# IEEE 802.11
## Wireless Access Method and Physical Layer Specifications

**Title:** **Frame Prioritization in a CSMA/CA Media Access Control Protocol**

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**Abstract:** This submission describes a method of prioritizing frames using a CSMA/CA Media Access Control Protocol. This approach will support time bounded services with no overhead for stations that only support asynchronous data transfers. It also allows the PHY layer access to the media transparent to the MAC.

## Introduction

There has been discussion of being able to provide time bounded services using a non-TDMA based Media Access Control Protocol. [1] It is important to define a media access protocol that does not carry a large amount of overhead for stations that support only asynchronous data transfers therefore producing low-cost MAC ICs. This is achieved using a scheme described in [1]. This approach is extended to support additional functionality in the MAC such as beaconing in a frequency hop system, windowing of multi-fragment frame and transparent transmission of frames by the PHY layer.

This submission also describes an approach for hop synchronization using the priority scheme in a frequency hopping system.

## Prioritization

Prioritization is accomplished by timing the interframe gap. In other words, the longer the channel is idle, the lower the priority of the traffic that can be sent. This is illustrated in Figure 1. A station begins timing the interframe gap at $t_0$. At $t_1$ a station can transmit traffic of Priority 1 if it has any in its queue. At $t_2$ it can transmit traffic of Priority 2 and so on. The interframe gaps are very small when compared to the length of a frame. The Physical layer would provide an indication of the length of the interframe gap to the MAC. This would eliminate the need for the MAC to have knowledge of the transmission speed in order to determine the interframe gap.

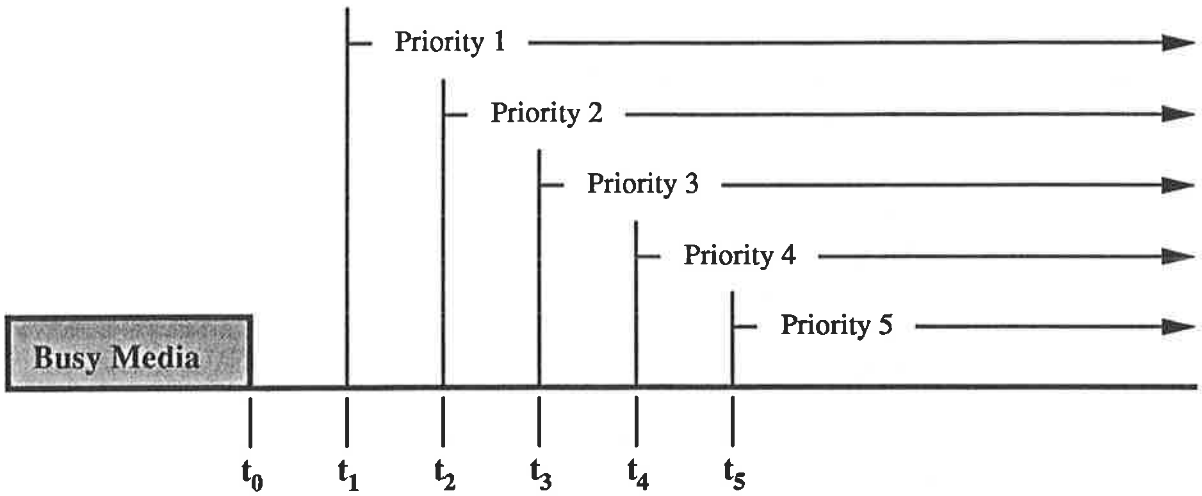


Figure 1: Prioritization using Timed Interframe Spacing

An example of priority transmission is shown in Figure 2. In the example, station 'A' has two frames ready for transmission, one of priority 1 and one of priority 5. Station 'B' has a single frame of priority 2. Since 'A' has the highest priority frame, it will transmit after it has determined the media has been idle for a period of at least $t_1$. After the transmission is complete, both 'A' and 'B' will begin timing the interframe gap. When the media is still idle at $t_2$, 'B' will transmit its priority 2 frame. Again after the transmission is complete, the stations will begin timing the interframe gap. Assuming that there are no other stations with frames to transmit, 'A' will transmit its priority 5 frame after $t_5$. The above example assumes that the frames were put into the transmission queue only after they completed a backoff before transmission algorithm.

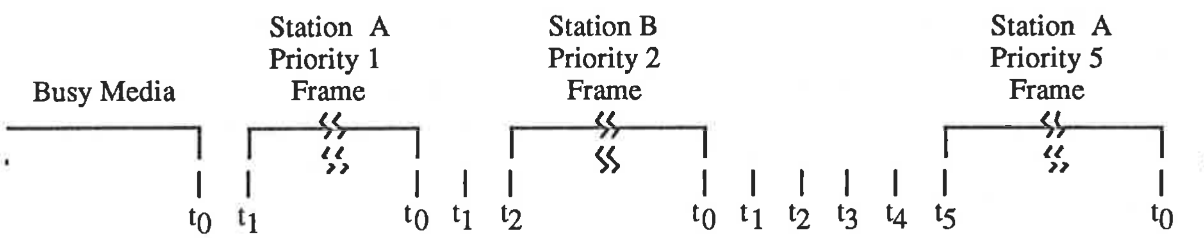


Figure 2: Prioritization Example

Priorities can be assigned to any type of frame. The following is an example of the types of frames that could be assigned specific priorities. A diagram illustrating the priorities is shown in Figure 3. It should be noted that the priorities could be assigned in any order. This is only an example.

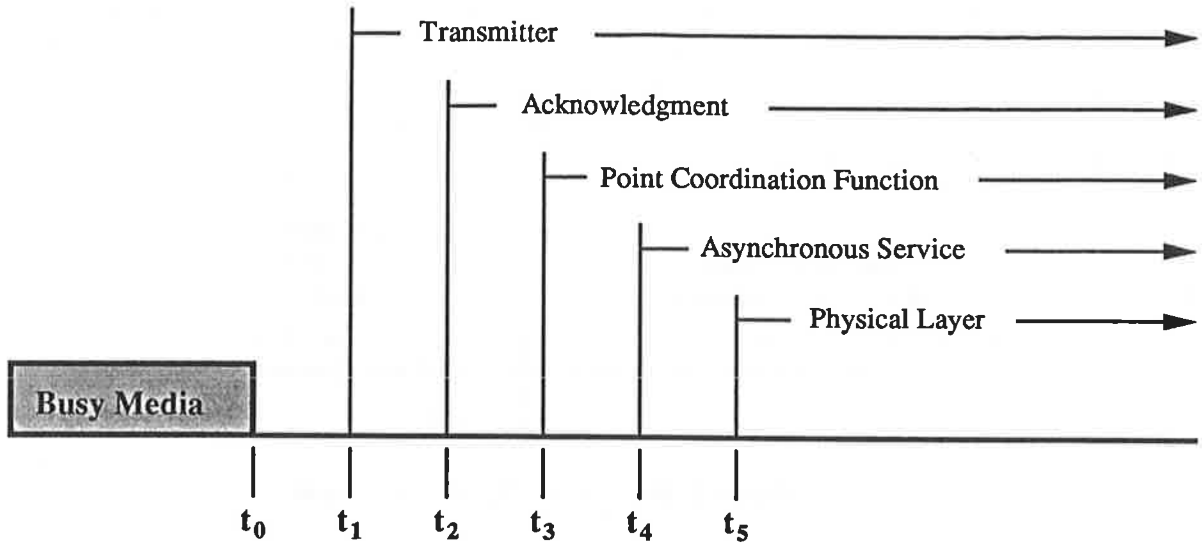


Figure 3: Traffic Prioritization

## Transmitter – Priority 1

This priority is used to allow a station to send multiple asynchronous frames without being preempted by another station. In order to minimize the amount of time that a station can "hold-on" to the channel, a limited number of frames can be sent. This also allows windowing of the frames in order to cut down overhead.

Windowing allows a station to send a burst of frames and only receiving a single ACK. This is shown in Figure 4. The example uses a window size of three. Station 'A' has three frames to send to Station 'B'. 'A' will send the first frame and wait for am interframe time of $t_1$. 'A' will send the second frame and again wait for $t_1$. At this point, 'A' will send the third frame and wait for an ACK. Assuming that 'B' received all the frame without error, it will wait $t_2$ and send the ACK.

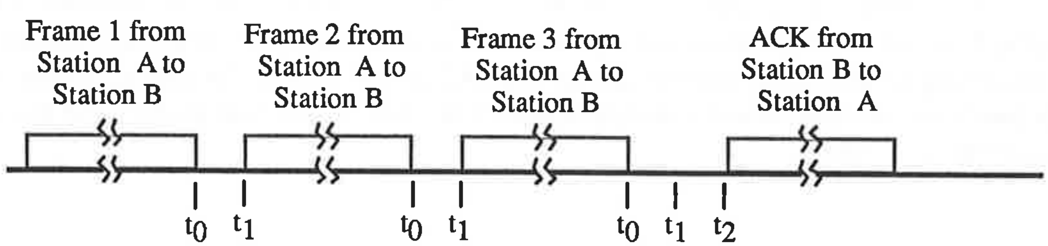


Figure 4: Multi-Frame Windowing

## Acknowledgment – Priority 2

This priority allows acknowledgments to be sent by a receiving station following the successful reception of a frame or windowed frames addressed to the station. This allows a receiver to send an ACK uncontested since no other station will be receiving the frame. This illustrated in Figure

5. A frame is transmitted from station 'A' to station 'B'. After an interframe gap of $t_2$, station 'B' will transmit the acknowledgment frame to station 'A'. Acknowledgments will only be transmitted for frames that are addressed to a specific station. In other words, broadcast and multicast frames will not be acknowledged. Since the frame was addressed to station 'B' there will not be a collision with any other station.

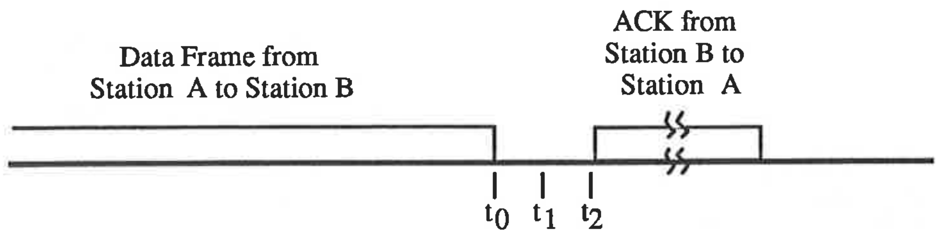


Figure 5: Priority 2 – Acknowledgment

## Point Coordination Function– Priority 3

This priority allows a Point Coordination Function (Access Point) to transmit control frames. These control frames can be beacons used synchronization (beacons), a frame used to begin a period of time bounded traffic or any other Access Point frame that may require a priority higher than normal data traffic.

This allows beacons to be transmitted when the channel is idle or immediately following a frame transmission and ACK. A frame can be sized to the available space left before a beacon is to be transmitted or the priority can be used to stretch the dwell time.

### Synchronization in a Frequency Hopping System

The Point Coordination Function priority can be used to synchronize the hopping in a frequency hopping system. Synchronization is achieved through the use of beacons. This is shown in Figure 6. In a wireless network with an Access Point present, the Access Point will send the beacons. In an ad hoc network, a "master" station will be elected to transmit the beacons. The frequency hopping beacons will be transmitted at the end of a dwell time. The beacon identifies the time and the frequency to which the stations are to hop. All stations know the hop sequence and also time each dwell. In the case where a station misses a beacon, it will hop to the next frequency after a timeout has occurred.

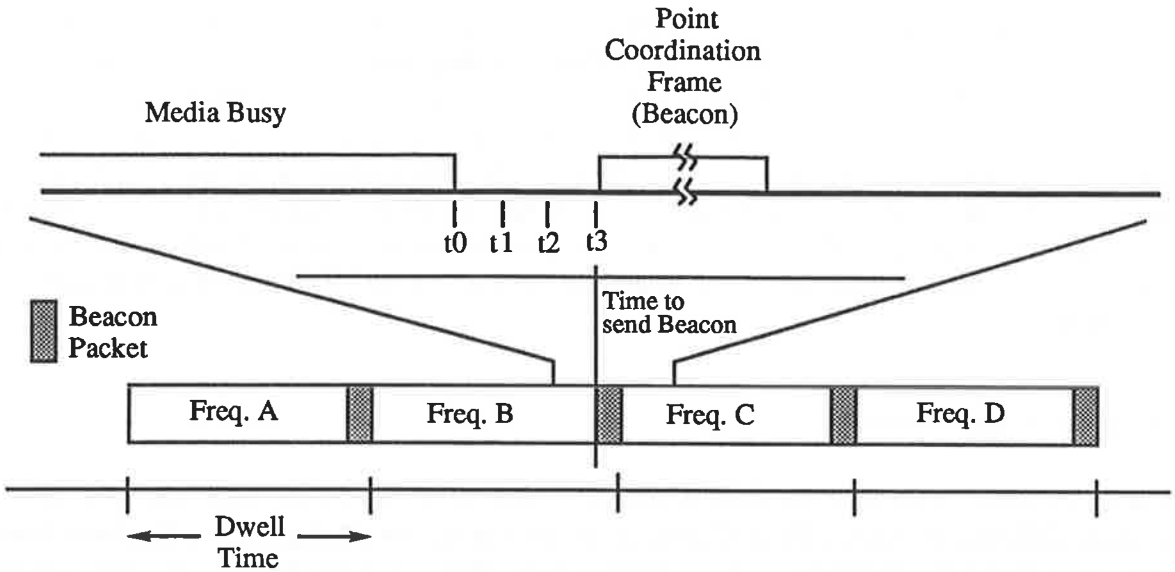


Figure 6: Synchronization in a Frequency Hopping System

**Dwell Time Stretch**

In order to stretch a dwell time to allow a transmission to complete, it is assumed that the beacon frame is transmitted at the end of a dwell time. The beacon frame indicates that it is time to hop to a specified frequency. If a frame transmission starts before the end of a dwell time and is not completed before the end of the dwell time, the beacon will not be transmitted until the frame transmission is complete. This stretches the dwell time. This is illustrated in Figure 7.

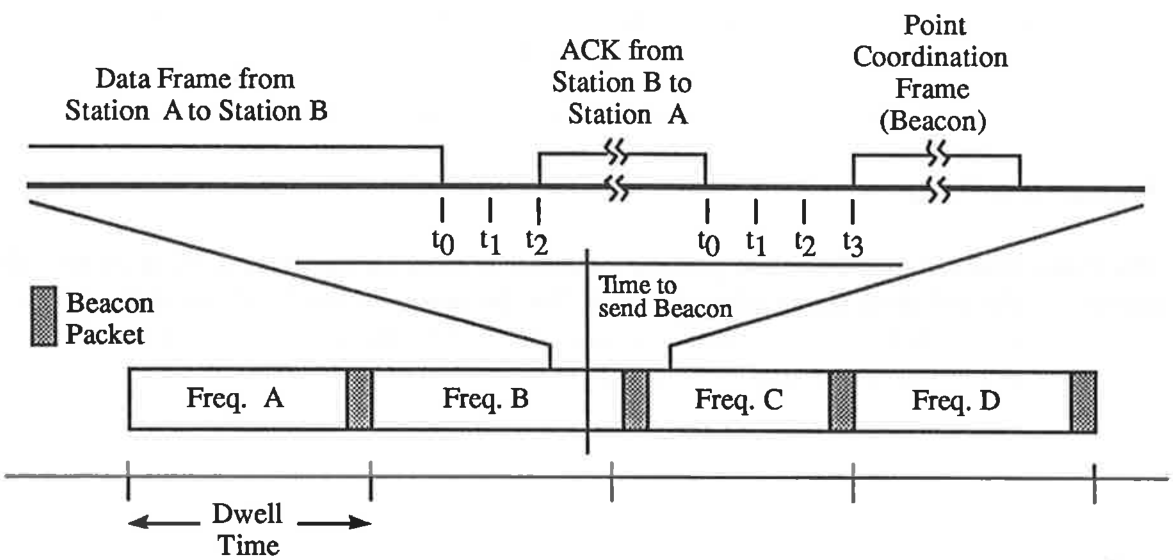


Figure 7: Dwell Stretching using Prioritization

In the example shown in Figure 7, when it is time to send a beacon at the end of the dwell for frequency B, the channel is busy completing a frame transmission. The Point Coordination Function will sense that the channel is busy and will wait until $t_3$ after the completion of the transmission. At this point, the beacon frame will be transmitted. As can be seen from the time line, the dwell time for frequency B is lengthen and the dwell time for frequency C is shorten. This is due to the fact that the beacon at the end of the dwell for frequency C is sent based on the desired dwell time instead of the actual. The process in the Point Coordination Function that triggers the sending of the beacon is independent of the actual time the beacon is transmitted on the channel.

### Time Bounded Services

Using a priority approach for time bounded service also allows for time bounded services that require differing periods. This is illustrated in Figure 8. For example, a voice conversation may require a frame transmission every 5 milliseconds where as a multimedia session may require a frame transmission every 3 milliseconds. This would be difficult to do in a TDMA approach unless the framing was 1 millisecond. A 1 millisecond frame would introduce a lot of overhead and unused bandwidth.

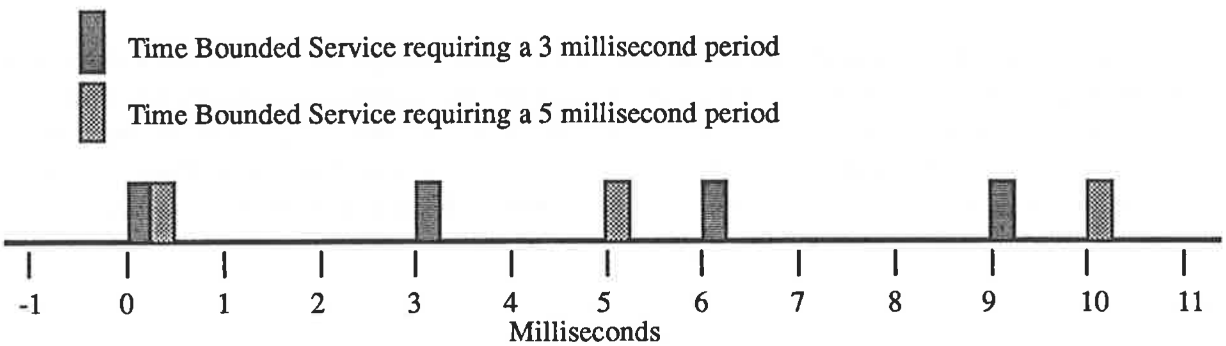


Figure 8: Time Bounded Services Requiring Different Periods

### Transparent Relay

The Point Coordination Function priority can also be used by the Access Point to provide a relay service. If the AP does not receive the ACK for the previous frame, it could then retransmit the frame to the destination station, assuming it is serviced by the same AP. This type of relay would be transparent to the originating station. This is illustrated in Figure 9.

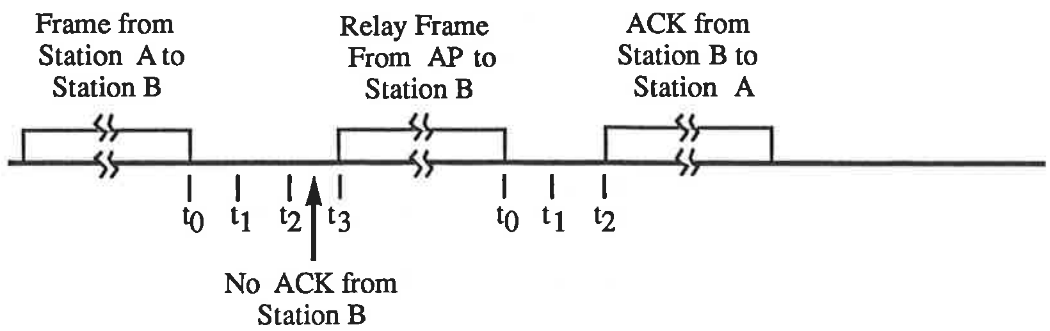


Figure 9: Transparent Relay

## Asynchronous Service – Priority 4

This priority allows a user to send a 'new' frame or window of frames. This allows a transmission of a frame or window of frames to occur before another user tries to access the channel. Since the Access Point service handles time bounded services, it also provides a lower priority to asynchronous service with respect to time bounded service. The asynchronous service is used for data frames, association and reassociation requests, requests for time bounded services, and other control frames.

## Physical Layer Service – Priority 5

This priority allows the Physical layer to send frames transparent to the MAC. These frames would be ones that are specific to a given physical layer (frequency hopping, direct sequence, etc.). This would allow a generic MAC to be specified without specific frames for each physical layer.

The Physical Layer priority could be used to control the timing of the frequency hopping in the system. This allows the physical layer to hop the radio without impacting the MAC. When the PHY was using the channel, it would give a busy indication to the MAC.

The following is an example of how the Physical Layer priority could be used to control the hopping in a frequency hopping system. When the PHY controlling the hopping decided it was time for the radio to hop, it would send a frame on the media when it is available to the Physical Layer. The media would look busy to the MAC, so it would be unable to send a frame. This is shown in Figure 10. This priority can also be used for other radio control traffic specific to a particular PHY. It is transparent to the MAC and allows unique PHY control traffic with no impact on the MAC.

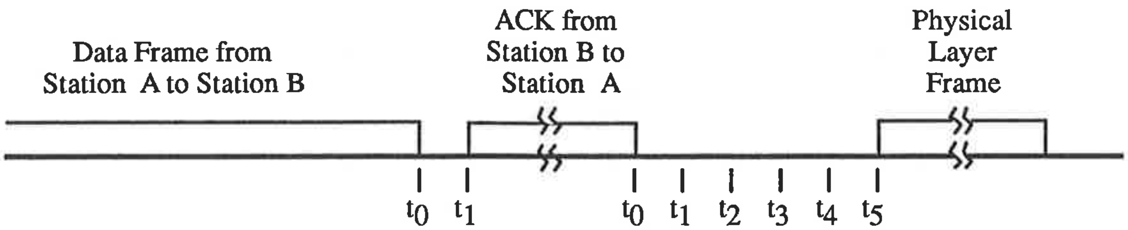


Figure 10: Priority 5 - Physical Layer

## Conclusion

The approach of using the timing of interframe gaps allows for a very flexible implementation of the MAC. A MAC that only supports certain priorities such as acknowledgments and asynchronous traffic does not have to carry overhead to operate in a system that does supports all priorities. The timing of the interframe gap is done by the physical layer.

This approach not only handles asynchronous and time bounded services but also address multi-fragment windowing and PHY dependent traffic. The dependencies determined by the physical layer being used are removed and allows the physical layers to exchange frames transparently to the MAC.

## References

[1] Wim Diepstraten, NCR, "A Distributed Access Protocol proposal supporting Time Bounded Services", Doc IEEE P802.11-93/70 May 1993.