IEEE P802.11

Wireless Access Method and Physical Layer Specifications

Title: Detailed Draft Standard text changes to support DTBS.

Authors:

Wim Diepstraten
AT&T WCND
Nieuwegein The Netherlands
Tel: (31)-3402-97482
Fax: (31)-3402-97555
Email: Wim.Diepstraten@utrecht.ncr.com

0.0.1. Distributed Coordination Function[This is section 5.1.1]

The fundamental access method of the 802.11 MAC is a distributed coordination function known as carrier sense multiple access with collision avoidance, or CSMA/CA. The Distributed Coordination Function can handle multiple access priority levels, that may be invoked based on the Quality of Service (QoS) requested at the MAC/LLC interface. The distributed coordination function shall be implemented in all stations and access points. It is used within both ad hoc and infrastructure configurations.

A station wishing to transmit shall sense the medium to determine if another station is transmitting. If the medium is not busy, the transmission may proceed. The CSMA/CA distributed algorithm mandates that a gap of a minimum specified duration exist between contiguous frames (a **distributed interframe space**, or **DIFS**). A transmitting station shall ensure that the medium is idle for the required DIFS duration before attempting to transmit. If the medium is sensed busy (a collision) the station shall defer until the end of the current transmission. After deferral the station shall first enter a priority resolution phase, followed by a "Contention resolution" phase based on random backoff delays. ~~After deferral, t~~The station shall select a random interval and shall check that the medium remains idle for that interval. ~~A refinement of the method may be used under various circumstances to further minimize collisions - here the transmitting and receiving station exchange short control frames (RTS and CTS frames) prior to the data transmission. The details of CSMA/CA are described in section ??. RTS/CTS exchanges are presented in Section 5.2.~~ For further protection against hidden stations, where the medium sensing function may not provide adequate information about the state of the medium, a "Virtual medium sensing" mechanism is available that uses small control frames (RTS and CTS) prior to the data transmission to reserve the medium for the duration of the subsequent data.

0.0.2. MAC Data Service

The MAC Data Service shall translate MAC service requests from LLC into signals utilized by the MAC State Machines. It shall also translate signals from the MAC State Machines into service indications and confirmations to LLC. The translations are given below.

The MA_DATA.request from LLC shall initiate one of the transmit cycles in the MAC State Machine. The psuedo-code below shall be used to translate this request into particular signal indications to the MAC State Machine.

Tx_data_req = { requested_service_class = async & length(MSDU) > RTS_threshold
& destination_address <> (broadcast | multicast) }
Tx_broadcast_req = { requested_service_class = async & destination_address = broadcast }
Tx_multicast_req = { requested_service_class = async & destination_address = multicast }
Tx_unitdata_req = { requested_service_class = async & length(M_SDU) < RTS_threshold}
DA = { destination_address }
Length = { Rate_factor * (length(MSDU) + Overhead) }
Type = { ??? }
Control = { ??? }
Priority = QoS translation

The MAC Data Service shall translate signals from the MAC State Machine to MA_DATA.confirmation as shown in the psuedo-code below.

transmission_status = { !Tx_failed }

The MAC Data Service shall translate signals from the MAC State Machine to MA_DATA.indication as shown in the following psuedo-code.

control = { type,control }
destination_address = { DA }
source_address = { SA }
M_SDU = { info_field }
reception_status = { !(CRC_error | Format_error) }

5.1.5.1 QoS translation

For the Distributed Time Bounded Service (DTBS) a QoS translation should be implemented as is indicated in section 5.2.13. For the Asynchronous service a default translation will be needed to assure proper coexistance with the DTBS service.

5.1.5.2 Default QoS translation.

A MAC that does not implement DTBS services shall use a default low priority level as the priority parameter.

0.0.2.1. MAC Management Service

The MAC Management Service shall translate MAC service requests from external management entities into signals utilized by the MAC Management State Machines. It shall also translate signals from the MAC Management State Machines into service indications and confirmations to external management entities. The translations are given below.

The MAC Management Service shall translate a SM_MA_DATA.request from an external management entity as defined in the following psuedo-code.

Tx_data_req = { requested_service_class = async & length(M_SDU) < RTS_threshold
& destination_address <> (broadcast | multicast) }
Tx_broadcast_req = { requested_service_class = async & destination_address = broadcast }
Tx_multicast_req = { requested_service_class = async & destination_address = multicast }
Tx_unitdata_req = { requested_service_class = async & length(M_SDU) > RTS_threshold}
DA = { destination_address }
Length = { Rate_factor * (length(M_SDU) + Overhead) }
Type = { ??? }
Control = { ??? }
Priority = QoS translation

The MAC Management Service shall translate signals from the MAC State Machine to SM_MA_DATA.confirmation as shown in the psuedo-code below.
transmission_status = { !Tx_failed }

[This should be qualified with the management frame type - Bob]
The MAC Management Service shall translate signals from the MAC State Machine to SM_MA_DATA.indication as shown in the following psuedo-code.
control = { type,control }
destination_address = { DA }
source_address = { SA }
M_SDU = { info_field }
reception_status = { !(CRC_error | Format_error) }

5.1.6.1 Default QoS translation.

A MAC that does not implement DTBS services shall use a default low priority level as the priority parameter.

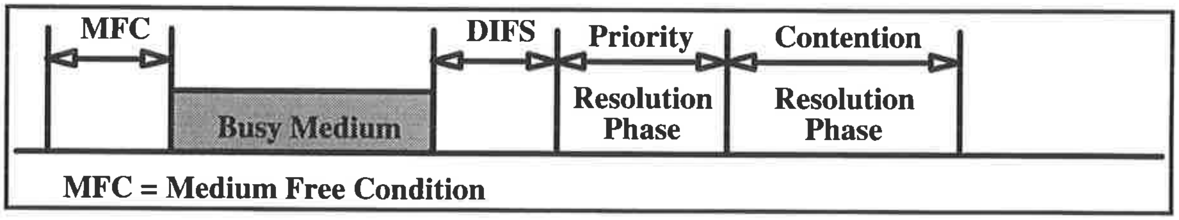
[This also should be qualified with the management frame type - Bob]

5.2. Distributed Coordination Function

The basic medium access protocol is a Distributed Coordination Function (DCF) that allows for automatic medium sharing between similar and dissimilar PHYs through the use of CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) and a contention resolution phase using a -random backoff time following a busy medium condition. In addition, all directed traffic uses immediate positive acknowledgements (ACK frame) where retransmission is scheduled by the sender if no ACK is received.

The CSMA/CA protocol is designed to reduce the collision probability between multiple stations accessing a medium, at the point where they would most likely occur. Just after the medium becomes free following a busy medium (as indicated by the CS function) is when the highest probability of a collision occurs. This is because multiple stations could have been waiting for the medium to become available again. This is the situation where a random backoff arrangement is needed to resolve medium contention conflicts.

Prior to the contention resolution phase, we can distinguish a "Priority Resolution" phase. This phase contains either an active or a passive priority resolution mechanism, such that subsequent contention resolution will primarily occur between stations of the same priority level.
The priority mechanism can be configured per Phy, to use an active or a passive priority mechanism or to use no priority scheme at all.



Carrier Sense shall be performed both through physical and virtual mechanisms.

The virtual Carrier Sense mechanism is achieved by distributing medium busy reservation information through an exchange of special small RTS and CTS (medium reservation) frames prior to the actual data frame. The RTS and CTS frames contain a duration field for the period of time that the medium is to be reserved to transmit the actual data frame. This information is distributed to all stations within detection range of both the transmitter and the receiver, so also to stations that are possibly "hidden" from the transmitter but not from the receiver. This scheme can only be used for directed frames. When multiple destiniations are addressed by broadcast/multicast frames, then this mechanism is not used.

It can also be viewed as a Collision Detection mechanism, because the actual data frame is only transmitted when a proper CTS frame is received in response to the RTS frame, resulting in a fast detection of a collision if it occurs on the RTS.

However the addition of these frames will result in extra overhead, which is especially considerable for short frames. Also since all stations will likely be able to hear traffic from the AP but may not hear the traffic from all stations within a BSA, its use may be benificial for inbound traffic only.

Therefore the use of the RTS/CTS mechanism is under control of RTS_Threshold attribute, which indicates the payload length under which the data frames should be send without any RTS/CTS prefix.

This parameter is a manageable object and can be set on a per station basis. This mechanism allows stations to be configured to use RTS/CTS either always, never or only on frames longer then a specified payload length.

Although a station can be configured not to initiate RTS/CTS to transmit its frames, every station shall respond to the duration information in the RTS/CTS frames to update its virtual Carrier Sense mechanism, and respond with a proper CTS frame in response to an addressed RTS frame.

0.0.3. Physical Carrier Sense Mechanism

A physical carrier sense mechanism shall be provided by the PHY. See Section 8, Physical Service Specification for how this information is conveyed to the MAC. The details of carrier sense are provided in the individual PHY specification sections.

0.0.4. Virtual Carrier Sense Mechanism

A virtual carrier sense mechanism shall be provided by the MAC. This mechanism is referred to as the Net Allocation Vector(NAV). The NAV maintains a prediction of future traffic on the media based on duration information that is announced in RTS/CTS frames prior to the actual exchange of data. The mechanism for setting the NAV is described in 5.2.6.4

0.0.5. MAC-Level Acknowledgments

To allow detection of a lost or erred frame an ACK frame shall be returned to the source STA by the destination STA immediately following a successfully received frame. Success shall be determined by an identical CRC generated from the received frame and the FC field of the same frame. The gap between the received frame and the ACK frame shall be the SIFS. This technique is known as positive acknowledgement.

The following frame types shall be acknowledged with an ACK frame:

- Data
- Poll
- Request
- Response

The lack of an ACK frame from a destination STA on any of the listed frame types shall indicate to the source STA that an error has occurred. Note however, that the destination STA may have received the frame correctly and the error has occurred in the ACK frame. This condition shall be indistinguishable from an error occurring in the initial frame.

5.2.4. Medium Free Condition (MFC)

The Medium Free Condition is a time interval which is used to determine whether a medium is considered free for an immediate initial access. So when a station has a new frame to transmit (not immediately following a previous frame), it will initially determine whether the medium is busy. When the medium has been free for the duration of the MFC, (as indicated by the physical and Virtual carrier sense mechanism) then the medium is considered free and the station may access the medium immediately without a prior priority and contention resolution phase.

Typically the length of the MFC will be equal to DIFS plus the priority resolution phase duration. It can therefore be priority dependent.

0.0.6. 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 different IFS are defined so as to provide a corresponding number of priority levels for access to the wireless media.

0.0.6.1. Short-IFS (SIFS)

This inter-frame space shall be used for an ACK frame, a CTS frame, by a STA responding to any polling as is used by the Point Coordination Function (PCF) (See Section 5.3, Point Coordination Function) and between frames in the sequences described in section 4.3. Any STA intending to send only these frame types shall be allowed to transmit after the SIFS time has elapsed following a busy medium.

The SIFS has both a minimum and maximum specification. The maximum (SIFSmax) prevents another STA from claiming the medium and in physical terms is the maximum receive to transmit (R2T) turn around time allowed by the specific PHY. The transmit to receive (T2R) time need not be specified because it is only related to the stability of a specific implementation. Clearly T2R must be less than or equal to SIFSmax.

The minimum time (SIFSmin) prevents a STA from getting onto the medium too soon for another STA to process the transition. This minimum time may be very short. It is related to the need by a STA to see a minimum number of preamble bytes, so the length of the preamble needs to accommodate the difference between the minimum and maximum allowable SIFS timing. The assumption on the minimum is that the number of preamble bytes is fixed for a given PHY.

0.0.6.2. PCF-IFS (PIFS)

This PCF priority level shall be used only by the PCF to send certain~~any~~ of the Contention Free Period (CFP) frames. The PCF shall be allowed to transmit after it detects the medium free for the period PIFS (PCF Interframe Space), at the start of and during a CF-Burst .

0.0.6.3. DCF-IFS (DIFS)

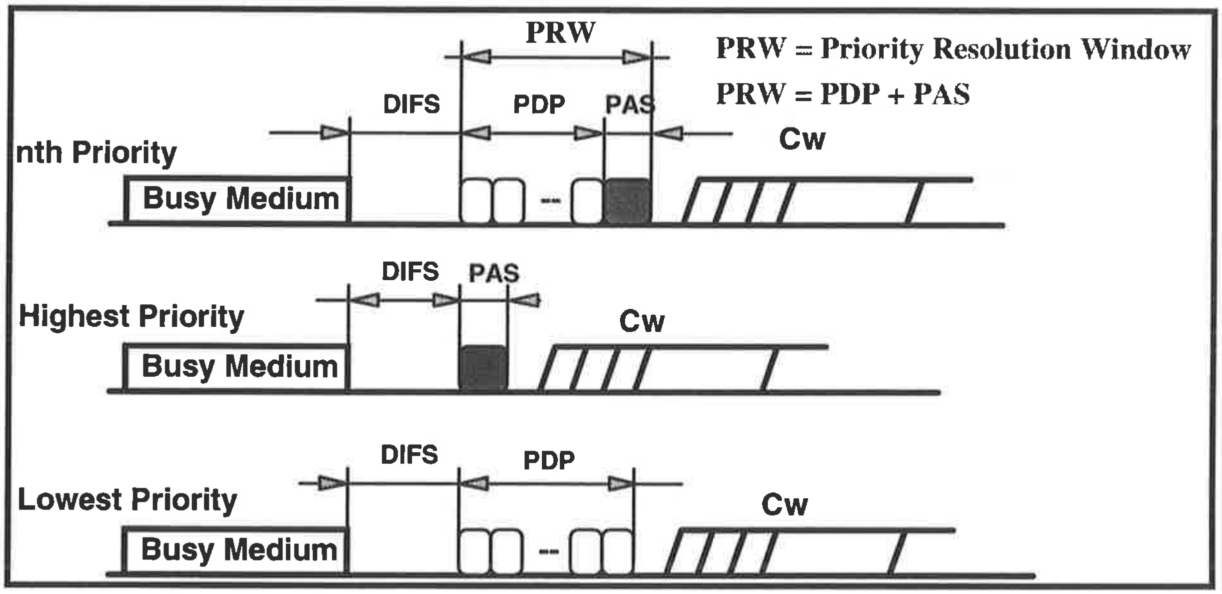
The DCF priority level shall be used by the DCF to transmit asynchronous MPDUs. A STA using the DCF shall be allowed to transmit after it detects the medium free for the period DIFS, as long as it is not in a backoff period.

5.2.5 Priority resolution phase

The Priority resolution phase is designed to distinguish access between different priority levels, such that the subsequent Contention Resolution Phase will resolve contention between traffic of equal access priority. The MAC State Machine supports two different mechanisms by specifying two different access parameters.

- A passive priority resolution mechanism.
- or an active priority resolution mechanism.

A separate MIB variable will identify the number of priority levels available for the MAC to utilize. This variable is called the aNumber_of_Priorities.
When this variable is zero, then no DTBS service will be available for that Phy.
To support DTBS services, a minimum of 2 priority levels need to be specified.



The Priority resolution window (PRW) consists of a "Priority Detection Period" (PDP), and a Priority Assertion Signal period (PAS). Either of the two periods can be specified as zero.
The following procedure will be used to resolve priority resolution:

If during the PDP period the medium is detected Busy (by using the available carrier sensing mechanism), then a station shall defer until DIFS after the next frame to compete for the medium again. The PDP period can also be zero.

After the PDP period, a station shall generate Ph-DATA.request (SEND_PAS) signal to the Phy to generate the PAS. This will turn on the transmitter to send the normal Phy preamble for the duration of a PAS interval.
This is to signal its priority level to the other stations contending for the medium. The PAS interval can also be specified zero, which will cause that no Ph-DATA.request (SEND_PAS) will be generated by the MAC.

With this mechanism multiple priority levels can be specified, by specifying different values for the PDP and PAS periods per priority level.

For a given Phy, that does support a priority resolution period, a set of priority levels are specified by specifying the PDP and PAS parameters for each individual priority level.
A special case is the set of parameters that does represent the passive priority set. In this set the PAS value is always zero, which indicate that no active signal burst is generated to identify priority.

5.2.5.1 Minimum Coexistance level to be implemented.

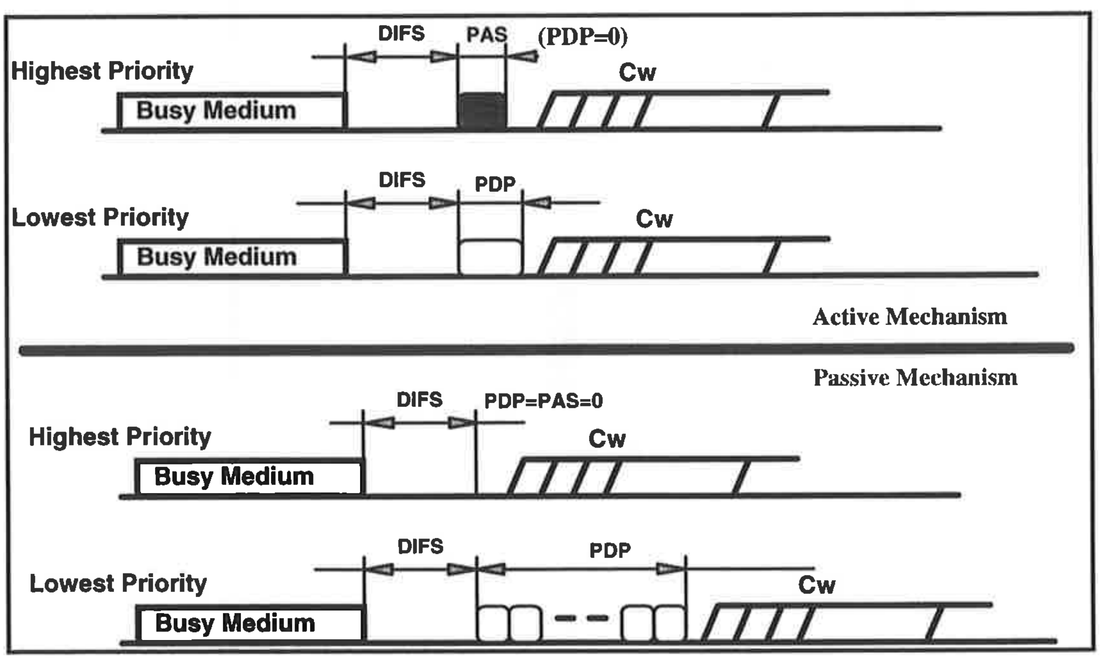
As a minimum all stations should implement the priority detection mechanism, independent whether the station does support the optional DTBS service or not.
The main MAC level implementation difference is that the PDP detection period should always be implemented, but the PAS Generation provisions are optional.

5.2.5.2 Priority level set examples.

The following set is an example of an "active priority set" for a 2 priority system:
Low priority: PDP = 2 slots, PAS = 0 slots.
High priority: PDP = 0 slots, PAS = 2 slots.

In contrast the following is an example of a "passive priority set" for a 2 priority system:
Low priority: PDP = 16 slots, PAS = 0 slots.
High priority: PDP = 0 slots, PAS = 0 slots.

Please note that the duration of the different periods in the above examples are specified in slots, just for ease of illustration. The PAS is at least 1 slot, and may need to be longer to handle the internal Phy delays and Phy specific synchronization requirements.



Please note that the PRW (Priority Resolution Window) is different per priority level, and is equal to the PDP + PAS duration.

0.0.7. Contention resolution PhaseRandom Backoff Time

STA desiring to initiate transfer of asynchronous MSPDUs shall utilize the carrier sense function to determine the state of the mediumia. A station that senses the medium busy, will need to defer, and subsequently resolve priority and resolve contention between the number of stations that are competing for the medium.

The contention resolution method is based on a random backoff delay that causes additional deferral time before transmission. A station shall select a Backoff time when it initially detects the medium busy.

If the media is busy, the STA shall defer until after a DIFS gap is detected, and then generate a random backoff period for an additional deferral time before transmitting. This process resolves contention between multiple STA that have been deferring to the same MPDU occupying the medium.

Backoff Time = CW * Random() * Slot time

where:

CW = An integer between CWmin and CWmax

Random() =

Slot Time = Transmitter turn-on delay + medium propagation delay + medium busy detect response time.

The Contention Window (CW) parameter shall contain an initial value of CWmin for every MPDU queued for transmission. The CW shall increase exponentially after every retransmission attempt., up to a maximum value CWmax. This is done to improve the stability of the access protocol under high load conditions. See figure 5-2.

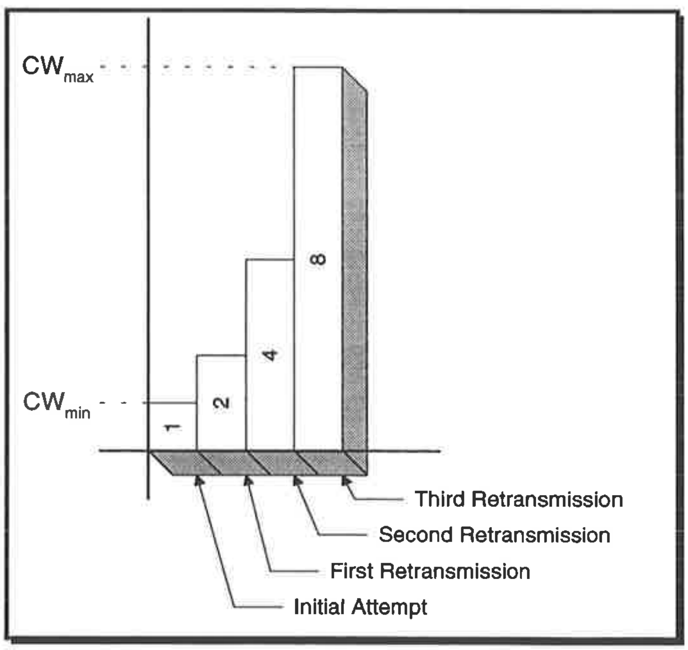


Figure 5-2: Exponential Increase of CW

0.0.8. DCF Access Procedure

The CSMA/CA access method is the foundation of the Distributed Coordination Function. This access method shall be used when there is no PCF detected and when in the Contention Period of a Superframe when using a PCF.

Initial transmission or access to the media using the DCF is divided into two cases; when the media has been free for greater than or equal to a MFC~~DIFS~~ and when it has not. Initial transmission is defined as an attempt to transfer an RTS, Data, Poll, Request or Response MPDU for the first time.

0.0.8.1. Basic Access

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

Both the Physical and Virtual Carrier Sense functions are used to determine the busy state of the medium. When either of them indicate a busy medium, the medium shall be considered busy. The opposite of a busy medium shall be known as a free medium.

A STA with a pending MPDU may transmit when it detects a free medium for greater than or equal to a MFC~~DIFS~~ time. This rule applies both when using the DCF access method exclusively and when using the PCF access method in the Contention Area.

If the medium is busy when a STA desires to initiate a Data, Poll, Request or Response MPDU transfer, and only a DCF is being used to control access, then a priority resolution phase and a contention resolution phase using the Random Backoff Time algorithm shall be followed.

Likewise, if the medium is busy when a STA desires to initiate a Data, Poll, Request or Response MPDU transfer, and a Contention Period portion of a Superframe is active (See 5.3 PCF), then the priority resolution and Random Backoff Time algorithm shall be followed.

The basic access mechanism is illustrated in the following diagram.

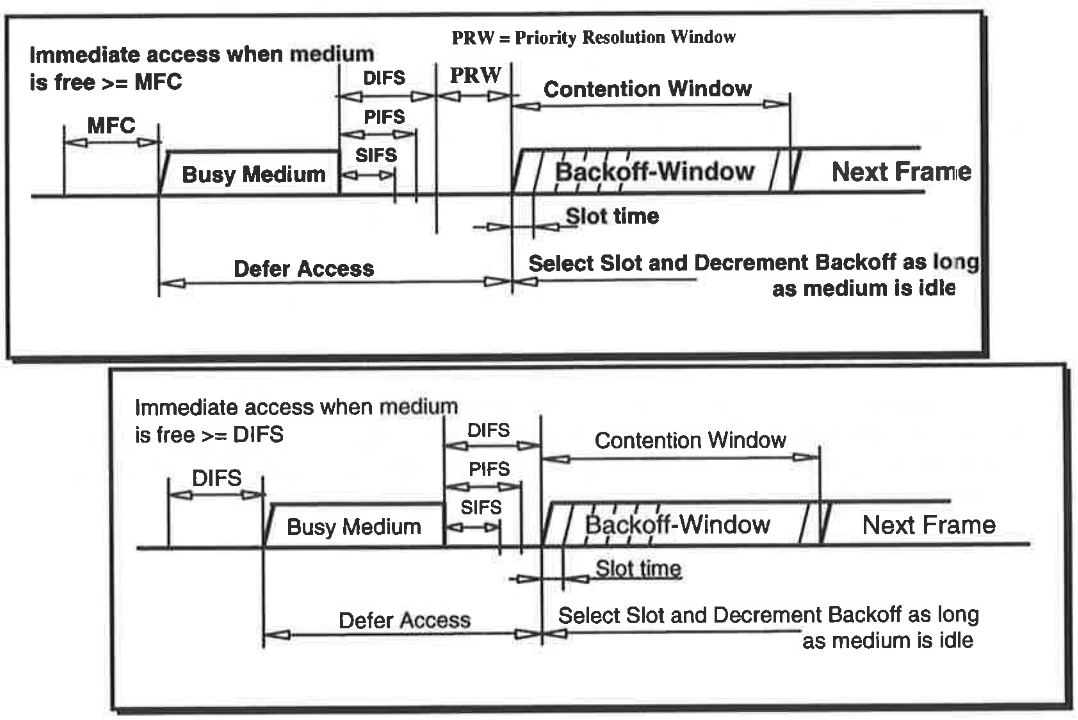


Figure 5-3: Basic Access Method

0.0.8.2. Backoff Procedure

The backoff procedure shall be followed whenever a STA desires to transfer an MPDU and finds the medium busy.

The backoff procedure consists of selecting a backoff time from the equation in Section 5.2.5 Random Backoff Time. The Backoff Timer shall decrement only when the medium is free. The Backoff Timer shall be frozen while the medium is sensed busy. Decrementing the Backoff Timer shall resume whenever a station is in the contention resolution phase and the medium is free~~, period longer than DIFS is detected.~~ Transmission shall commence whenever the Backoff Timer reaches zero.

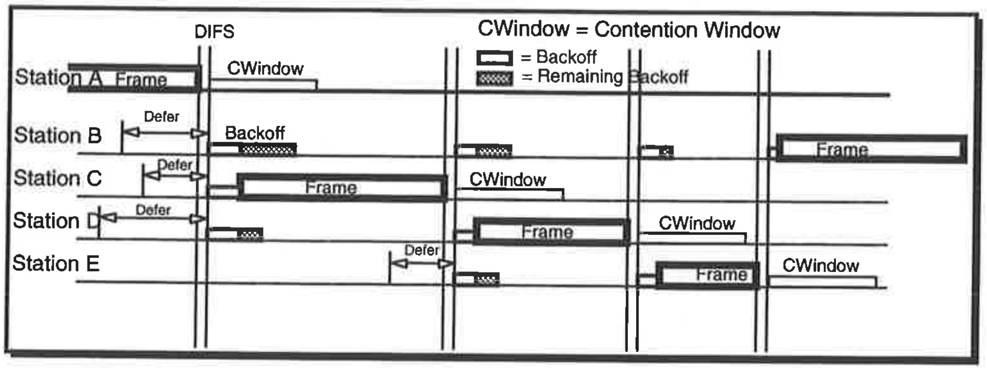


Figure 5-4: Backoff Procedure

A station that has just transmitted a frame and has another frame 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 DIFS period, 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.*

0.0.8.3. RTS/CTS Recovery Procedure and Retransmit Limits

Many circumstances may cause an error to occur in a RTS/CTS exchange.

For instance, CTS may not be returned after the RTS transmission. This can happen due to a collision with another RTS or a DATA frame, or due to interference during the RTS or CTS frame. It can however also be that CTS fails to be returned because the remote station has an active carrier sense condition, indicating a busy medium time period.

If after an RTS is transmitted, the CTS fails in any manner within a predetermined CTS_Timeout (T1), then a new RTS shall be generated while following the basic access rules for backoff. Since this pending transmission is a retransmission attempt, the CW shall be doubled as per the backoff rules. This process shall continue until the RTS_RE-TRANSMIT_Counter reaches an RTS_RE-TRANSMIT_Limit.

The same backoff mechanism shall be used when no ACK frame is received within a predetermined ACK_Window (T3) after a directed DATA frame has been transmitted. Since this pending transmission is a retransmission attempt the CW will be greater than one * CWmin as per the backoff rules. This process shall continue until the ACK_RE-TRANSMIT_Counter reaches an ACK_RE-TRANSMIT_Limit.

0.0.8.4. Setting the NAV Through Use of RTS/CTS Frames

In the absence of a PCF, reception of RTS and CTS frames are the only events that shall set the NAV to a non-zero duration. Various conditions may reset the NAV.

RTS and CTS frames contain a Duration field based on the medium occupancy time of the MPDU from the end of the RTS or CTS frame until the end of the ACK frame. (See Section 4.x.x: RTS and CTS Frame Structure.) All STA receiving a these frame types with a valid FCS field shall interpret the duration field in these frames, and maintain the Net Allocation Vector (NAV).

Maintence of the NAV shall consist of an internal state accurate to X nS of the busy/free condition of the medium. Figure 5-5 indicates the NAV for stations that can hear the RTS frame, while other stations may only receive the CTS frame, resulting in the lower NAV bar as shown. *Although the NAV effectively will "count-down" from a non-zero value, only the fact of whether the NAV is non-zero or not is necessary for correct protocol operation.*

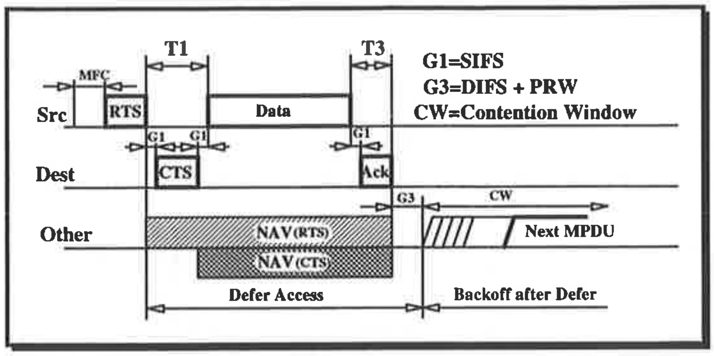


Figure 5-5: RTS/CTS/DATA/ACK MPDU

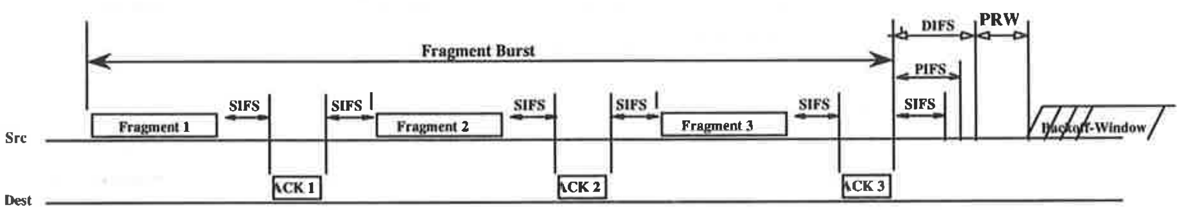


Figure 5-xx: Transmission of a Multiple Fragment MSDU using IFS

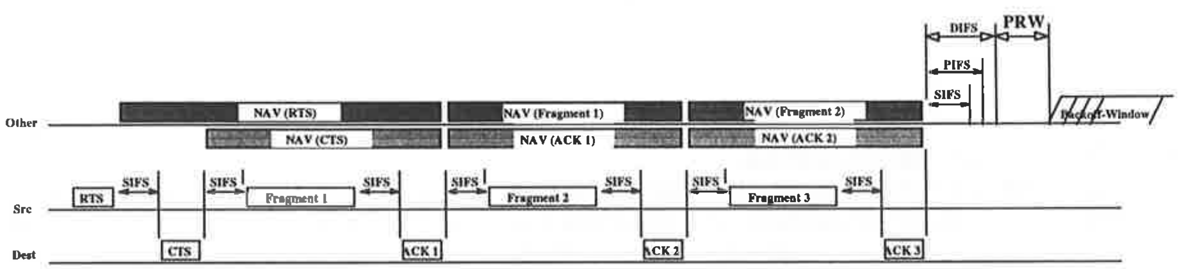


Figure 5-xx: RTS/CTS with Fragmented MSDU

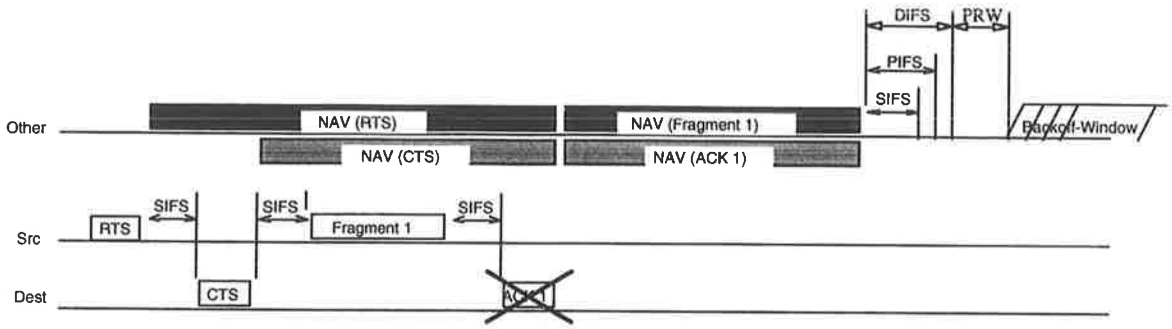


Figure 5-xx: RTS / CTS with Transmitter Priority with missed Acknowledgment

0.0.9. Directed MPDU Transfer Procedure without RTS/CTS

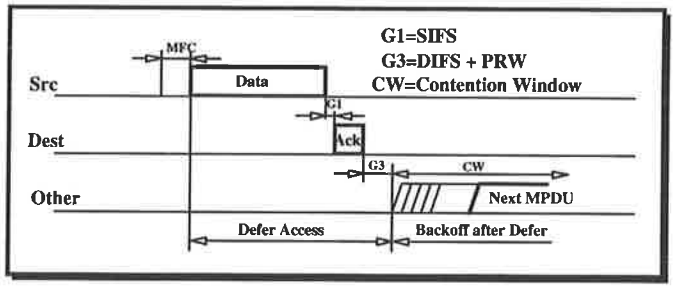


Figure 5-6: Directed Data/ACK MPDU

0.0.10. Distributed Time Bounded Service (DTBS)

An optional Distributed Time Bounded Service (DTBS) may be based on the connectionless-mode MAC Service provided by the DCF. DTBS can be characterized as a "best effort" service providing bounded transit delay~~ and delay variance~~.

DTBS requires a mechanism to map requested Quality of Service (QoS) onto channel access priority. QoS parameters include transit delay, delay variance, and user priority. If the MAC Service user does not explicitly state QoS parameters, the MAC Service provider shall use default values. MAC Service requests that cannot be satisfied are rejected by the MAC Service provider, thus avoiding overload conditions.

DTBS assumes that the MAC Service provides multiple hierarchically independent levels of channel access priority. Hierarchical independence means that increasing load from lower priority classes does not degrade the performance of higher priority classes.

0.0.10.1. Quality of Service

Associated with each MAC connectionless-mode transmission, certain measures of QoS are requested by the sending MAC Service user when the primitive action is initiated. The requested measures (or parameter values and options) are based on a priori knowledge by the MAC Service user of the service(s) made available to it by the MAC Service provider. Knowledge of the characteristics and type of service provided (i.e., the parameters, formats, and options that affect the transfer of data) is made available to the MAC Service user through some layer management interaction prior to (any) invocation of the MAC connectionless-mode service. Thus the MAC Service user not only has knowledge of the characteristics of the parties with which it can communicate, it also has knowledge of the statistical characteristics of the service it can expect to be provided with for each MAC Service request.

0.0.10.1.1. Transit Delay

Transit delay is the elapsed time between MA-UNITDATA.request primitives and the corresponding MA-UNITDATA.indication primitives. Elapsed time values are calculatetd only on MSDUs that are transferred successfully.

Successful transfer of a MSDU is defined to occur when the MSDU is transferred from the sending MAC Service user to the intended receiving MAC Service user without error.

For connectionless-mode transfer, transit delay is specified independently for each MAC connectionless-mode transmission. In general, satisfaction of the transit delay bound is managed by the sender.

~~0.0.10.1.2. Delay Variance~~

~~Delay variance is the jitter associated with transit delay. In general, satisfaction of the delay variance bound is managed by the receiver and may be used to regenerate the regular periodic interval of related sequences of MSDUs~~.

0.0.10.1.3. User Priority

The MAC Service user may transfer to the MAC Service provider a priori knowledge about the characteristics of the parties with which it can communicate via the user priority QoS parameter.

0.0.10.2. Mapping QoS onto Channel Priority

There is a standardized mapping of QoS Transit Delay and Delay Variance parameters to initial Time to Live (TTL). The inititial transmit queue position is determined by TTL, possibly qualified by the QoS User Priority parameter. All MSDUs in the transmit queue count down their associated TTL while waiting to reach the head of the queue and be dequeued for transmission.

The channel access priority is determined, in a standardized way, from remaining TTL at dequeue time. At transmission time, the measured queue delay must be subtracted from the TTL to give the Residual Time to Live (RTL) i.e. the time left before the MSDU becomes out of date. RTL may be used in subsequent handling of the MSDU. If RTL should become less than or equal to zero, the MSDU should in all cases be discarded.

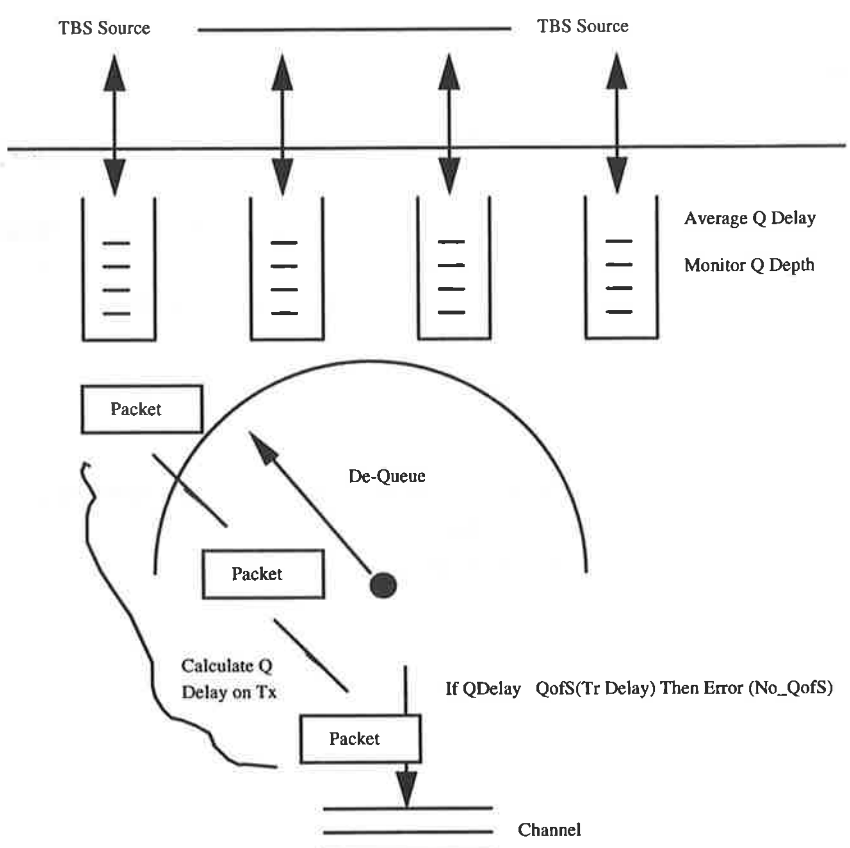


Figure ?.?: Mapping QoS onto Channel Access Priority

0.0.10.3. Partitioning of Channel Capacity

Partitioning of channel capacity amongst conceptual user classes (e.g. low priority async requests and higher priority time bounded requests) is a natural side effect of the mapping of TTL to channel access priority at dequeue time. Since *all* queued MSDUs progress towards the head of the queue as a function of their decreasing TTL, the relationship between channel access priority and conceptual user class is a function of channel load.

0.0.10.4. Channel Access Priority Mechanism

The channel access priority mechanism is described in section 5.2.5. and is embedded in the DCF function. The priority mechanism can be either a passive or an active signalling method under control of two parameters. The method selected is dependent on the Phy standard, which is to specify the parameter sets per priority level.

Relative priority mechanism between Station and AP

Apart from the active or passive priority mechanism, a relative priority difference can be obtained within the assigned access priority levels, by the Control of the initial/minimal "Contention Window" (CWmin).

Two different values can be specified within the MAC. One value that is to be used in stations, while an other value (smaller) can be set for an AP. This will favor AP traffic such that on average the random backoff delay is lower compared to a Stations average backoff delay. Given that most traffic will go via the AP, this arrangement is advantageous for the overall system throughput.

Managed Objects relevant to the Priority Mechanism:

The following are the MIB parameters that should be added to the MIB, in section 7.3.1.2.2.

- **aNumber_of_Priorities:** This parameter indicates the number of different priority levels supported by the Phy (range 1-n). A one indicates that no priority mechanisms are supported, because only one level is distinguished.

For x is in the range 1-n the following two parameters are specified per priority level.

- **aPDPx:** This is the PDP duration parameter for priority level x (x between 1 and n).
- **aPaSx:** This is the PaS duration parameter for priority level x (x between 1 and n).

The following MIB variable is also Phy dependent, and is used in the contention resolution phase.

- **aBusyFilt:** This is the minimum filtering duration for exiting the Backoff procedure. It should for instance be specified to be the expected PaS duration as specified by a Phy, to prevent that the Backoff algorithm is affected by PaS signals that are not in Sync.

The MFC duration can be derived from the priority specific variables difined in the MIB as follows:

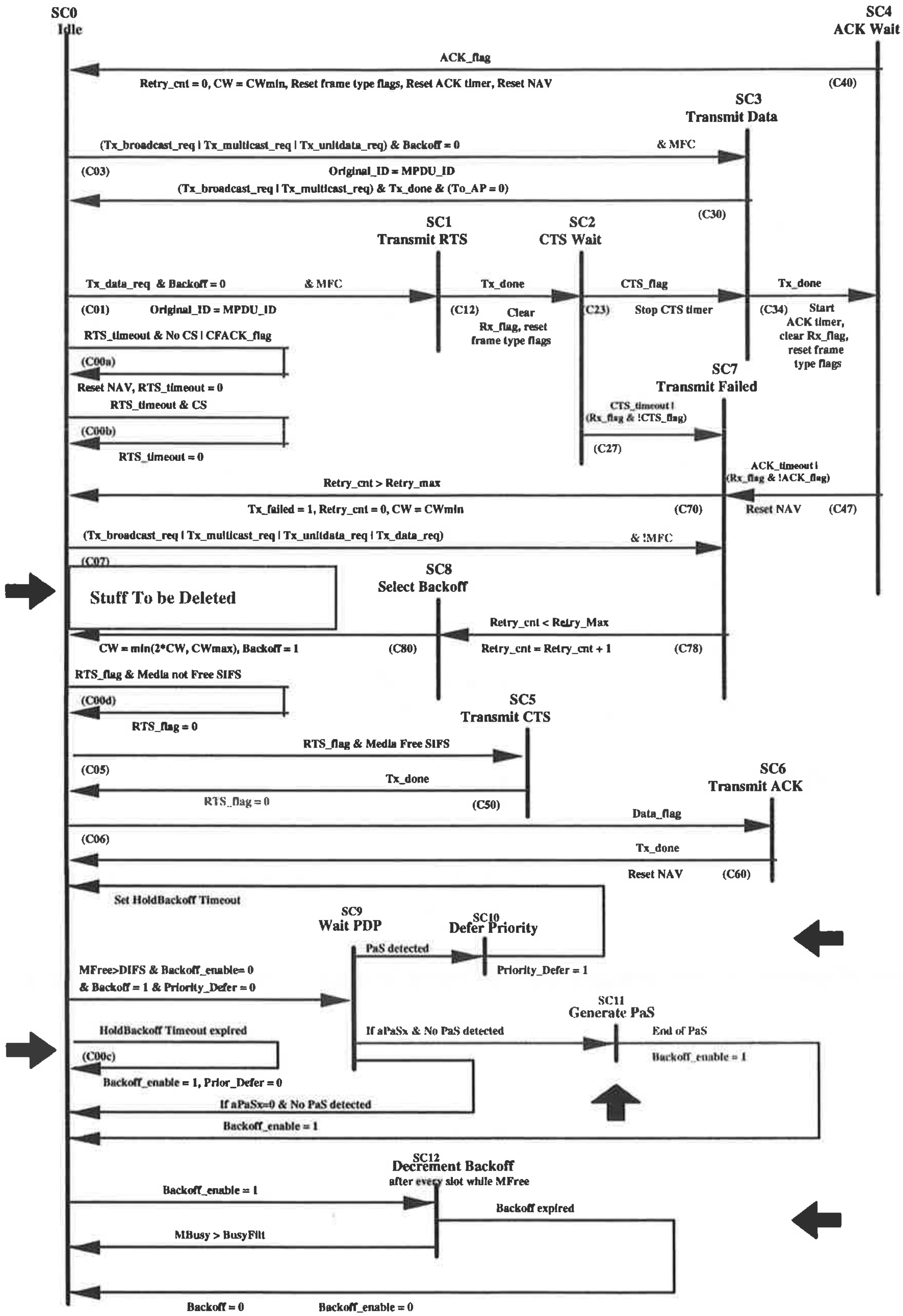
- **MFCx:** This is the Medium Free Condition, which is the minimum duration that the medium should have been sensed free to assume that the medium is indeed free, to allow access without following the priority and contention resolution mechanism. It will be specified per priority level, and should be equal to DIFS + PDP + PaS.

Modifications to the Control State Machine.

The following changes are needed in the Control State Machine:
Currently there is an annotation problem because the states have the same identification numbers as the state transitions. I therefore suggest to add an "S" prefic to the state-ID's. So all "State XY" names should change to ***"State SXY"***. *This is illustrated in the "Modified Control State Machine" diagram.*

Text changes needed in current Control State Machine notes:
- Change "media free longer than DIFS" into "media free longer than MFC" in the C01, C03, and C07 transitions.
- **State SC9, Wait PDP:** In this state the medium will be monitored for the duration of PDP to detect a PAS signal from other stations, by monitoring the !CCA. Note that the duration of PDP can be set to zero, which will then yield in a No PaS detected exit.
- **C09, Start priority resolution:** This transition will be taken when the medium has been free for DIFS after a defer (Backoff = 1), and Backoff enable = 0. This is the condition to start priority resolution.
- **State SC10, Defer Priority:** This state shall be entered when a PaS (active priority signalling) is detected, so that the station should defer for higher priority traffic.
- **C910, PaS Detected:** This transition is taken when in state SC9 an active medium has been detected via the CCA indication.
- **C100, Set HoldBackoff Timeout:** This transition shall be taken after the HoldBackoff Timer has been initialized. Also the Prior_Defer flag will be set.
- **State SC11, Generate PaS:** This is the state where the PaS signal will be generated by turning the transmitter on for the duration of the PaS interval. Note that the duration of the PaS interval can also be zero, so that no PaS signal is generated, and the state machine will fall trough immediately. This state and any associated transition is optional, and does not need to be implemented by stations that do not support DTBS services.
- **C911, If PaS & No PaS Detected:** This transition is taken, when a PaS has been specified, and when during the PDP Wait period, no PaS has been detected, so when there was no medium activity.
- **C90, If aPaSx=0 & No PaS Detected:** This transition is taken when no PaS is detected and the PaS parameter is specified to be zero, so that no subsequent PaS signal will be generated.

- **C110, End of PaS:** This transition will be taken when the PaS period has elapsed, after which the Backoff_enable flag will be set, to start the contention resolution phase.
- **C00c, Enable Backoff:** This transition shall be taken when the Hold Backoff timer expires. The Backoff_enable flag shall be set to allow participation in the contention resolution process. The Prior_Defer flag will be reset.
- **State SC12, Decrement Backoff:** This is the state during which the Backoff timer is decremented after every slot interval, while the medium is free as indicated by the CCA or the NAV.
- **C012, Start Backoff:** This transition will be taken whenever the Backoff_enable is set.
- **C120a, Backoff expire:** This transition will be taken when the Backoff Timer has expired (counter reach zero). The Backoff and Backoff_enable flags shall be reset.
- **C120b, Busy detected:** This transition will be taken whenever a MBusy condition is detected with a duration that is longer then the PaSDur parameter. The Backoff_enable flag will be reset, to force a new priority resolution cycle before the backoff process will proceed, so before SC12 is entered again.


SC0
Idle
SC4
ACK Wait
ACK_flag
Retry_cnt = 0, CW = CWmin, Reset frame type flags, Reset ACK timer, Reset NAV
(C40)
SC3
Transmit Data
(Tx_broadcast_req | Tx_multicast_req | Tx_unitdata_req) & Backoff = 0
& MFC
(C03)
Original_ID = MPDU_ID
(Tx_broadcast_req | Tx_multicast_req) & Tx_done & (To_AP = 0)
(C30)
SC1
Transmit RTS
SC2
CTS Wait
Tx_data_req & Backoff = 0
& MFC
Tx_done
CTS_flag
Tx_done
(C01)
Original_ID = MPDU_ID
(C12)
Clear Rx_flag, reset frame type flags
(C23)
Stop CTS timer
(C34)
Start ACK timer, clear Rx_flag, reset frame type flags
RTS_timeout & No CS | CFACK_flag
(C00a)
Reset NAV, RTS_timeout = 0
RTS_timeout & CS
(C00b)
RTS_timeout = 0
SC7
Transmit Failed
CTS_timeout | (Rx_flag & !CTS_flag)
(C27)
ACK_timeout | (Rx_flag & !ACK_flag)
Retry_cnt > Retry_max
Tx_failed = 1, Retry_cnt = 0, CW = CWmin
(C70)
Reset NAV
(C47)
(Tx_broadcast_req | Tx_multicast_req | Tx_unitdata_req | Tx_data_req)
& !MFC
(C07)
Stuff To be Deleted
SC8
Select Backoff
Retry_cnt < Retry_Max
CW = min(2*CW, CWmax), Backoff = 1
(C80)
Retry_cnt = Retry_cnt + 1
(C78)
RTS_flag & Media not Free SIFS
(C00d)
RTS_flag = 0
SC5
Transmit CTS
RTS_flag & Media Free SIFS
(C05)
Tx_done
RTS_flag = 0
(C50)
SC6
Transmit ACK
Data_flag
(C06)
Tx_done
Reset NAV
(C60)
Set HoldBackoff Timeout
SC9
Wait PDP
SC10
Defer Priority
PaS detected
Priority_Defer = 1
MFree>DIFS & Backoff_enable= 0
& Backoff = 1 & Priority_Defer = 0
SC11
Generate PaS
HoldBackoff Timeout expired
If aPaSx & No PaS detected
End of PaS
(C00c)
Backoff_enable = 1
Backoff_enable = 1, Prior_Defer = 0
If aPaSx=0 & No PaS detected
Backoff_enable = 1
SC12
Decrement Backoff
after every slot while MFree
Backoff_enable = 1
Backoff expired
MBusy > BusyFilt
Backoff = 0
Backoff_enable = 0

Phy Service Specification needed to support DTBS.

This section describes the changes that are needed in the Phy service specification section 8, to support DTBS. One new primitive is needed to allow the generation of the PAS signal by the Phy upon a command from the MAC.

This should be implemented by specifying one new Class for the Ph-DATA request primitive, with a Data parameter that indicates the length in symbols. In the Phy this would presumably be translated into an action, whereby the transmitter is enabled, and transmits a part of the Phy preamble, in particular the PLCP synchronization pattern.

For that purpose section 8.1.1 should be updated with an extra Class specification: Add one buttel item to the list (line 22?):

> **- SEND_PAS: request the transmission of a Priority assertion signal. The Phy can determine the modulation for this signal, such that it can be detected by the appropriate Carrier Sense mechanism.**

After line 26 the following should be added:

In the case of Ph-DATA.request with class SEND_PAS, the data contains the same parameters as in the START_OF_ACTIVITY class, but the length parameter is a PAS duration indication in units of the PhPLCP header modulation rate.

Question is: wheater a specific length field is needed when the PAS_Duration is a Phy specific MIB variable.

In the sections 10 and 11 updates are needed to handle the new class of request, in a way that depends on whether the specific Phy will support active priority signalling.

The following are the suggested additions to section 9, relevant for DTBS support:

aPAS_Duration GET,

Further explanation in a subsequent section 9.1. section:

PAS_Duration
WITH APPROPRIATE SYNTAX
integer;
BEHAVIOUR DEFINED AS
A zero value indicates whether the Phy does support active priority signalling. Any other value will indicate the time in micro seconds of the PAS signal that

will be send in response to a Ph-DATA.request(SEND_PAS,data) primitive.
The time will include the ramp-up and ramp-down periods.

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