function

The 802.11 MAC may also incorporate an optional access method described as a point coordination function. This optional access method shall be implemented on top of the distributed coordination function. This access method uses a point coordinator 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 sepcified in this standard, to permit effiecent 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. 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~~point~~ 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 ~~away from~~ the other 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 for a limited period of time.

5.1.3.Coexistence of DCF and PCF

The distributed coordination function and the point coordination function shall coexist in a manner that permits both to operate concurrently in the same BSS~~without interference~~. When a point coordinator is operating in a BSS, t~~T~~he two access methods alternate, with ~~are integrated in a **superframe** in which~~ a contention-free period~~burst occurs at the beginning of the superframe,~~ followed by a contention period. This is ~~also~~ described in greater detail in Section 5.3.

5.1.4. Fragmentation/Reassembly Overview

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5.1.5.MAC Data Service

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5.2. Distributed Coordination Function

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5.3. Point Coordination Function

The Point Coordination Function (PCF) provides Contention Free frame transfer~~services~~. It is an option for a STA to be able to become the Point Coordinator (PC). All STA inherently~~shall~~ 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 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 frames sent under PCF control.~~This means that if any STA finds itself in an 802.11 environment where a PCF is being used, it must coexist with the PCF rules~~. 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. ~~However, not all STAs must be capable of becoming the Point Coordinator (PC), which generates the Superframe. Nor, must all STAs be capable of transmitting PCF data 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 5.3.3.3.~~The use of the PCF access method may be restricted to certain PHY types. The basic restriction is that a PCF can not overlap with another PCF on the same channel in a manner that results in destructive interference with frame transfer. This is because contention between multiple overlapping PCF's is not addressed by this protocol.~~

As shown in Figure 5-2, 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.

5.3.1.Contention Free Period ~~Superframe~~ Structure and Timing

The PCF controls frame transfers during~~uses~~ a Contention Free Period~~Superframe~~ (CFP~~SF~~) ~~structure~~. The CFP alternates with a Contention Period (CP), when the DCF controls frame transfers, as shown in Figure 5-15. 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.~~The Superframe is constructed of two major components; a Contention Free (CF) period and a Contention Period. Within a given SF period, the PCF shall be active in the Contention Free Period, while the DCF shall be active in the Contention Period.~~

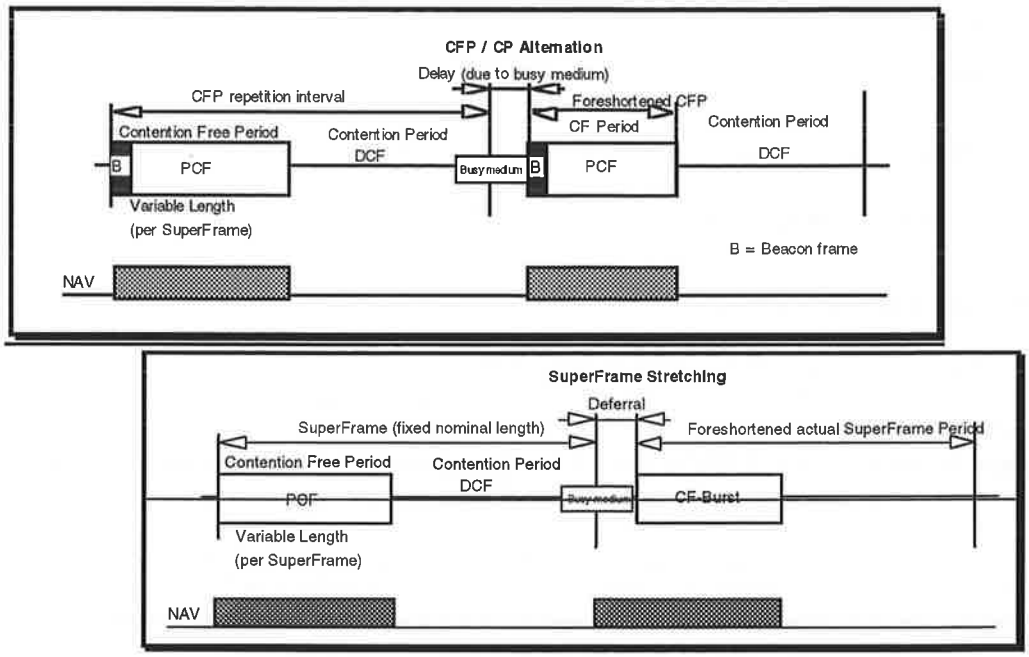


Figure 5-15: CFP / CP Alternation~~PCF Superframe Construction~~

The PC generates CFPs at the **Contention–Free Repetition Rate** (CFP-Rate), which shall 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 a SF is a manageable parameter. If a Frequency Hopping PHY is used, the hop dwell time shall equal n * SF_Length where n is an integer with a minimum value of 1.~~

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 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 5–16, 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. ~~Although the overall nominal boundary of the SF remains fixed as explained above, the actual boundary may vary from one SF to the next. The process of SF stretching is explained in 5.3.2. below.~~

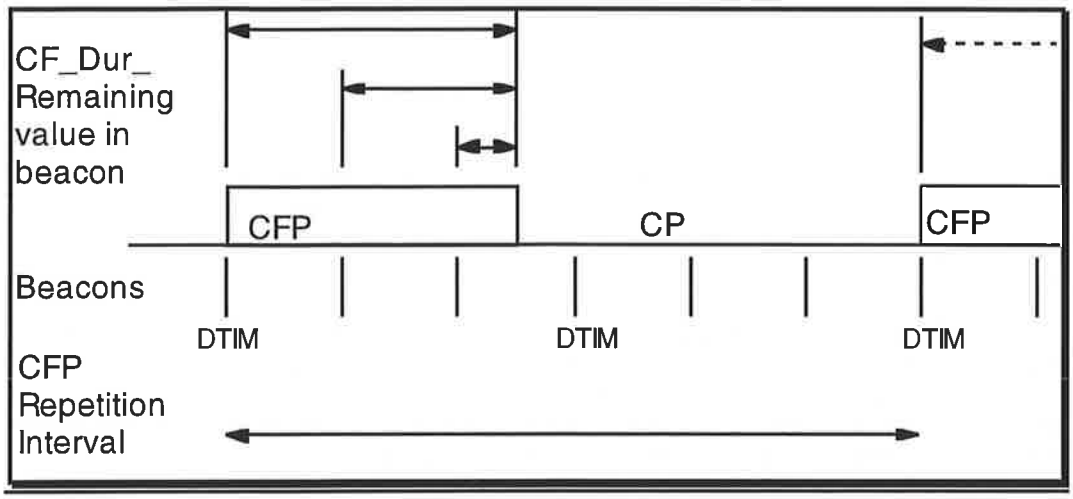


Figure 5-16: Beacons & Contention Free Periods

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 5–17.~~The length of the Contention Free Period may be variable in length on a per SF basis.~~

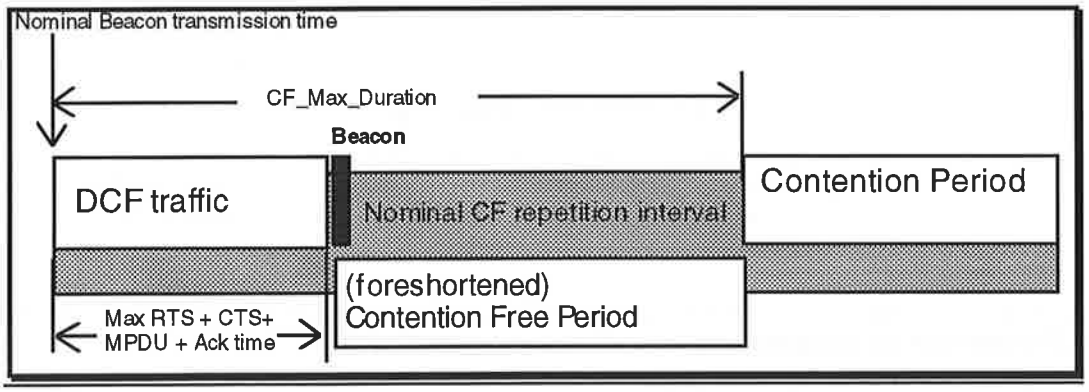


Figure 5-17: Example of Delayed Beacon and Foreshortened CFP

5.3.2.PCF Access Procedure

The contention free transfer~~PCF~~ protocol is based on a polling scheme controlled by a Point Coordinator operating at the AP of the ~~one special STA per BSS called the Point Coordinator (PC)~~. The PC gains control of the medium at the beginning of the CFP~~SF~~ and attempts to maintain~~s~~ control for the entire CFP~~Contention Free period~~ by waiting a shorter time between transmissions than the stations using the DCF access procedure~~normal STA in the BSS~~. ~~Data frames sent from the PCF to associated STA may be termed CF-Down frames and Data frames sent from STA to the PCF may be termed CF-Up frames. However, these terms are strictly descriptive, and the formats of the Data frames are as defined in Section 4.~~ Acknowledgement of ~~Data~~ 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~~a bit~~ in cases where ~~the head~~ a data (or null) frame~~r of~~

immediately follows ~~subsequent Data~~ the frames being acknowledged, thereby avoiding the overhead of separate Ack frames.

5.3.2.1. Fundamental Access

At the nominal beginning of each CFP~~the Superframe~~, the PC~~F~~ shall sense the medium. When~~If~~ the medium is free (both CCA and NAV) for one ~~the PCF shall wait a~~ 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 ~~time and~~ transmits either a Data frame, a CF–Poll frame, a Data+CF–Poll frame, or a CF–End frame. If a null CFP ~~period~~ is desired ~~for this Superframe~~, a CF–End frame shall be transmitted immediately after the initial beacon. ~~If a non-null CF period is desired, the PCF shall transmit a Data frame, with the CF–Poll Subtype bit set, to the next station on the polling list.~~

~~If the medium is sensed busy, the PCF shall continue to monitor the medium until it is free. At the point the medium is sensed free, the PCF shall wait a PIFS time and follow the tansmission procedure described above. This will result in stretching of the Superframe, causing a variable start of the Contention Free period.~~

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 5.3.3. If the recipient station is not CF–Aware, the response to receipt of an error-free Data frame is always an Ack frame.

~~The Asynchronous traffic that uses the DCF will automatically defer until after the Contention Free period because the PCF uses the PCF priority level of the CSMA/CA access protocol. The shorter PIFS gap causes a burst of traffic with inter-frame gaps that are shorter than the DIFS gap needed by stations using the Contention period.~~

5.3.2.2. NAV Operation During the Contention Free Period

Each station, except the station with the PC~~F~~, shall preset it's NAV to the ~~maximum~~ CF_Dur_Remaining value in the PCF Element of the beacon frame ~~CF-Period length~~ at the beginning of every CFP~~SF~~. This ~~is done for several reasons. It~~ prevents stations from taking control of the mediuma duringat the CFP, which is especially important in cases where the CFP spans multiple medium-occupancy intervals, such as dwell periods of an FH PHY ~~beginning of the SF, reducing the likelihood of Superframe stretching~~. This setting of the NAV also minimizes~~It~~ eliminates the risk~~possibility~~ of hidden station ~~from~~ sensing a DIFS gap during the CFP~~Superframe~~ and possibly corrupting a ~~CF~~ transmission in progress.

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

5.3.3.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 5–18 depicts a frame transfer during a typical CFP. The rules under which this frame transfer takes place are detailed in the following paragraphs.

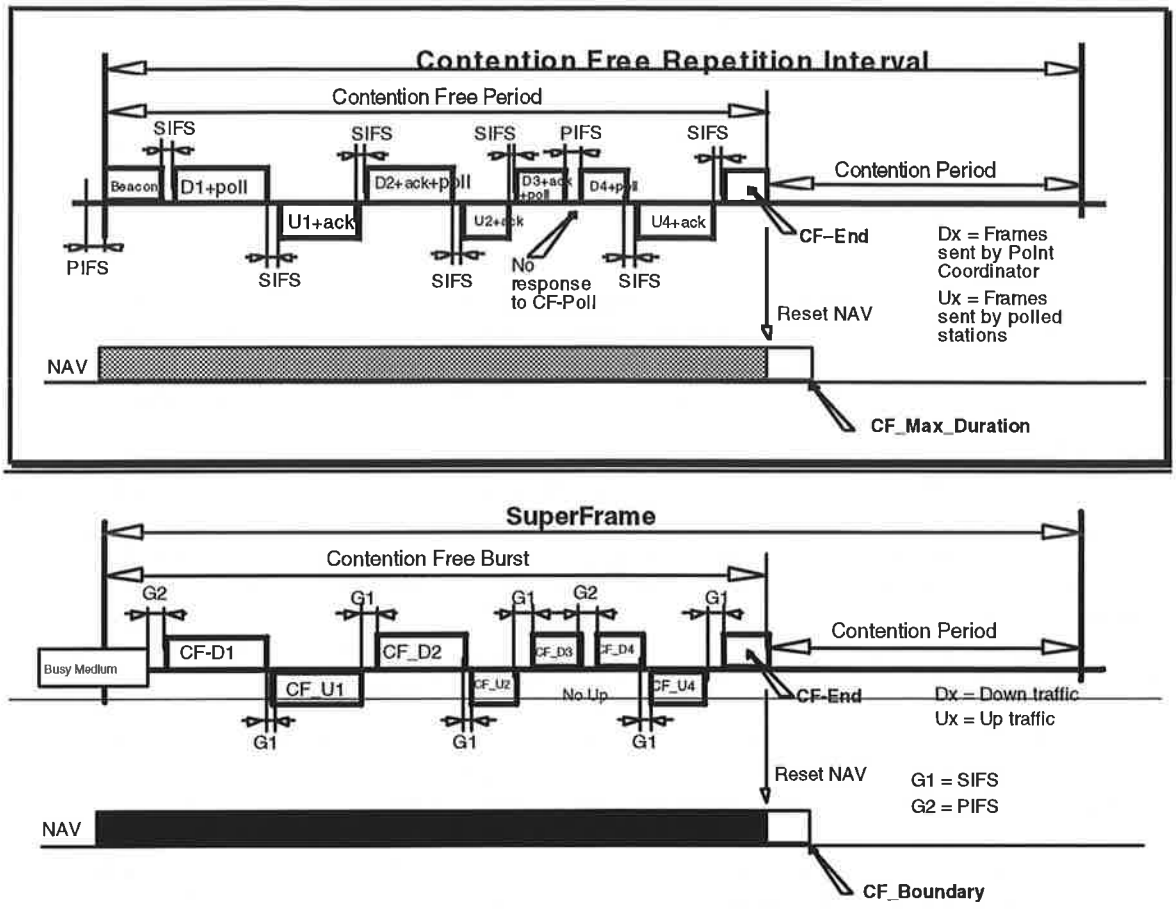


Figure 5-1~~8~~6: Example of PCF Frame Tranfser~~Protocol Operation~~

5.3.3.1. PCF Transfers When the PC~~F Station~~ is Transmitter or Recipient

The PC~~F~~ shall transmit~~send (CF Down)~~ frames between the beacon which start~~s of~~ the CF~~–Period~~ 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~~F~~ and an SIFS gap elapses without the receipt of the expected transmission. In such cases the PC~~F~~ shall send its~~the~~ next pending transmission ~~(CF Down) frame~~ a PIFS gap after the end of its~~the~~ 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~~services~~ that require MAC level acknowledgment, CF–Aware stations that received a CF–Poll (of any type) ~~the~~ may perform this acknowledgment ~~is preferrably done~~ using~~through~~ the Data+CF-Ack ~~bit in the S~~subtype in the response to the CF–Poll.~~field of the responding (CF-Up) frame.~~ For example ~~T~~the U1 frame in Figure 5-1~~8~~6 contains the ~~CF-Ack bit to~~ acknowledgement to the preceding~~previous~~ D1 frame. Also the D2 frame ~~will~~ contains the ~~CF-Ack bit to~~ acknowledgement 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's transmission to the PC. If a ~~(CF-Down)~~ frame that requires MAC level acknowledgement is received by a non–CF–Aware station ~~that is not CF-aware~~, that station does not interpret the CF-Poll indication (if any)~~bit~~, and acknowledges the frame by sending an Ack ~~Control~~ 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~~duration~~ of the frames can 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) ~~react~~ within the SIFS gap following a transmission from the PC~~delay time~~, 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~~F~~ shall resume control and transmit its~~the~~ next frame after a PIFS gap from the end of the PCF's last

transmission. Neither the PC nor CF-Aware stations shall use RTS or CTS frames when attempting to communicate with each other during the CFP.

ANote that a CF–Aware station mustneed not respond to a CF–Poll. Ifwhen the station has no frameCF-Up traffic to send when polled, the response shall be a Null frame. If the station has no frame to send when polled, but an, and no acknowledgment is required to be returned for the preceding CF-Down 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. A responding CF-Up frame in these cases shall not be considered an error.

The the CFP ends when the CF_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.

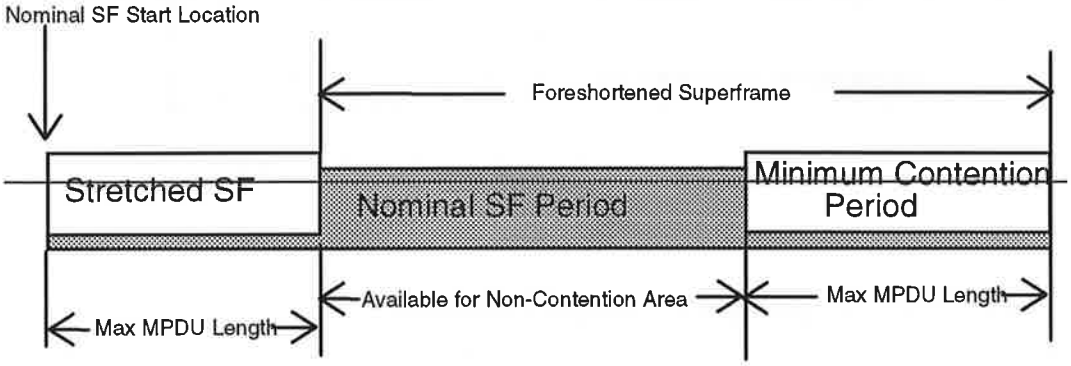


Figure 5-17: Example of SF Stretching Effect

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

A CF-Aaware station, when transmitting in response to a CF–Poll (any type)polled by thePCF, may send a Data frame to any station in the BSS an SIFS gapperiod after receiving the CF-Poll. If the addressed recipient of this transmission is not the AP,PCF station the Data frame is received and acknowledged according to the DCF rules for in the same manner as a contention-based Data frames. This is illustrated in Figure 5–19. The PCF resumes (CF-Down) transmittingssions an SIFS gapperiod after the Ack frame, if the PC hears the Ack, or a PIFS gap after the expected time for the Ack frame if the PC does not hear the Ack. If the station-to-station Data frame is not acknowledged, the PCF resumes (CF-Down) transmissions a PIFS period after the end of the (unacknowledgd) Data frame.

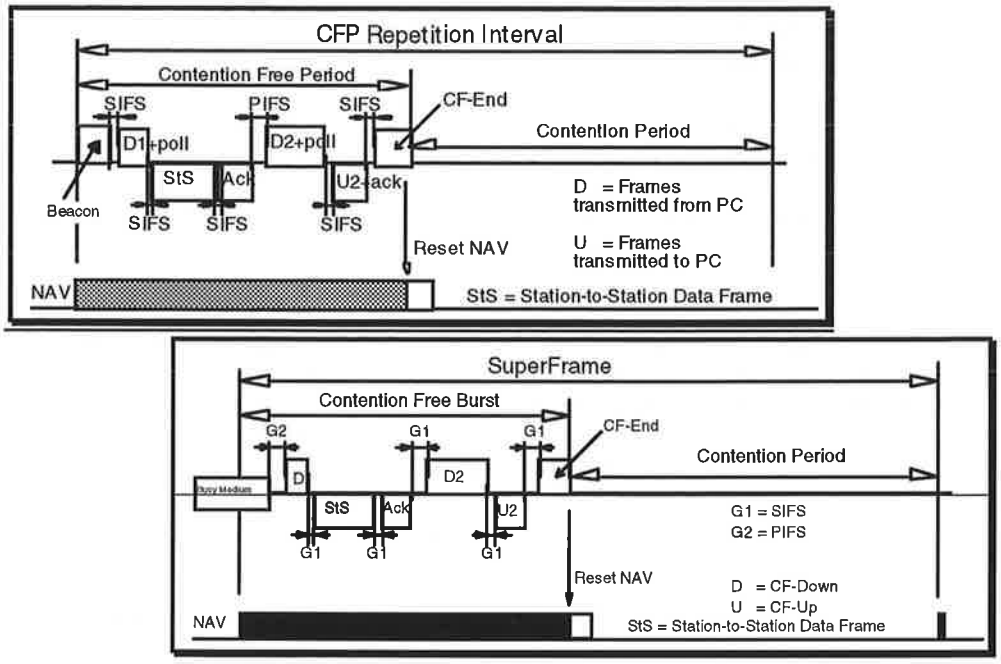


Figure 5–198: Station-to-Station Contention Free~~PCF~~ Transfer

5.3.3.3. 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 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.)

5.3.3.4. CFP_Max_Duration~~Contention Free Length~~ Limit

The value of aCFP_Max_Duration~~Contention Free period~~ 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.

~~The absolute maximum time that is allowed to be allocated to these services in a Superframe is such that at least one maximum size Asynchronous MPDU can still be transmitted during the Superframe period. So:~~

~~CF_Boundary = SF_Period – Max. Async MPDU~~

~~This will allow at least one Asynchronous MPDU to be transmitted during the contention period of each superframe. Note that the start of the CF-Burst can jitter due to the Superframe stretching that may occur when the PCF must defer for *current* DCF traffic.~~

5.3.3.5. Contention Free Usage Rules

~~1. Only Data frames (and resulting Ack frames, if any) shall be sent during the CF-period. All management frames shall be sent during the contention period.~~

~~2.~~ A PC~~F~~ may send ~~Async~~ broadcast or multicast frames, and directed Data or management frames to any active station, as well as to CF–Aware Power Save stations. ~~(not to stations in PSP or PSNP mode).~~ During the CFP, CF-aware stations shall acknowledge receipt of each ~~Async~~ Data+CF-Poll frame, Data+CF-Ack+CF-Poll frame, ~~(from the PCF)~~ CF-Poll (no data) frame, or CF-Ack+CF-Poll frame ~~that has CF-Poll=1~~ using ~~CF-Ack=1 in a~~ Data+CF-Ack or CF-Ack (no data) frames ~~(possibly with No-Data=1)~~, sent after an SIFS–interval (CCA only, NAV ignored); and shall acknowledge the receipt of all other ~~Async~~ 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) ~~Async~~ 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.~~contention–based async.)~~

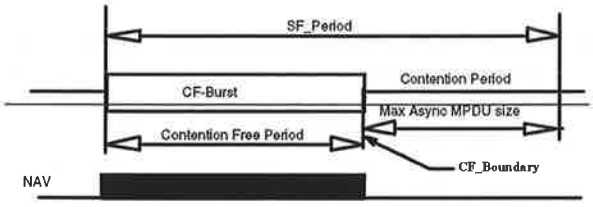
~~3.~~ When polled by the PCF (Data+CF-Poll, Data+CF-Ack+CF-Poll, CF-Poll, or CF-Ack+CF-Poll) ~~=1 in the header of a directed Data frame),~~ a CF-aware station may send one Data or managment frame to any destination. Such a frame directed to or through the PC~~F~~ station shall be acknowledged by the PC~~F~~, using the CF-Ack indication (Data+CF-Ack, Data+CF-Ack+CF-Poll, CF-Ack, CF-Ack+CF-Poll, or CF-End+Ack)~~CF-Ack=1 in a Data frame (possibly with No-Data=1),~~ 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 ~~not~~ respond by transmitting a Null frame after an SIFS–interval~~, permitting the PCF to resume transmission after a PIFS–interval~~.

~~4.~~ The PC~~F~~ shall not issue ~~send Data frames with~~ CF-Polls~~=1~~ if insufficient time remains in the current CFP~~-Period~~ to permit the polled station to transmit a Data frame containing a maximum–length MPDU.

5.3.4. Contention Free Service Types

The PCF provides a frame transfer mechanism, not a service class. This transfer mechanism may be used for delivery of ~~following service types are provided:~~

———asynchronous traffic (data and management frames) that would otherwise be sent in the contention period,~~Asynchronous Service~~and connection-oriented traffic, which may include
———Time-Bounded Services (TBS)~~, that may have multiple service levels~~ as defined elsewhere in this standard.



~~Figure 5-19: PCF Contention-Free Limits~~

5.3.5. Contention Free Polling List~~Asynchronous Contention Free Service~~

~~Asynchronous traffic is characterized by its bursty, connectionless nature. The ACFS allows the PCF to utilize the CF area for asynchronous traffic. The asynchronous traffic conveyed during the contention free period is of the same (asynchronous) service class as the asynchronous traffic conveyed during the contention period.~~

The PC~~F~~ 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~~facilitate~~ polling of CF–Aware stations, whether or not ~~for which~~ the PC~~F~~ has no pending ~~(CF-Down)~~ traffic to transmit to those stations. The polling list~~,~~ ~~and~~ may be used to control the use~~setting~~ of Data+CF-Poll and Data+CF-Ack+CF-Poll types for transmission ~~the CF-Poll bits in the headers~~ of ~~(CF-Down)~~ Data frames being sent to CF-Aware stations by the PC~~F~~. The polling list is a *logical* construct, which is not exposed outside of the PCF. A minimum set of polling list ~~the~~ 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 ~~for~~ which are outside the scope of this standard.

5.3.5.1. Polling List Processing~~CF-Burst~~

The PC~~F~~ shall send a CF-Poll to at least one station ~~Data frame with the CF-Poll bit set~~ during each CFP that ~~superframe when a superframe~~ begins when ~~and~~ there are entries in the polling list. The PCF shall ~~may~~ 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. ~~work through the polling list,~~

While time remains in the CFP, the PC may generate~~ing~~ one or more CF-Polls to *any* stations on the polling list~~, until the CF_Boundary is reached~~. While time remains in the CFP, t~~T~~he PC~~F~~ *may* send Data or managment frames ~~during the CF-Period~~ to *any* stations~~, until the CF_Boundary is reached~~.

In order to gain maximum efficiency~~advantage~~ from the contention free period~~communication~~, and the ability to piggyback acknowledgements on successor Data ~~CF~~ frames in the opposite direction, the PC~~F~~ should generally use~~set the~~ Data+CF-Poll and Data+CF-Ack+CF-Poll types~~bit in the headers~~ for ~~of~~ each ~~(CF-Down) D~~data frame transmitted while sufficient time for the potential response to the CF-Poll remains

in the CFP. ~~by the PCF. The PCF is not required to do this, and in certain cases, such a (CF-Down) frame that acknowledging a (CF-Up) frame less than one MPDU duration from the CF-boundary, the CF-Poll must not be set.~~ 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.

5.3.5.2. Polling List Maintenance Techniques~~ACFS Procedure~~

A station~~STA~~ indicates it's CF-Awareness ~~ability to transmit during the CF period~~ during the Association process. If a station~~STA~~ desires to change the PCF's record of CF-Awareness~~this ability~~, that station~~it~~ 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 indicate the ability to transmit during the CF period are said to be "CF-aware."~~

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 manner in which the PCF updates the polling list is outside the scope of this standard. One possible mechanism, provided as an example, is for~~ the PC~~F to~~ 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 ~~responded~~ to the~~a predefined~~ 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~~a predefined number of~~ Data frames during the previous contention period~~s~~, then the PCF may add that station to the polling list. -This is illustrated in Figure 5–20.

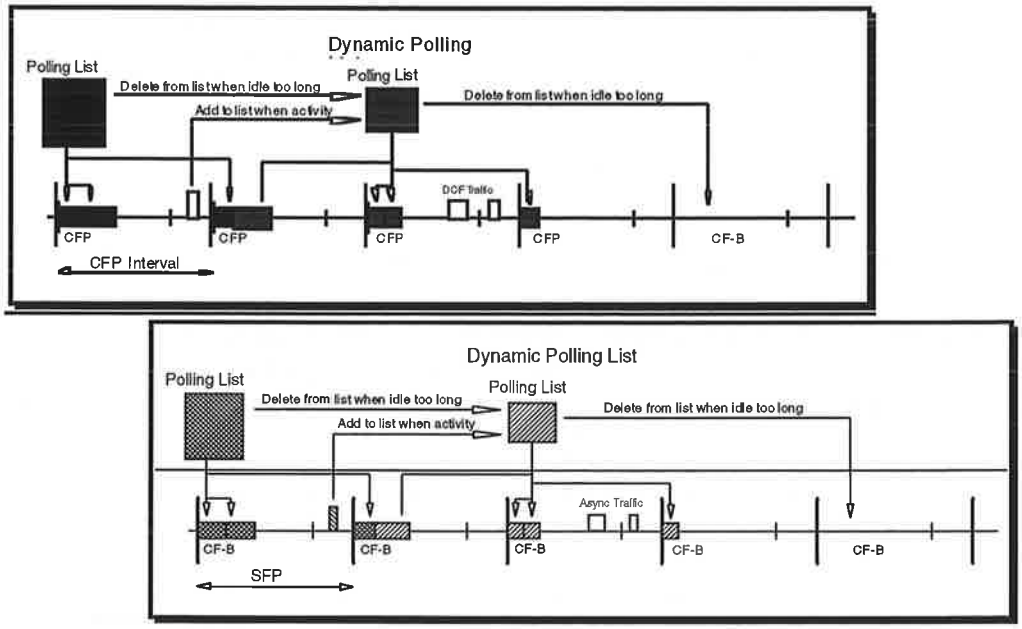


Figure 5-20: Dynamic~~Example~~ Polling List Update Technique

5.3.6. Connection~~Contention Free~~ 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.

5.3.6.1. 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 ~~within the contention free period~~. The Payload ~~element (or field)~~ must be included in this frame.

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

5.3.6.2. 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 ~~elements (or fields)~~ 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.

~~N.B. AP and STA Start Connection Request frames can be the same type, using the "To AP" bit to distinguish them.~~

5.3.6.3. Grant Connection

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

If t~~T~~he 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~~a MAC~~ connection ID that was proposed by the access point. The MAC Connection ID ~~element (or field)~~ must be included in this frame.

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

~~When a connection is granted, the connection may be added to the poll list.~~

5.3.6.4. 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 ~~element (or field)~~ must be included in this frame. When the connection is ended, the PC removes the entry corrresponding to that station from the polling list.

<remainder of section unaffected by PCF-related updates>