IEEE 802.11
Wireless Access Method and Physical Layer Specifications

Title: **Power Management in an Ad Hoc Network**

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Abstract: This submission provides ad hoc network power management text for the draft standard.

Introduction

The May 1995 letter ballot removed power management for ad hoc networks. This submission provides text for draft that defines power management in an ad hoc network. I believe that power management is required for ad hoc networks since at this point in time no one can define how this standard will be used. A standard that does not define power management in an ad hoc network may well overlook important markets.

Action

Adopt the text presented in this document into the next version of the draft standard.

8.2.2. Power Management in an Ad Hoc Network

This section specifies the power management mechanism for ad hoc networks.

8.2.2.1. Basic Approach

The basic approach is similar to the infrastructure case in that the stations are synchronized, and frames which are to be transmitted to a power conserving station are first announced. The announcement is done via an Ad Hoc Traffic Indication Message (ATIM). A power conserving station need only listen for these announcements to determine if its receiver must be left on.

When a frame is to be transmitted to a destination station that is in a Power Save (PS) mode, the transmitting station first transmits an ATIM frame during the ATIM Window, in which all the stations including those operating in a Power Save (PS) mode are awake. The ATIM Window is defined as a specific period of time following a beacon during which only ATIM frames can be transmitted using the DCF Access procedure. The ATIM is not acknowledged. If a station receives an ATIM frame during the ATIM Window, it will stay awake for the entire Beacon Interval waiting for the frame to be received. If a Station does not receive an ATIM, it can go back to PS Mode after the end of the ATIM Window.

It is possible that an ATIM can be received from more that one station and that a station that receives an ATIM may receive more than a single frame from the transmitting station. ATIM frames are only addressed to the destination station of the frame.

An ATIM will have a destination address of broadcast/multicast for broadcast/multicast frames. All stations will remain awake if they receive an ATIM with a broadcast/multicast destination address.

After the ATIM Interval, the frames are transmitted using the DCF Access procedure.

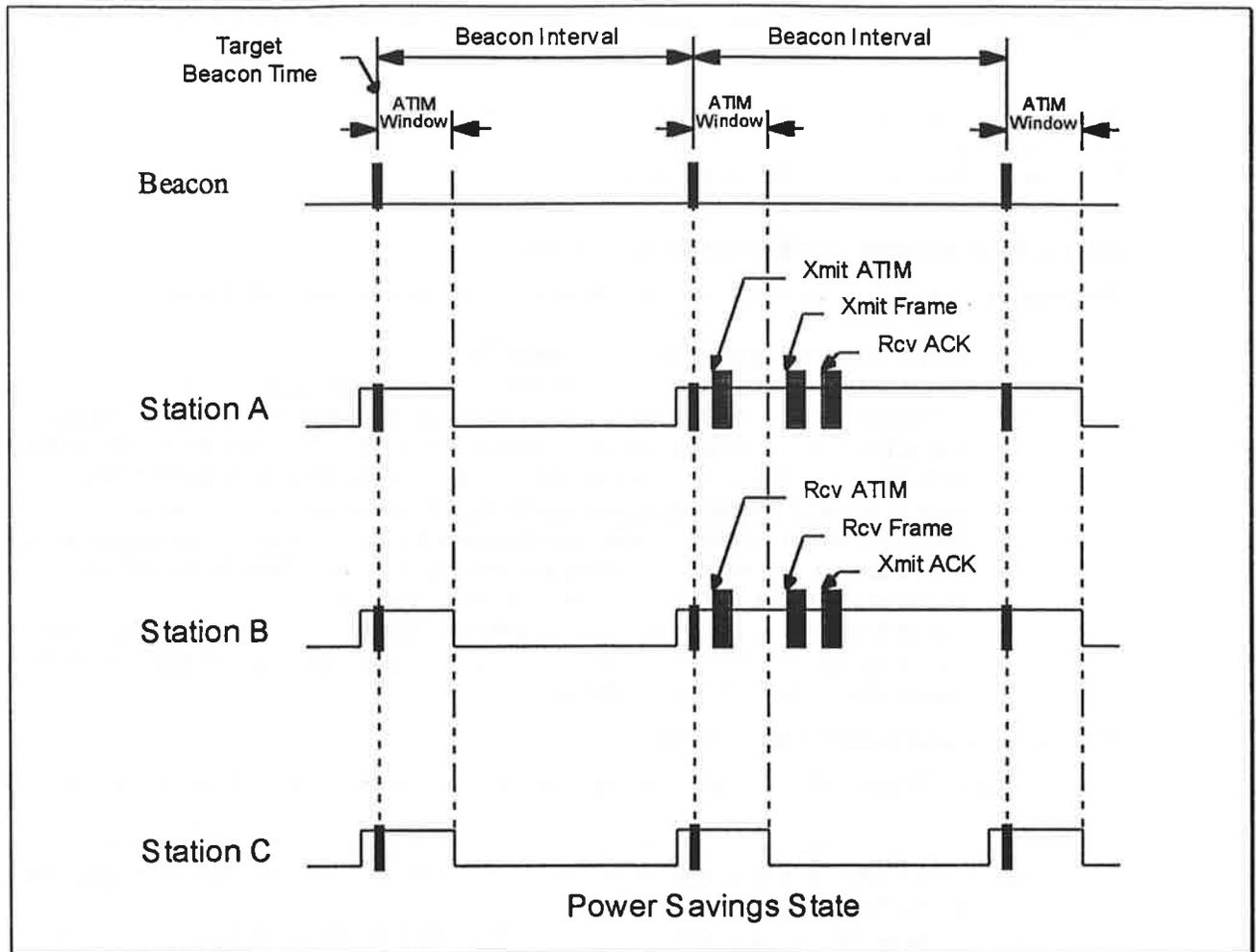The following figure illustrates the basic power save operation.

Figure 7-6: Ad Hoc Power Management - Basic Operation

The estimated power saving state of another station can be based on the power management information transmitted by that station and additional information available locally such as history of failed transmission attempts. The use of RTS/CTS in an ad hoc network can reduce the length of transmissions to a station that is in Power Save mode. It a RTS is sent and a CTS is not received, the transmitting station can assume that the destination station is Power Save mode.

8.2.2.2. Power Management State Estimation

Each station can estimate the power management state of station with which it needs to exchange frames. This can be done in one of four ways.

1) A station can monitor the Power Management bits within the frames generated by other stations in the network. A station that intends on using PS mode must indicate that in all frames transmitted.

2) A station can transmit the frame when received from the LLC and assume the destination station is in PS mode if an Ack is not received.

3) A station can use RTS/CTS to transmit a frame. If a CTS is not received, the destination station can be assumed to be in PS mode.

4) A station can always assume all other stations are operating in PS Mode. In this case, the station will always transmit an ATIM in the ATIM Window before transmitting a frame

A station will transmit a frame when received from the LLC to the destination station if the destination station is assumed not to be in PS mode and it is not during an ATIM interval.

If RTS/CTS is used, the destination station will be assumed to be in PS mode and the frame will be buffered if a CTS is not received. If RTS/CTS is not being used, the destination station will be assumed to be in PS mode and the frame will be buffered if an Ack is not received.

8.2.2.3. ATIM Window and Beacon Transmission

The following procedure is used to receive and transmit beacons and transmit ATIM frames:

     a)   Station shall wake up prior to Target Beacon Time.
                Target Beacon Time is defined as: [TSFTIMER]MODaBeacon_Interval = 0
     b)   The length of the ATIM window is defined in the Ad Hoc Parameters Set element in the Beacon. A station that receives a beacon will update its aATIM_Window MIB variable with the value contained in the beacon. A station that transmits a beacon will use the value of the aATIM_Window MIB variable for the ATIM Window parameter in the Ad Hoc Parameter Set element.
     c)   Station receives/transmits a Beacon. The procedure for generating Beacons is defined in Section 8.1.
     d)   After a Beacon is received/transmitted, a station may transmit ATIMs for all buffered frames until the end of the ATIM Window using the DCF Access Procedure.
                End of ATIM Window is defined as: [TSFTIMER]MODaBeacon_Interval – aATIM_Window = 0
     e)   If a station has an ATIM to transmit and is unable to do so before the end of the ATIM Window, it must wait until the next ATIM Window.

8.2.2.4. ATIM and Frame Transmission

A station that has frames buffered for a station that is assumed to be in PS mode shall operate as follows:

     a)   The station will send an ATIM during the ATIM Window using the DCF Access procedure.
     b)   Only ATIMs shall be transmitted during the ATIM Window. ATIMs can only be transmitted during the ATIM Window.
     c)   Following the ATIM Window, the station will transmit the buffered frames using the DCF Access procedure.
     d)   The station transmitting the ATIM will remain awake for the entire Beacon Interval.
     e)   Buffered frames may be fragmented.
     f)   If more than one frame is buffered for a given station, multiple frames can be transmitted using the DCF Access procedure. A frame will indicate if more frames are buffered via the Power Management bits.

A frame that is in the process of backoff will be considered a buffered frame for the purpose of ad hoc power management. In other words, an ATIM will be transmitted every ATIM Window until the frame is successfully delivered or times out, even if the frame may not be transmitted during the beacon interval because it is in the process of backoff.

A fragmented frame that has outstanding fragments will also be considered a buffered frame for the purpose of ad hoc power management.

8.2.2.5. Receive Operation for PS Mode

A station which wishes to conserve power in ad hoc mode shall operate as follows:

     a)   Stations shall wake up prior to Target Beacon Time.
     b)   The station will remain awake for the duration of the ATIM Window.
     c)   If an ATIM addressed to the station is not received, the station may go back to Power Save mode at the end of the ATIM Window.

    d)   If the station receives an ATIM frame, then the station shall remain awake for the entire Beacon Interval to receive the subsequent Data frame/s.

Author's Note: The following changes should be made in Section 5.

5.2.3.1. BEACON Frame Format

The Frame Body of a Management frame of Subtype Beacon shall contain the following information:

Order	Information	Note
1	Timestamp	
2	Beacon Interval	
3	Regulatory Domain	
4	Capability Information	
5	ESS ID	
6	Supported Rates	
7	FH Parameter Set	1
8	CF Parameter Set	2
9	Ad Hoc Parameter Set	3
109	DTIM	
110	TIM	

Notes:

1   The FH Parameter Set information shall be mandatory only within Beacon Frames generated by STAs using Frequency Hopping Physical Layers

2   The CF Parameter Set information shall be mandatory only within Beacon Frames generated by APs supporting a PCF

3   The Ad Hoc Parameter information set shall be mandatory only within Beacon Frames generated by STAs in an Ad Hoc Network

5.2.3.2 Ad Hoc Traffic Indicator Message (ATIM) Frame Format

The Frame Body Shall be Null.

5.2.3.9. Probe Response Frame Format

The Frame Body of a Management frame of Subtype Probe Response shall contain the following information:

Order	Information	Note
1	Timestamp	
2	Beacon Interval	
3	Regulatory Domain	
4	Capability Information	
5	ESS ID	
6	Supported Rates	
7	FH Parameter Set	1
8	CF Parameter Set	2
9	Ad Hoc Parameter Set	3

Notes:

1   The FH Parameter Set information shall be mandatory only within Probe Response Frames generated by STAs using Frequency Hopping Physical Layers

2   The CF Parameter Set information shall be mandatory only within Probe Response Frames generated by APs supporting a PCF

3   The Ad Hoc Parameter set information shall be mandatory only within Probe Response Frames generated by STAs in an Ad Hoc Network

5.4.2   Information Elements

Elements are defined to have a common general format consisting of a one-octet Element ID field, a one octet length field and a variable-length element-specific information field. Each element is assigned a unique Element ID as defined in this specification.   The length field shall specify the number of octets in the information field.
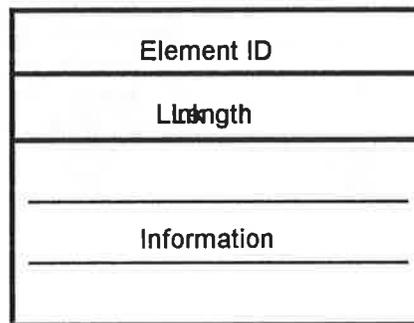

Figure 5-13, Element Format

The set of valid elements is defined below.

Information Element	Element ID
ESSID	0
Supported Rates	1
FH Parameter Set	2
CF Parameter Set	3
DTIM	4
TIM	5
Challenge Text	6
Ad Hoc Parameter Set	7

5.4.2.9 Ad Hoc Parameter Set

The Ad Hoc Parameter Set element shall contain the set of parameters necessary to support an Ad Hoc Network. The information Field shall contain ATIM Window parameter.

The ATIM Window field shall be 4 octets in length and contain the ATIM Window length in μs.

Author's Note: The following MIB Variable should be added to Section 8.4.

8.4.X.X.X   aATIM Window

ATIM_Window ATTRIBUTE
WITH APPROPRIATE SYNTAX
    integer
BEHAVIOUR
    "The ATIM Window shall indicate the time in microseconds of the ATIM window in an Ad Hoc Network. The ATIM Window defines the period of time that ATIM frames can be sent to Power Save mode Stations in an Ad Hoc network. The ATIM window begins at the Target Beacon Time.
REGISTER AS
    { iso(1) member-body(2) us(840) ieee802dot11(xxxx) SMT(x) attribute(x) atim_window(x) };