IEEE 802.11
Wireless Access Method and Physical Layer Specifications

Title: Changes Required on Draft 3.1 to Support MultiRate

Author:
Pablo Brenner
BreezeCom Ltd.
Atidim Technological Park, Bldg 1
Tel Aviv, 61131
ISRAEL
Phone: Intl+972-3-6459127
Fax: Intl+972-3-6459191
Email: pablob@breezecom.com

Johnny Zweig
Xircom, Inc.
2041 Landings Drive
Mountain View, CA 94043
Tel: (415) 691-2500
Fax: (415) 691-1064
Email: jzweig@xircom.com

Abstract:

This paper, which replaces documents IEEE P802.11-96/71 and IEEE P802.11-96/79 ~~together with document IEEE P802.11-96/71~~, reflects the changes required to the Draft Standard (D3.16) in order to support MultiRate as proposed by the MultiRate Working SubGroup in the March Meeting at La Jolla.

Related Docs:
IEEE P802.11-96/71 - "Extended Interframe Space (EIFS)", Johnny Zweig, Xircom

Action:
Adopt the text changes proposed in this paper for inclusion in P802.11/D4.0

1. Introduction

At the March 1996 meeting in La Jolla, a Multirate Working Group was formed to come up, once and for all, with an approach to the problems associated with supporting multiple different data rates. Among the recommendations of the group was adoption of a "Smart IFS" approach to dealing with traffic for which it is not possible to determine valid Duration information (whether it is due to bit-errors during reception or to the frame being transmitted at an unsupported data rate), the changes related to the Smart IFS are reflected on document P802.11-96/71. This document provides all the other changes which cover Paragraph 9.6 (where MultiRate Support is explained), the related MIB definitions, and some other text changes through the Draft.
The text following this sentence represents the text changes proposed for incorporation into the next revision of the 802.11 specification.

6.2. Detailed Service Specification

6.2.1 MAC Data Services

6.2.1.1 MAUNITDATA request

Function

This primitive requests a transfer of a an 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 parameters of the primitive are as follows:

MAUNITDATA request (
sourceaddress,
destinationaddress,
routinginformation,
data,
priority,
serviceclass
)

The sourceaddress parameter (SA) shall specify an individual MAC sublayer address of the sublayer entity to which the MSDU is being transferred.

The destinationaddress parameter (DA) shall specify either an individual or a group MAC sublayer entity address.

The routinginformation parameter specifies the route desired for the data transfer (a null value indicates source routing is not to be used). For 802.11 the routinginformation parameter shall be Null.

The data parameter specifies the MAC service data unit (MSDU) to be transmitted by the MAC sublayer entity. For 802.11 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. 802.11 allows this parameter to have two values: contention or contention-free.

The serviceclass parameter specifies the serviceclass desired for the data unit transfer. 802.11 allows one value: asynchronous..

When Generated

This primitive is generated by the LLC sublayer entity whenever a MSDU is to be transferred to a peer LLC sublayer entity or entities.

Effect of Receipt

The receipt of this primitive shall cause the MAC sublayer entity to append all MAC specified fields, including DA, SA, and all fields that are unique to 802.11, and pass the properly formatted frame to the lower layers for transfer to peer MAC sublayer entity or entities.

a) The transmission rate used for the frame is controlled by the rate switching algorithm which is implementation dependent and beyond the scope of this standard, whose output is a MAC internal variable (aMAC_Current_Rate), defined in Paragraph 9.6.

7.2 Format of Individual Frame Types

7.2.1.8 RTS Frame Format

The frame format for the RTS frame shall be as defined in Figure 1.

octets: 2	2	6	6	4
Frame Control	Duration	RA	TA	CRC

MAC Header

Figure 1, RTS Frame

The RA of the RTS frame shall be the address of the STA, on the wireless medium, that is the intended immediate recipient of the pending directed Data or Management frame.

The TA shall be the address of the STA transmitting the RTS frame.

The Duration value shall be the time, in microseconds, required to transmit the pending Data or Management frame, plus one CTS frame, plus one ACK frame, plus three SIFS intervals. If the calculated duration includes a fractional microsecond, that value shall be rounded up to the next higher integer.

7.2.2 Data Frames

The frame format for a Data frame is independent of subtype and shall be as defined in Figure 2.

Octets: 2	2	6	6	6	2	6	0 - 2312	4
Frame Control	Duration / ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	Frame Body	CRC

MAC Header

Figure 2, 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 1, 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 1, 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 shall 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 if an acknowledgment 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 which initiated 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 IBSS, the BSS Identifier shall be the BSSID of the IBSS.

The Frame Body shall consist of the MSDU or a fragment thereof, and a WEP IV and ICV (IFF the WEP subfield in the frame control field is set to 1). The frame body is null (zero octets length) in Data frames of Subtype value 01xx.

Data frames sent during the contention period shall use the Data Subtypes: Data, or Null Function. Data frames sent by, or in response to polling by, the point coordinator during the contention free period shall use the appropriate ones of the Data Subtypes based upon the usage rules:

- Data+CF-ACK, Data+CF-ACK+CF-Poll, CF-Poll, and CF-ACK+CF-Poll shall only be sent by a point coordinator.
- Data, Data+CF-ACK, Null Function, and CF-ACK may be sent by a point coordinator or by any CF-aware station.

Stations receiving Data Type frames shall only consider the frame body as the basis of a possible indication to LLC, if the frame has a Subtype field value of 00xx. CF-Aware stations shall interpret all Subtype bits of received Data Type frames for CF purposes, but shall only inspect the frame body if the frame has a Subtype field value of 00xx.

Within all Data Type frames sent during the contention free period, the Duration field shall be set to the value 32768. Within all Data Type frames sent during the contention period the Duration field shall be set according to the following rules:

If the More Fragments bit is set to 0 in the Frame Control field of a frame and the Address 1 field contains an individual address, the Duration value shall be set to the time, in microseconds, required to transmit one ACK frame, plus one SIFS interval. If the More Fragments bit is set to 0 in the Frame Control field of this frame and the Address 1 field contains a group address, the Duration value shall be set to 0.
If the More Fragments bit is set to 1 in the Frame Control field of a frame, and the Address 1 field contains an individual address, the Duration value 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 More Fragments bit is set to 1 in the Frame Control field of the frame, and the Address 1 field contains a group address, the Duration value shall be the time, in microseconds, required to transmit the next fragment of this Data frame, plus one SIFS interval.

<u>The duration value for the Data frame shall be based on the rules in clause 9.6 that will determine the data rates at which the control frames involved are transmitted.</u>

If the calculated duration includes a fractional microsecond, that value shall be rounded up to the next higher integer. All stations shall process Duration field values less than or equal to 32767 from valid data frames to update their NAV settings as appropriate under the coordination function rules.

7.2.3 Management Frames

The frame format for a Management frame is independent of subtype and shall be as defined in Figure 3.

Octets: 2	2	6	6	6	2	0 - 2312	4
Frame Control	Duration	DA	SA	BSS ID	Sequence Control	Frame Body	CRC
MAC Header							

Figure 3, Management Frame Format

The address fields for Management frames shall not vary by frame subtype.

The BSS Identifier of the Management 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 IBSS, the BSS Identifier shall be the BSS ID of the IBSS.
c) In Management frames of Subtype Probe, the BSSID shall either be a specific BSSID, or the broadcast BSSID as defined in the procedures specified in clause **Error! Reference source not found.**.

The DA shall be the destination of the frame.

The SA shall be the address of the station transmitting the frame.

Within all Management Type frames sent during the contention free period, the Duration field shall be set to the value 32768. Within all Management Type frames sent during the contention period the Duration field shall be set according to the following rules:

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

The duration value for the Management frame shall be based on the rules in clause 9.6 that will determine the data rates at which the control frames involved are transmitted.

If the calculated duration includes a fractional microsecond, that value shall be rounded up to the next higher integer. All stations shall process Duration field values less than or equal to 32767 from valid Management frames to update their NAV settings as appropriate under the coordination function rules.

The Frame Body shall consist of the fixed fields and information elements defined for each management frame subtype. All fixed fields and information elements are mandatory unless stated otherwise and shall only appear in the specified order. Stations encountering an element type they do not understand shall ignore that element. Element type codes not explicitly defined in the standard are reserved, and shall not appear in any frames.

7.3.1.10 Status Code

This Status Code shall be used in a response management frame to indicate the success or failure of a requested operation. The length of the Status Code field is two octets. 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
2–9	Reserved
10	Cannot support all requested capabilities in the Capability Information Field
11	Reassociation denied due to inability to confirm that Association exists

12	Association denied due to reason outside the scope of this standard
13	Responding station does not support the specified Authentication Algorithm
14	Received an Authentication Frame with Authentication Transaction Sequence Number out of expected sequence
15	Authentication rejected because of challenge failure
16	Authentication rejected due to timeout waiting for next frame in sequence
17	Association denied because AP is unable to handle additional associated stations
18	Association denied because requesting Station does not support all the rates in the aBSSBasicRateSet
20 - 65535	Reserved

Table 2, Status Codes

7.3.2.4 Supported Rates

The Supported Rates element shall specify all the rates which this station is capable of receiving. The information field is encoded as 1 to 8 octets where each octet describes a single supported rate in units of 100 kbit/s (e.g. a 1 Mbit/s~~Mbit/s~~ rate shall be encoded as 0x0A).

Each rate belonging to the aBSSBasicRateSet as defined in 11.4.4.1.32, shall be encoded as an octet with the most significant bit (bit 7) set to 1 (e.g. a 1 Mbit/s rate belonging to the aBSSBasicRateSet shall be encoded as 0x8A). Rates not belonging to the aBSSBasicRateSet shall be encoded with the most significant bit set to 0.

This information shall be used by STAs in order to avoid associating with a BSS if they do not support all the rates in the aBSSBasicRateSet.

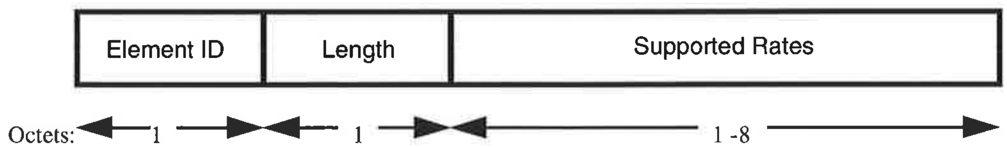

Figure 4, Supported Rates Element Format

9.2.3 Inter-Frame Space (IFS)

The time interval between frames is called the inter-frame space. A STA shall determine that the medium is free through the use of the carrier sense function for the interval specified. ~~Three~~Four different IFSs are defined so as to provide of priority levels for access to the wireless media. The following ~~three~~four different IFSs are defined:

a) SIFS	**Short Interframe Space**
b) PIFS	**Point Coordination Function (PCF) Interframe Space**
c) DIFS	**Distributed Coordination Function (DCF) Interframe Space**
d) EIFS	Extended Interframe Space

The different IFSs are independent of the station bit rate. The IFS timings are defined as time gaps on the medium, and are a fixed per each PHY (even in multi-rate capable PHYs). PHY MIB parameters are specify IFS values.

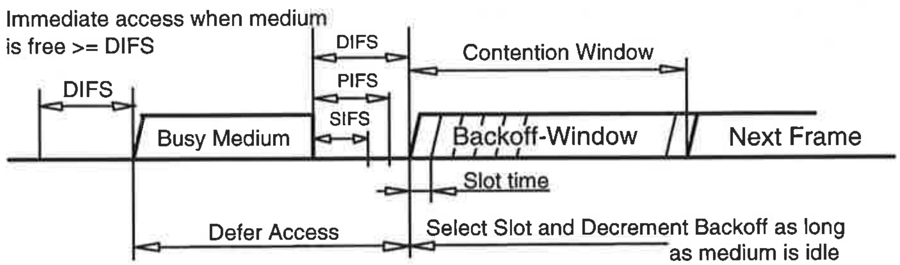

Figure 5, IFS Relationships

9.2.3.1 Short-IFS (SIFS)

The Short Interframe Space shall be used for an ACK frame, a CTS frame, a Data frame of a fragmented MSDU, and by a STA responding to any polling as is used by the Point Coordination Function (PCF) ; and may be used by a point coordinator for any types of frames during the contention free period(See clause **Error! Reference source not found.**, Point Coordination Function). The SIFS is the time from the end of the last symbol of the previous frame to the beginning of the first symbol of the pre-amble of the subsequent frame as seen at the air interface. The valid cases where the SIFS may or shall be used are listed in Frame Exchange Sequences found in clause **Error! Reference source not found.**.

The SIFS timing will be achieved when the transmission of the subsequent frame is started at the Tx_SIFS Slot boundary as specified in clause 0.

This is the shortest of the interframe spaces. It is used when stations have seized the medium and need to keep it for the duration of the frame exchange they have to perform. Using the smallest gap between transmissions within the frame exchange prevents other stations, which are required to wait for the medium to be free for a longer gap, from attempting to use the medium, thus giving priority to completion of the frame exchange in progress.

9.2.3.2 PCF-IFS (PIFS)

The PCF Interface Space shall be used only by the PCF to gain priority access to the medium at the start of the Contention Free Period (CFP). The PCF shall be allowed to transmit contention free traffic after it detects the medium free at the Tx-PIFS slot boundary as defined in clause 0. Clause **Error! Reference source not found.** describes the use of the PIFS by the PCF.

9.2.3.3 DCF-IFS (DIFS)

The DCF Interframe Space shall be used by the DCF to transmit data and management MPDUs. A STA using the DCF shall be allowed to transmit if it detects the medium to be free at the Tx_DIFS slot boundary as defined in clause 0 after a correctly-received frame, and its backoff time has expired. A STA using the DCF shall not transmit within an EIFS after it detects the medium to be free following reception of a frame for which the PHY_RXEND.indicate primitive contained an error or for which the MAC CRC value was not correct.

9.2.3.4 Extended-IFS (EIFS)

The Extended Interface Space shall be used by the DCF whenever the PHY has indicated to the MAC that a frame transmission was begun that did not result in the correct reception of a complete MPDU with a correct CRC value. The duration of an EIFS is defined in clause 9.2.10. The EIFS interval shall begin following indication by the PHY that the medium is free after detection of the erroneous frame, without regard to the virtual carrier-sense mechanism. The EIFS is defined to provide enough time for another station to acknowledge the incorrectly-received frame before the STA commences transmission.

9.2.4 Random Backoff Time

A STA desiring to initiateo transfer of data and management MPDUs shall utilize both the physical and virtual carrier sense functions to determine the state of the medium. If the medium is busy, the STA shall defer until after a DIFS is detected, or an EIFS if last frame detected on the medium was not received correctly, and then generate a random backoff period for an additional deferral time before transmitting. This process minimizes collisions during contention between multiple STA that have been deferring to the same event.

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

where:

CW = An integer between the values of MIB variables aCW_{min} and aCW_{max}
Random() = Pseudo random number between 0 and 1
Slot Time = The value of MIB variable aSlot_time

The Contention Window (CW) parameter shall take an initial value of aCW_{min} for every MPDU queued for transmission. The CW shall take the next value in the series at every retry to send a particular MPDU until it reaches the value of aCWmax. A retry is defined as the entire sequence of frames sent to attempt to deliver an MPDU. The CW will remain at a value of aCWmax for the remaining retries. This improves the stability of the access protocol under high load conditions. See Figure 6.

The set of CW values are 7 (Cwmin), 15, 31, 63, 127, 255 (CWmax).

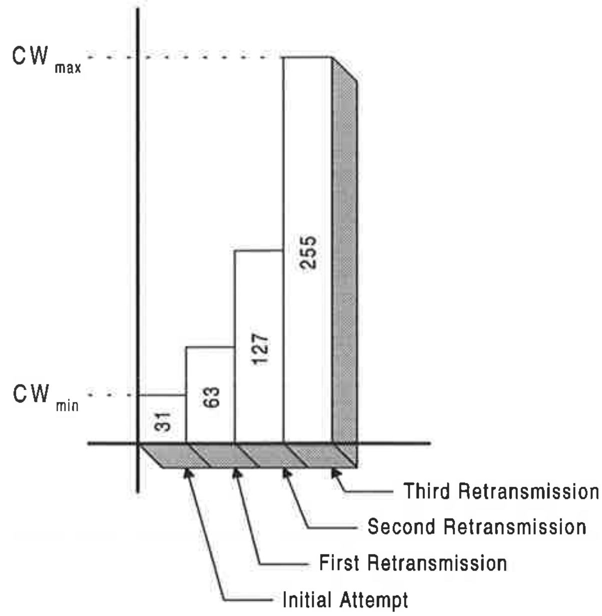

Figure 6, Exponential Increase of CW

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

9.2.5 DCF Access Procedure

The CSMA/CA access method is the foundation of the Distributed Coordination Function. The operational rules vary slightly between Distributed Coordination Function and Point Coordination function.

9.2.5.1 Basic Access

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

A STA may transmit a pending MPDU when it is operating under the DCF access method, either in the absence of a Point Coordinator or in the Contention Period of the PCF, when it detects the free medium for greater than or equal to a DIFS, or an EIFS if the medium-busy event was caused by detection of a frame that was not received with a correct MPDU CRC value. If, under these conditions, the medium is busy when a STA desires to initiate the initial frame of one of the frame exchanges described in clause **Error! Reference source not found.**, exclusive of the CF period, the Random Backoff Time algorithm shall be followed.

The basic access mechanism is illustrated in the following diagram.

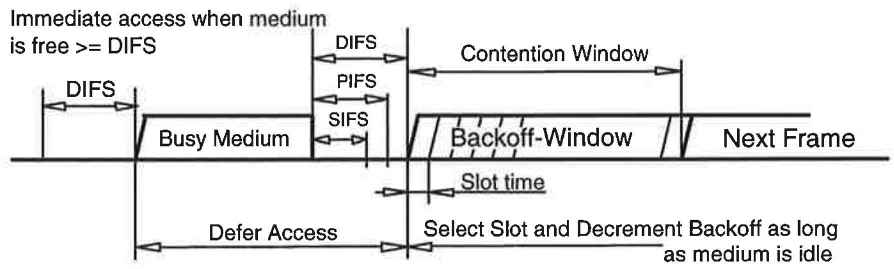

Figure 7, Basic Access Method

9.2.5.2 Backoff Procedure

The backoff procedure shall be followed whenever a STA desires to transfer an MPDU and finds the medium busy as indicated by either the physical or virtual carrier sense mechanism (Figure 8).

To begin the backoff procedure, the STA shall select a backoff time from the equation in clause 0 Random Backoff Time. All backoff slots occur following a DIFS period during which the medium is free for the duration of the DIFS period, or following an EIFS period during which the medium is free for the duration of the EIFS period following detection of a frame that was not received correctly.

A STA in backoff must monitor the medium for carrier activity during backoff slots. If no carrier activity is seen for the duration of a particular slot, then the random backoff process shall decrement its count by aSlot_time.

If there is carrier activity sensed at any time during a slot, then the backoff procedure is suspended, that is, the backoff timer shall not be decrement for that slot; The medium must be sensed as idle for the duration of a DIFS or EIFS (as appropriate) period before the backoff procedure is allowed to resume. Transmission shall commence whenever the Backoff Timer reaches zero.

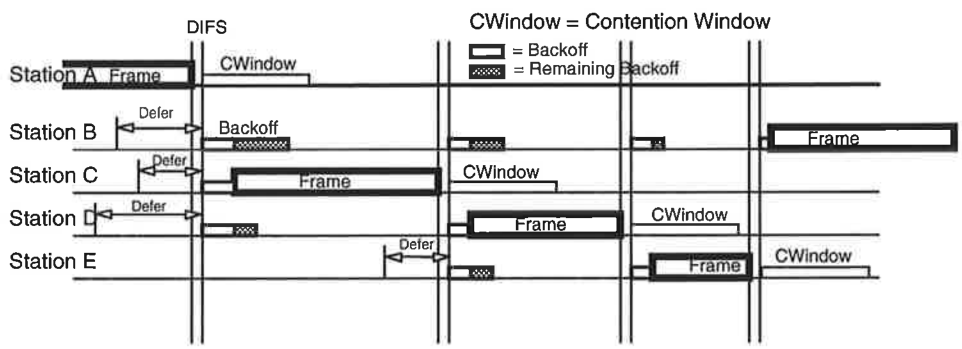

Figure 8, Backoff Procedure

A station that has just transmitted an MSDU and has another MSDU ready to transmit (queued), shall perform the backoff procedure. This requirement is intended to produce a level of fairness of access amongst STA to the medium.

The effect of this procedure is that when multiple stations are deferring and go into random backoff, then the station selecting the lowest delay through the random function will win the contention. The advantage of this approach is that stations that lost contention will defer again until after the next medium busy event, and will then likely have a shorter backoff delay than new stations entering the backoff procedure for the first time. This method tends toward fair access on a first come, first served basis.

9.2.10 DCF Timing Relations

The relationships between the IFS specifications are defined as time gaps on the medium. The associated MIB variables are provided per PHY.

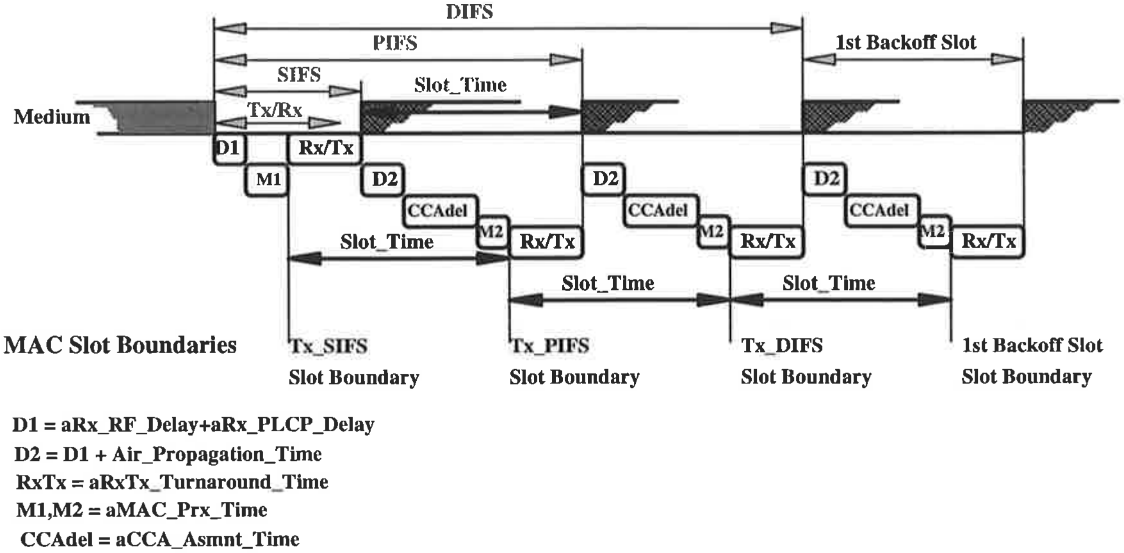

Figure 9, DCF Timing Relationships

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

The aSIFS_Time, and aSlot_time are defined in the MIB, and are fixed per PHY.

aSIFS_Time is: aRx_RF_Delay + aRx_PLCP_Delay + aMAC_Prc_Delay + aRxTx_Turnarounf_Time.

ASLoT_time is: aCCA_Asmnt_Time + aRxTx_Turnaround_Time + aAir_Propagation_Time

The PIFS and DIFS are derived by the following equations, as illustrated in Figure 9.

PIFS = aSIFS_Time + aSlot_time

DIFS = aSIFS_Time + 2 * ASLoT_time

aAir_Propagation_Time is fixed at 1 usec.

The EIFS is derived from the SIFS and the DIFS and the length of time it takes to transmit an Acknowledge control frame at 1 Mbps by the following equation:

EIFS = aSIFS_Time + aACK_Time + aDIFS_Time

Figure 9 illustrates the relation between the SIFS, PIFS and DIFS as they are measured on the medium and the different MAC Slot Boundaries Tx_SIFS, Tx_PIFS and Tx_DIFS. These Slot Boundaries define when the transmitter can be turned on by the MAC to meet the different IFS timings on the medium, after subsequent detection of the CCA result of the previous slot time.

The following equations define the MAC Slot Boundaries, using parameters defined in the MIB, which are such that they compensate for implementation timing variations. The reference of these slot boundaries is again the end of the last symbol of the previous frame on the medium.

Tx_SIFS = SIFS - aRxTx_Turnaround_Time

Tx_PIFS = Tx_SIFS + ASLoT_time

Tx_DIFS = Tx_SIFS + 2 *aSlot_time.

The tolerances are specified in the PHY MIB, and will only apply to the SIFS specification, so that tolerances will not accumulate.

9.6 Multirate Support

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

All Control Frames shall be transmitted at one of the PHY mandatory rates so they will be understood by all stations.

All Multicast and Broadcast Frames shall be transmitted at one of the rates included in the aBSSBasicRateSet, regardless of their type.

Unicast Data and/or Management Frames shall be sent on any supported data rate selected by the rate switching mechanism (whose output is an internal MAC variable called aMACCurrentRate, defined in units of 100KBit/s, which is used for calculating the duration field of each frame). A station shall not transmit at a rate that is known not to be supported by the destination station, as reported on the Supported Rates Element in the Management Frames.

Under no circumstances shall a station initiate transmission of a Data or Management frame at a data rate higher than aMaxRate.

In order to allow the transmiting station to calculate the Duration, the responding station shall transmit the Control Response frame (either CTS or ACK) at the same rate as the immediately previous frame in the frame exchange sequence (as defined in Paragraph 9.7), if this rate belongs to the PHY mandatory rates, or else at the highest possible rate belonging to the PHY mandatory rates.

11.4.1.2 MAC Attributes

11.4.1.2.1 agAddressgrp

aMACAddress,
aGroupAddresses;

11.4.1.2.2 agOperationgrp

aMaxRate~~Factor~~,
~~aHandshakeOverhead,~~
aRTSThreshold,
aCWmax,
aCWmin,
aCTSSize~~Time~~,
aACKSize~~Time~~,
aACKTimeout,
aShortRetryLimit,
aLongRetryLimit,
aMaxFrameLength,
aFragmentationThreshold,
aProbeDelay,
aMinProbeResponseTime,
aMaxProbeResponseTime,
aMaxTransmitMSDULifetime,
aMaxReceiveMSDULifetime;

11.4.2 Managed Object Class Templates

11.4.2.1 SMT Object Class

11.4.2.1.1 oSMT

SMT MANAGED OBJECT CLASS
DERIVED FROM "ISO/IEC 10165-2":top;
CHARACTERIZED BY
pSMTbase PACKAGE
BEHAVIOUR
bSMTbase BEHAVIOUR
DEFINED AS "The SMT object class provides the necessary support at the station to manage the processes in the station such that the station may work cooperatively as a part of an 802.11 network.";
ATTRIBUTES

aStationID	GET,
aActingasAPStatus	GET,
aActingasWirelessAPStatus	GET,
aCurrentBSSID	GET,
aCurrentSSID	GET-REPLACE,
aKnownAPs	GET,
aAuthenticationAlgorithms	GET,
aAuthenticationType	GET-REPLACE,
aPrivacyOptionImplemented	GET,
aPrivacyInvoke	GET-REPLACE,
aDefaultWEPKey	GET-REPLACE,
aWEPDefault	GET-REPLACE,
aWEPKeyMapping	GET-REPLACE,
aExcludeUnencrypted	GETREPLACE,
aICVErrorCount	GETREPLACE,
aAssociatedState	GET,
aBeaconPeriod	GET-REPLACE,
aPowerManagementMode	GET-REPLACE,
aPassiveScanDuration	GET-REPLACE,
aListenInterval	GET-REPLACE,
aScanMode	GET-REPLACE,
aScanState	GET,
aMediumOccupancyLimit	GET-REPLACE,
aMaxMPDUTime	GET-REPLACE,
aCFPMaxDuration	GET-REPLACE,
aCFPRate	GET-REPLACE
aDTIMPeriod	GETREPLACE,
aATIMWindow	GET-REPLACE,
aCFAware	GET,
aBSSBasicRateSet	GET-REPLACE;

ATTRIBUTE GROUPS
agStationConfiggrp,
agAuthenticationgrp,
agPrivacygrp;
ACTIONS
acInitializeSMT;
REGISTERED AS { iso(1) member-body(2) us(840) ieee802dot11(10036) SMT(1) };

11.4.2.2 MAC Object Class

11.4.2.2.1 oMAC

MAC MANAGED OBJECT CLASS
DERIVED FROM "ISO/IEC 10165-2":top;
CHARACTERIZED BY
pMACbase PACKAGE
BEHAVIOUR
bMACbase BEHAVIOUR
DEFINED AS "The MAC object class provides the necessary support for the access control, generation and verification of frame check sequences, and proper delivery of valid data to upper layers.";
ATTRIBUTES

aMACAddress	GET,
aGroupAddresses	GET-REPLACE,
aPromiscuousStatus	GET,
aTransmittedMPDUCount	GET-REPLACE,
aTransmittedMSDUCount	GET-REPLACE,
aOctetsTransmittedCount	GET-REPLACE,
aMulticastTransmittedFrameCount	GET-REPLACE,
aBroadcastFrameCount	GET-REPLACE,
aFailedCount	GET-REPLACE,
aRetryCount	GET-REPLACE,
aMultipleRetryrCount	GET-REPLACE,
aRTSSuccessCount	GET-REPLACE,
aRTSFailureCount	GET-REPLACE,
aACKFailureCount	GETREPLACE,
aFrameDuplicateCount	GET-REPLACE,
aReceivedFrameCount	GET-REPLACE,
aOctetsReceivedCount	GET-REPLACE,
aMulticastReceivedFrameCount	GET-REPLACE,
aBroadcastReceivedFrameCount	GET-REPLACE,
aReceivedFrameErrorCount	GET-REPLACE,
aFCSErrorCount	GET-REPLACE,
aMACEnableStatus	GET,
aMaxRate~~Factor~~	GET-REPLACE,
aHandshakeOverhead	GET,
aRTSThreshold	GET-REPLACE,
aTotalAccumulatedBackoffTime	GET-REPLACE,
aCWmax	GET-REPLACE,
aCWmin	GET-REPLACE,
aCTSSize~~Time~~	GET,
aACKSize~~Time~~	GET,
aACKTimeout	GET,
aShortRetryLimit	GET-REPLACE,
aLongRetryLimit	GET-REPLACE
aMaxFrameLength	GET,
aFragmentationThreshold	GET-REPLACE,
aProbeDelay	GET-REPLACE,
aMinProbeResponseTime	GET-REPLACE,
aMaxProbeResponseTime	GET-REPLACE,
aMaxTransmitMSDULifetime	GET-REPLACE,
aMaxReceiveMSDULifetime	GET-REPLACE,
aManufacturerID	GET,

```
        aProductID                          GET;
    ATTRIBUTE GROUPS
        agCapabilitiesgrp,
        agConfiggrp,
        agAddressgrp,
        agOperationgrp,
        agCountersgrp,
        agFrameErrorConditiongrp,
        agStatusgrp;
    ACTIONS
        acInitializeMAC,
        acAddGroupAddress,
        acDeleteGroupAddress;
REGISTERED AS { iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(2) };
```

11.4.3 Attribute Group Templates

11.4.3.1. Station Management Attribute Group Templates

11.4.3.1.1 agStationConfiggrp

StationConfiggrp ATTRIBUTE GROUP
GROUP ELEMENTS
aActingasAPStatus,
aActingasWirelessAPStatus,
aAssociatedState,
aBeaconPeriod,
aPowerManagementMode,
aPassiveScanDuration
aListenInterval,
aScanMode,
aScanState,
aMediumOccupancyLimit,
aMaxMPDUTime,
aCFPMaxDuration,
aCFPRate,
aDTIMPeriod,
aATIMWindow
aCFAware
aBSSBasicRateSet;
REGISTERED AS { iso(1) member-body(2) us(840) ieee802dot11(10036) SMT(1) attributeGroup(8) StationConfiggrp(1) };

11.4.3.2.2 agOperationgrp

Operationgrp ATTRIBUTE GROUP
GROUP ELEMENTS
aMaxRate~~Factor~~,
~~aHandshakeOverhead,~~
aRTSThreshold,
aCWmax,
aCWmin,
aCTSSize~~Time~~,
aACKSize~~Time~~,
aACKTimeout,
aShortRetryLimit,
aLongRetryLimit,
aMaxFrameLength,
aFragmentationThreshold,
aProbeDelay,
aMinProbeResponseTime,
aMaxProbeResponseTime,
aMaxTransmitMSDULifetime,
aMaxReceiveMSDULifetime;
REGISTERED AS { iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(0) attributeGroup(8) Operationgrp(2) };

11.4.4.1.32 aBSSBasicRateSet

BSSBasicRateSet ATTRIBUTE
WITH APPROPRIATE SYNTAX
Null Terminated list of integers;
BEHAVIOR DEFINED AS
" The list of rates (in 100Kbit/s) that all the stations in the BSS are required to be capable of receiving. The default sets are: {10} for 2.4GHz FHSS, {10,20} for 2.4GHz DSSS, and {10,20} for IR"

11.4.4.2.21 aMaxRate

MaxRate ATTRIBUTE
WITH APPROPRIATE SYNTAX
integer;
BEHAVIOUR DEFINED AS

" This attribute indicates the maximum data rate (in 100 Kbits per second) that this station will use for transfering data across the medium. The default value of this attribute is the maximum supported data rate as defined in aSuprtDataRates (13.1.4.21)"
REGISTERED AS
{ iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(2) attribute(7)MaxRate(22) };

~~11.4.4.2.22 aHandshakeOverhead~~

~~HandshakeOverhead ATTRIBUTE~~
~~WITH APPROPRIATE SYNTAX~~
~~integer;~~
~~BEHAVIOUR DEFINED AS~~
~~"This attribute shall indicate the amount of time, in microseconds, required to complete an RTS/CTS handshake. This value, may be used to determine the desirable setting of the RTSThreshold to maximize data throughput.";~~
~~REGISTERED AS~~
~~{ iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(2) attribute(7) HandshakeOverhead(23) };~~

11.4.4.2.27 aCTSTime

CTSSize ATTRIBUTE
WITH APPROPRIATE SYNTAX
integer;
BEHAVIOUR DEFINED AS
"This attribute shall indicate the size, in bytes, of a CTS frame, which is used to calculate the time it takes to transmit it.";
REGISTERED AS
{ iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(2) attribute(7) CTSSize(28) };

11.4.4.2.28 aACKTime

ACKSize ATTRIBUTE
WITH APPROPRIATE SYNTAX
integer;
BEHAVIOUR DEFINED AS
"This attribute shall indicate the size, in bytes, of an ACK frame, which is used to calculate the time it takes to transmit it.";
REGISTERED AS
{ iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(2) attribute(7) ACKSize(29) };

11.4.4.2.29 aACKTimeout

ACKTimeout ATTRIBUTE
WITH APPROPRIATE SYNTAX
integer;
BEHAVIOUR
"This attribute shall specify the length of time, in microseconds, in which an ACK frame may be received in response to transmission of a frame which requires acknowledgment, timed from receipt of PHYDATA.confirm at the MAC. ~~The following equation is used to determine aACKTimeout: aSIFSTime + aACKTime~~ ";
REGISTERED AS
{ iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(2) attribute(7) ACKTimeout(30) };

11.4.4.2.30 aCTSTimeout

CTSTimeout ATTRIBUTE
WITH APPROPRIATE SYNTAX
integer;
BEHAVIOUR
"This attribute shall specify the length of time, in microseconds, in which a CTS frame may be received in response to the transmission of an RTS frame, timed from receipt of PHYDATA.confirm at the MAC. ~~The following equation is used to determine aCTSTimeout: aSIFSTime + aCTSTime~~ ";
REGISTERED AS
{ iso(1) member-body(2) us(840) ieee802dot11(10036) MAC(2) attribute(7) CTSTimeout(30) };

12.3.5.11 PHY_RXSTART.indicate

12.3.5.11.1 Function

This primitive shall be an indication by the PHY sublayer to the local MAC entity that the PLCP has received a valid start frame delimiter and PLCP header.

12.3.5.11.2 Semantics of the Service Primitive

The primitive shall provide the following parameters:

PHY_RXSTART.indicate (RXVECTOR)

The RXVECTOR represents a list of parameters that the PHY sublayer shall provide the local MAC entity upon receipt of a valid PLCP header. This vector may contains both MAC and MAC Management parameters. The required parameters are listed in clause **Error! Reference source not found.**.

12.3.5.11.3 When Generated

This primitive shall be generated by the local PHY entity to the MAC sublayer whenever the PHY has successfully validated the PLCP header error check CRC at the start of a new PLCP_PDU. Note that this includes the case where the PLCP header indicates a data rate that the station does not support.

12.3.5.11.4 Effect of Receipt

The effect of receipt of this primitive by the MAC is unspecified.

12.3.5.12 PHY_RXEND.indicate

12.3.5.12.1 Function

This primitive shall be an indication by the PHY sublayer to the local MAC entity that the MPDU currently being received is completed. It shall also be used to indicate that the MPDU currently being received has terminated due to an error, such as loss of carrier or unsupported data rate.

12.3.5.12.2 Semantics of the Service Primitive

The primitive shall provide the following parameters:

PHY_RXEND.indicate (RXERROR)

The RXERROR parameter can be one or more of the following values: No_Error, Format_Violation, Unsupported_Data_Rate, or Carrier_Lost. A number of error conditions may occur after the PLCP's receive state machine has detected what it thought may be a valid preamble and start frame delimiter. This service primitive shall be generated immediately upon detection of an error condition by the PHY. The following describes the parameter returned for each of those error conditions.

No_Error. This value shall be used to indicate that no error occurred during the receive process in the PLCP.

Format_Violation. This value shall be used to indicate that the format of the received PLCP_PDU was in error.

Unsupported_Data_Rate. This value shall be used to indicate that the PLCP header was correctly decoded but indicated a data rate for the PLCP_PDU at which the station is unable to receive.

Carrier_Lost. This value shall be used to indicate that during the reception of the incoming MPDU, carrier was lost and no further processing of the MPDU can be accomplished.

12.3.5.12.3 When Generated

This primitive shall be generated by the PHY sublayer for the local MAC entity to indicate that the receive state machine has completed the reception of the MPDU, or to indicate that reception could not take place due to an unsupported data rate.

12.3.5.12.4 Effect of Receipt

The effect of receipt of this primitive by the MAC is unspecified.

14.3.3.3.1 Receive State Machine

The PLCP receive procedure shown in **Error! Reference source not found.** includes functions that must be performed while receiving the PLCP_PDU data. The PLCP receive procedure begins upon detection of a valid start frame delimiter and PLCP header in the CS/CCA procedure. The PLCP shall set a PLCP_PDU byte/bit counter to indicate the last bit of the packet, receive the PLCP_PDU data bits and perform the data whitening decoding procedure shown in **Error! Reference source not found.** on each PLCP_PDU bit. The PLCP shall pass correctly received data octets to the MAC with a series of *PHY_DATA.indicate(DATA)*. After the last PLCP_PDU bit is received and the last octet is passed up to the MAC, the PLCP shall send a *PHY_RXEND.indicate(RXERROR= no_error)* to the MAC layer. Upon error-free completion of a packet reception, the PLCP shall exit the receive procedure and return to the PLCP CS/CCA procedure with TIME_REMAINING=0.

If any error was detected during the reception of the packet, the PLCP shall immediately complete the receive procedure with a *PHY_RXEND.indicate(RXERROR=error type)* to the MAC, and return to the CS/CCA procedure with TIME_REMAINING set to indicate the predicted end of the frame given thebyte/bit count remaining. In the event that the PLCP header indicates an unsupported data rate, the PLCP shall immediately coplete the receive procedure (RXERROR=Unsupported_Data_Rate), and return to the CS/CCA procedure with TIME_REMAINING set to 0. Stations that do not use received power level to detect the end of the frame shall use a TIME_REMAINING value calculated as though the frame were being sent at 1.0 Mbps.

15.2.7 PLCP Receive Procedure

The PLCP receive procedure is shown in **Error! Reference source not found.**.

In order to receive data, PHY_TXSTART.request shall be disabled so that the PHY entity is in the receive state. Further, through Station Management via the PLME, the PHY is set to the appropriate CHNL_ID and the CCA method is chosen. Other receive parameters such as RSSI, SQ (signal quality), and indicated RATE may be accessed via the PHY-SAP.

Upon receiving the transmitted energy, according to the selected CCA mode, the PMD_ED shall be enabled (according to clause 12.4.8.4) as the RSSI strength reaches the ED_THRESHOLD and/or PMD_CS shall be enabled after code lock is established. These conditions are used to indicate activity to the MAC via PHY_CCA.indicate according to clause 12.4.8.4. PHY_CCA.indicate(BUSY) shall be issued for energy detection or code lock prior to correct reception of the PLCP frame. The PMD primitives PMD_SQ and PMD_RSSI are issued to update the RSSI and SQ parameters reported to the MAC.

After PHY_CCA.indicate is issued, the PHY entity shall begin searching for the SFD field. Once the SFD field is detected, CCITT CRC-16 processing shall be initiated and the PLCP 802.11 SIGNAL, 802.11 SERVICE, and LENGTH fields are received. The CCITT CRC-16 FCS shall be processed. If the CCITT CRC-16 FCS check fails, the PHY receiver shall return to the RX Idle state as depicted in **Error! Reference source not found.**. Should the status of CCA return to the IDLE state during reception prior to completion of the full PLCP processing, the PHY receiver shall return to the RX Idle state.

If the PLCP header reception is successful, a PHY_RXSTART.indicate(RXVECTOR) shall be issued. The RXVECTOR associated with this primitive includes the SIGNAL field, the SERVICE field, the LENGTH field, the antenna used for receive, PHY_RSSI, and PHY_SQ. If the PLCP header indicates that the frame is being sent at a data rate the station does not support, a PHY_RXEND.indicate primitive shall immediately be generated with an error of Unsupported_Data_Rate. If the station does not support energy detection as a means for detecting the end of the current frame, the PHY entity shall issue a PHY_CCA.indicate(IDLE) primitive no sooner than the 8.0

microseconds times the number of octets indicated in the PLCP header (that is, it shall assume the frame is being transmitted at 1.0 Mbps).

The received MPDU bits are assembled into octets and presented to the MAC using a series of PHY_DATA.indicate(DATA) primitive exchanges. The rate change indicated in the 802.11 SIGNAL field shall be initiated with the first symbol of the MPDU as described in clause 12.2.5. The PHY proceeds with MPDU reception. After the reception of the final bit of the last MPDU octet indicated by the PLCP preamble LENGTH field, the receiver shall be returned to the RX Idle state as shown in **Error! Reference source not found.**. A PHY_RXEND.indicate(No_Error) primitive shall be issued. A PHY_CCA.indicate(IDLE) primitive shall be issued following a change in PHY_CS and/or PHY_ED according to the selected CCA method.

In the event that a change in PHY_CS or PHY_ED would cause the status of CCA to return to the IDLE state before the complete reception of the MPDU as indicated by the PLCP LENGTH field, the error condition PHY_RXEND.indicate(carrier_lost) shall be reported to the MAC. The DSSS PHY shall ensure that the CCA shall indicate a busy medium for the intended duration of the transmitted packet.

A typical state machine implementation of the PLCP receive procedure is provided in **Error! Reference source not found.**.

16.2.5.2 PLCP Receive Procedure

The steps below are the receive procedure:

a) CCA is provided to the MAC via the PHY_CCA.indicate. When PHY senses activity on the medium it indicates that the medium is busy with a PHY_CCA.indicate with a state value of BUSY. This will normally occur during the SYNC field of the PLCP preamble.

b) The PHY entity will then begin searching for the SFD field. Once the SFD field is detected the PHY entity will receive the PLCP header. After receiving the DR and DCLA fields the CRC processing is initiated and LENGTH field is received. The change indicated in the DR field is initiated with the first symbol of the LENGTH field. The CRC-CCITT will be processed.

c) If the CRC-CCITT check fails ~~or no match is found for DR field~~ then NO PHY_RXSTART.indicate will be issued. When the medium is again free, the PHY will issue PHY_CCA.indicate with a state value of IDLE. If the PLCP indicates an unsupported data rate, the PHY_RXSTART.indicate pimitive shall immediately be followed by a PHY_RXEND.indicate primitive with an error value of Unsupported_Data_Rate. The PHY shall ensure that it does not issue a PHY_CCA.indicate(IDLE) primitive until the medium is sensed to be free.

d) If the PLCP preamble and PLCP header reception is successful, the PHY sends a PHY_RXSTART.indicate, including the parameters RATE and LENGTH.
A PHY must guarantee that the length reported to its MAC in the RXVECTOR of PHY_RXSTART.indicate is equal to the length sent from the peer MAC to the peer PHY entity in the TXVECTOR of PHY_TXSTART.request.

e) The received PSDU L-PPM symbols are assembled into octets and presented to the MAC using a series of PHY_DATA.indicate primitives. The PHY proceeds with PSDU reception.

f) Reception is terminated after the reception of the final symbol of the last PSDU octet indicated by the PLCP header LENGTH field. After the PHY_DATA.indicate for that octet is issued, the PHY will issue PHY_RXEND.indicate.

g) After the PHY_RXEND.indicate, when the medium is no longer busy, the PHY will issue PHY_CCA.indicate with a state value of IDLE.