IEEE P802.11

Wireless Access Method and Physical Layer Specification

Simplified Contention–Free Asynchronous Service

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Abstract

This submission defines a simplification of the rules and frame types used by the Point Coordination Function (PCF) to support contention–free asynchronous delivery of data frames (CF–Async). The basis of this simplification is the fact that CF–Async is a delivery modality not a service class. This permits the separate contention–free frame type to be eliminated, and a uniform set of frame subtypes defined in the asynchronous frame type for the asynchronous service. The resulting rules for CF–Async usage, are defined, including corrections to an item "broken" in draft 93/20b3, efficiency improvements, and clarification of the optional support for PCF

Purpose: Provides missing information, fixes a broken mechanism introduced in 93/20b3, and simplifies the operation of both the PCF and asychronous data frame delivery.

Objective: Inclusion of the relevant portions of this document into the Draft Standard.

General Characteristics of the PCF and CF–Async Service

The Point Coordination Function (PCF) of the 802.11 MAC protocol is an optional portion of station or AP functionality that provides contention–free asynchronous data frame delivery service. The optional nature of the PCF means that

- no station nor AP is required to be able to operate as a point coordinator, and
- no station is allowed to demand that contention–free asynchronous service be available in any given BSS.

However,

- all stations must be able to operate correctly while a PCF is active in their BSS, and
- any station may use contention–free asynchronous service while a PCF is active in their BSS.

The proposed changes are summarized in document 94/252A. The specific text changes to the draft standard are listed below.

Draft Text Changes

Section 4

4.1.2.1.2. Type and Subtype

The Type and Subtype fields shall identify the function and interpretation of a frame. There are three frame types: control, (asynchronous) data and management. There is also a reserved frame type. Each of the frame types may have several subtypes. The table below lists the valid combination 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	Privacy Request
00	Management	0111	Privacy Response
00	Management	1000	Beacon
00	Management	1001	ATIM
00	Management	1010	Disassociation
00	Management	1011	Authentication
00	Management	1100-1111	Reserved
01	Control	0000-1010	Reserved
01	Control	1011	RTS
01	Control	1100	CTS
01	Control	1101	ACK
01	Control	1110	CF-End
01	Control	1111	Poll
10	Asynchronous Data	0000	Data
10	Asynchronous Data	0001	Data + CF-Ack
10	Asynchronous Data	0010	Data + CF-Poll
10	Asynchronous Data	0011	Data + CF-Ack + CF-Poll
10	Asynchronous Data	0100	Null function (no data)
10	Asynchronous Data	0101	CF-Ack (no data)
10	Asynchronous Data	0110	CF-Poll (no data)
10	Asynchronous Data	0111	CF-Ack + CF-Poll (no data)
10	Asynchronous Data	1000-1111	Reserved
11	Reserved	0000-1111	Reserved

Table 4-1: Valid Type/Subtype Combinations

4.2.2.1. Data Frame Format

< add the following paragraphs at the end of the existing material for this section >

Data frames sent during the contention period shall use the Data Subtype (0000). Data frames sent by the PCF during the contention free period shall use the appropriate ones of the Data Subtypes 0000–0111 based upon the usage rules:

Data Subtypes 0010, 0011, 0110, and 0111 shall only be sent by a PCF.

Data Subtypes 0000, 0001, 0100, and 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 = 00xx. Stations capable of transmitting in response to polling by a PCF shall interpret all Subtype bits of received Data frames.

Section 5

5.3. Point Coordination Function

The Point Coordination Function (PCF) provides Contention Free services forconsisting of asynchronous data types. It is an option for a STA to become the Point Coordinator. All STA shall obey the access rules of the PCF. 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. 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..

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 PCFs 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.

5.3.1. Superframe Structure

The PCF uses a Superframe (SF) structure as shown in Figure 5-1. 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.

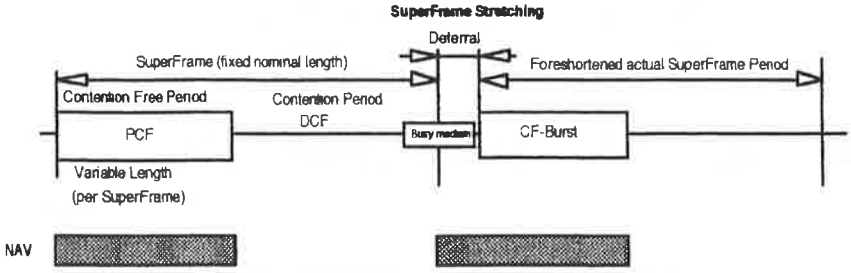

Figure 5-1: PCF Superframe Construction

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.

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.

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

5.3.2. PCF Access Procedure

The PCF protocol is based on a polling scheme controlled by one special STA per BSS called the Point Coordinator (PC). The PC gains control of the medium at the beginning of the SF and maintains control for the entire Contention-Free period by waiting a shorter time between transmissions than the 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 a bit in the header of subsequent Data frames, thereby avoiding the overhead of separate Ack frames.

5.3.2.1. Fundamental Access

At the nominal beginning of the Superframe, the PCF shall sense the medium. If the medium is free the PCF shall wait a PIFS time and transmit either a Data frame or a CF–End frame. If a null CF period is desired for this Superframe, a CF–End frame shall be transmitted. 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.

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

Each station, except the station with the PCF, shall preset it's NAV to the maximum CF-Period length at the beginning of every SF. This is done for several reasons. It prevents stations from taking control of the media at the beginning of the SF, reducing the likelihood of Superframe stretching. It eliminates the possibility of hidden station from sensing a DIFS gap during the Superframe and possibly corrupting a CF transmission in progress.

The PCF shall transmit a CF–End frame at the end of the CF-Period. The CF–End frame shall reset the NAV of all stations in the BSS.

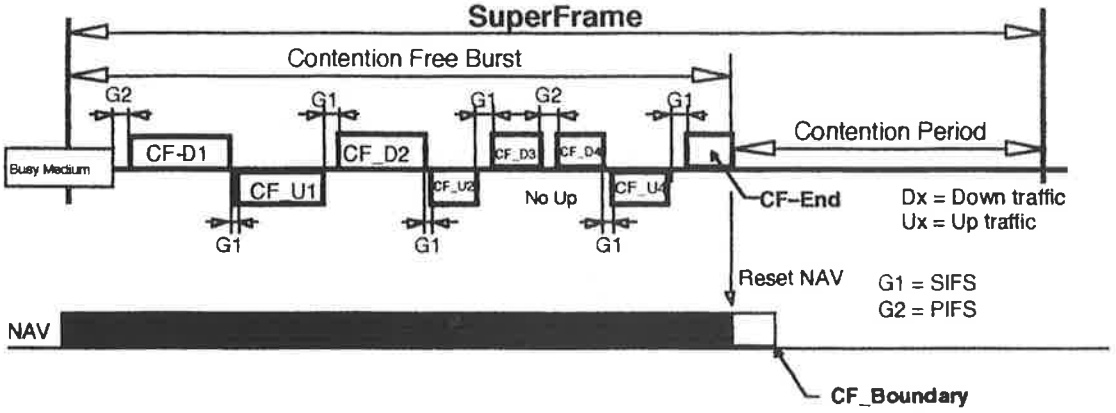

Figure 5-2: Example of PCF Protocol Operation

5.3.3. PCF Transfer Procedure

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

The PCF shall send (CF-Down) frames between the start of the CF–Period and the CF–End using the SIFS gap except in cases where a transmission by another station is expected by the PCF and an SIFS gap elapses without the receipt of the expected transmission. In such cases the PCF shall send the next (CF-Down) frame a PIFS gap after the end of the last transmission. 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.

For services that require MAC level acknowledgment, the acknowledgment is preferrably done through the CF-Ack bit in the Subtype field of the responding (CF-Up) frame. The U1 frame in Figure 5-2 contains the CF-Ack bit to acknowledge the previous D1 frame. Also the D2 frame will contain the CF-Ack bit to acknowledge the preceding U1

frame. If a (CF-Down) frame is received by a station that is not CF-aware, that station does not interpret the CF-Poll bit, and acknowledges the frame by sending an Ack Control frame after an SIFS gap.

The duration of the frames can be variable, only bounded by the frame and/or fragment size limitations that apply for the BSS. If a station does not react within the SIFS delay time, then the PCF shall resume control and transmit the next frame after a PIFS gap from the end of the PCF's last transmission.

Note that a station need not respond when the station has no CF-Up traffic to send, **AND** no acknowledgment is required to be returned for the preceding CF-Down frame. *A responding CF-Up frame in these cases shall not be considered an error.*

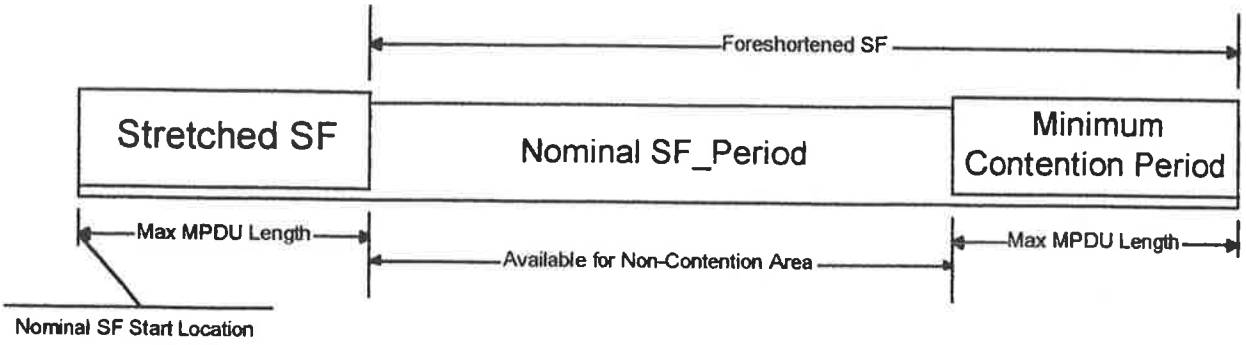

Figure 5-3 Example of SF Stretching Effect

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

A CF-aware station, when polled by thePCF, may send a Data frame to any station in the BSS an SIFS period after receiving the CF-Poll. If the recipient of this transmission is not the PCF station the Data frame is received and acknowledged in the same manner as a contention-based Data frame. The PCF resumes (CF-Down) transmissions an SIFS period after the Ack frame. 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.

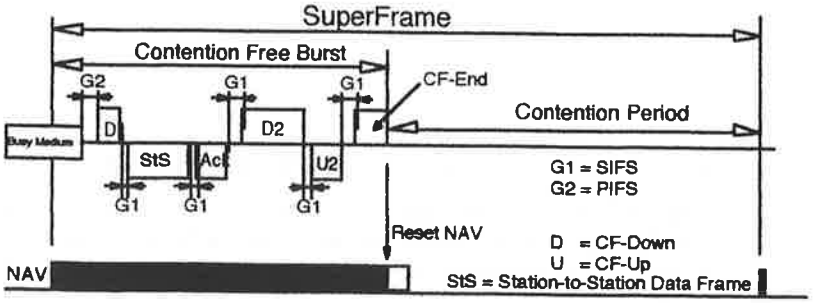

Figure 5–4: Station-to-Station PCF Transfer

5.3.4. Contention Free Service Types

5.3.4.1. Contention Free Length Limit

The Contention Free period shall be limited to allow coexistence between Contention and Contention Free traffic. 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. MPDU

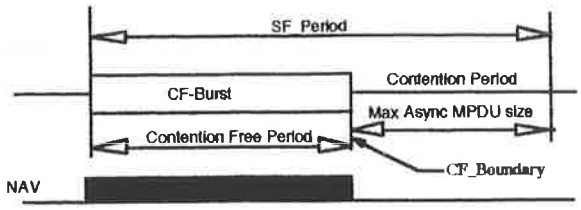

Figure 5-5: PCF Contention-Free Limits

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.

5.3.4.2. 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 PCF may send Async Data frames to any active station (not to stations in PSP or PSNP mode). CF-aware stations shall acknowledge receipt of each Async Data frame (from the PCF) that has CF-Poll=1 using CF-Ack=1 in a Data frame (possibly with No-Data=1), sent after an SIFS–interval; and shall acknowledge the receipt of all other Async Data frames using ACK Control frames sent after an SIFS–interval. Non-CF-aware stations shall acknowledge receipt of (all) Async Data frames using ACK Control frames sent after an SIFS–interval. (This is the same as these stations already do for contention–based async.)

3. When polled by the PCF (CF-Poll=1 in the header of a directed Data frame), a CF-aware station may send one Data frame to any destination. Such a frame directed to or through the PCF station shall be acknowledged by the PCF, using 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, permitting the PCF to resume transmission after a PIFS–interval.

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

5.3.5. 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 PCF 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 facilitate polling of stations for which the PCF has no (CF-Down) traffic, and *may* be used to control the setting of the CF-Poll bits in the headers of (CF-Down) Data frames being sent by the PCF. The polling list is a *logical* construct, the maintenance techniques for which are outside the scope of this standard.

5.3.5.1. CF-Burst

Tthe PCF shall send at least one Data frame with the CF-Poll bit set during each superframe when a superframe begins and there are entries in the polling list. The PCF *may* work through the polling list, generating one or more CF-Polls to *any* stations on the polling list, until the CF_Boundary is reached. The PCF *may* send Data frames during the CF-Period to *any* stations, until the CF_Boundary is reached.

In order to gain maximum advantage from the contention free communication, and the ability to piggyback acknowledgements on successor CF frames in the opposite direction, the PCF should generally set the CF-Poll bit in the headers of each (CF-Down) Data frame transmitted 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.

5.3.5.2. ACFS Procedure

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

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 PCF to monitor CF-aware station activity during both the Contention Free period and the contention period. When a CF-aware station on the polling list has not responded to a predefined number of successive CF-Polls, then the PCF may delete that station from the polling list. When a CF-aware station not on the polling list has transmitted a predefined number of Data frames during contention periods, then the PCF may add that station to the polling list. This is illustrated in Figure 5–6.

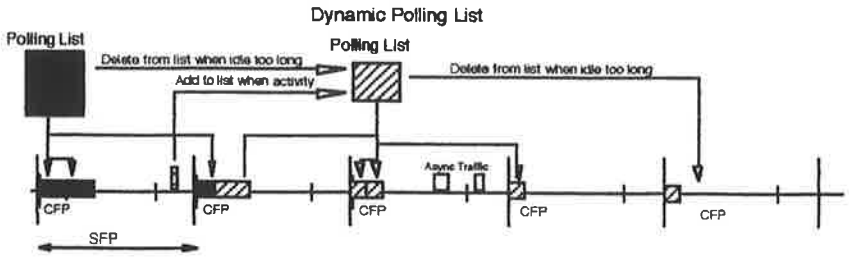

Figure 5-6: Example Polling List Update Technique