Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**Sleep Mode in MR network**	
Date Submitted	**2007-03-04**	
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Re:	IEEE 802.16j-06/027: “Call for Technical Proposals regarding IEEE Project P802.16j”
Abstract	This proposal clarifies the sleep mode in MR.
Purpose	Discuss and adopt proposed text.
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MS Sleep Mode in MR network

1. Introduction

In MR networks, the RS may use two types of scheduling. Centralized Scheduling is where MR-BS controls all the radio resource scheduling and MAP allocation. Distributed Scheduling is where some functionality of radio resource scheduling and MAC allocation are distributed to RS. This contribution proposes text to clarify the handling of MS sleep mode for distributed scheduling.

2. Distributed Scheduling

The MS sleep mode in distributed scheduling case is still centrally controlled by MR-BS. For example, the MS sleep-mode should be approved by the MR-BS, and MR-BS determines the duration of sleep, listening windows, and other properties of MS sleep mode. Also, the MR-BS determines to activate/deactivate power saving classes. However, to give RS convenience for the distributed radio resource scheduling, RS has to know the MS sleep-mode information, such as the sleep, listening windows. Based on this obtained information, the RS can allocate resources to MS on time for the event-based actions, also RS can avoid sending management messages to this MS, and can cancel the bandwidth allocated to MS during the sleep period. Therefore, it is essential to synchronize the MS sleep-mode information between MR-BS and RS.

In order to facilitate the centralized management of sleep mode in distributed MR networks, text is required to clarify how the RS and MR-BS shall synchronize the sleep-mode information between MR-BS and RS.

MR-BS can instruct the MS sleep mode by sending MOB_SLP-RSP, RNG-RSP, or DL sleep control extended subheader. If the RS could not share the security key (HMAC, CMAC) with MR-BS, it can only relay these message, rather than obtain the sleep mode information by decoding these received message. Therefore, in this case, the MR-BS has to send a MS_SLP-INFO message, which contains necessary sleep mode information, to RS to inform the sleep mode information, before sending MOB_SLP-RSP, RNG-RSP, or DL sleep control extended subheader to the MS, which is subordinate to the RS.

Sending a MS_SLP-INFO message to RS on its basic CID may cause inconsistency of sleep status among MR-BS, MS and RS. For example, MS receives the MOB_SLP-RSP and enters sleep-mode, but RS does not get the corresponding sleep-mode information due to packet loss on relay link. In this case, RS could send PDUs/Messages to the MS while the MS is in sleep interval. To avoid any inconsistency of sleep status if RS doesn't successfully obtain the information about the sleep mode context of the CIDs, RS shall send, SLP_INF-ACK, to MR-BS after it correctly receives the MS_SLP-INFO message.

When MR-BS decides to approve of the CIDs to enter sleep mode, or to activate/deactivate power-saving classes, it firstly sends a MS_SLP-INFO to RS on RS' basic CID to inform the RS the corresponding MS sleep-mode information. If RS receives the MS_SLP-INFO message sent on its' basic CID, it sends SLP_INF-ACK to MR-BS for acknowledgement. Then MR-BS starts to send MOB_SLP-RSP, RNG-RSP, or DL sleep control extended subheader to MS to instruct the sleep mode.

In conclusion, with some relatively simple modifications to the MR-BS, it is possible to support the RS obtaining sleep mode information through MS_SLP-INFO messages in an MR network. Furthermore, the design of MS_SLP-INFO message circumvents the problems associated with authenticating relayed messages of this type at the RS and also the inability of the RS to generate such messages in the absence of knowing the CMAC key or a security association between the RS and MS.

4. Specific Text Change

6.3.2.3 MAC management messages

[***Change Table 14 as indicated***]

Type	Message name	Message description	Connection
~~67-255~~		~~Reserved~~	
67	MS_SLP-INFO	MS sleep mode information	Basic
68	SLP_INF-ACK	MS Sleep mode acknowledge	Basic
69-255	-	Reserved	-

6.3.2.3.62 MS sleep mode information message (MS_SLP-INFO)

[Insert the following text after the second paragraph of subclause 6.3.2.3.45:]

An MR-BS sends the MS_SLP-INFO message to RS for informing about its subordinate MS sleep mode. This message conveys sleep mode information for the MSs attached through the RS. If any of an MS's connection is removed from the sleep mode to idle mode, the MR-BS sends MS_SLP-INFO with Definition=0 and Operation=0 for that particular CID. This removes only the corresponding sleep information from the RS.

Syntax	**Size**	**Notes**
MS_SLP-INFO_Message_format() {	-	-
Management message type = xx	8 bits	-
Transaction ID	16 bits	

Number of MS	8 bits	Number of MSs included in the message.
for (i=0; i<Number of MS; i++) {		
MS Basic CID	16 bits	Identification of an MS
Number of Classes	8 bits	Number of power saving classes
for (i=0; i<Number of Classes; i++) {	-	-
Definition	1 bit	-
Operation	1 bit	-
Power_Saving_Class_ID	6 bits	-
if (Operation = 1) {	-	-
Start_frame_number	6 bits	-
Reserved	2 bits	-
}	-	-
If (Definition = 1) {	-	-
Power Saving Class Type	2 bits	
Direction	2 bits	
Traffic_triggered_wakening_flag	1 bit	
TRF_IND required	1 bit	
Reserved	2 bits	
Initial sleep window	8 bits	
Listening window	8 bits	
Final-sleep window base	10 bits	
Final-sleep window exponent	3 bits	
Number_of_Sleep_CIDs	3 bits	

for (i=0; i<Number_of_Sleep_CIDs; i++ {		
CID		
}	16 bits	
If (TRF-IND required) {		
SLPID	10 bits	
Reserved	6 bits	
}		
}		
TLV encoded information	variable	TLV specific
}		

The following parameters shall be included in the message:

Transaction ID
Unique identifier set by the sender for identifying this transaction.
Number of MS
Total number of MS in the message.
Definition
0 = Definition of Power Saving Class absent; in this case the message shall request activation or deactivation of Power Saving Class identified by Power_Saving_Class_ID.
1 = Definition of Power Saving Class present.
Operation
0 = Deactivation of Power Saving Class (for types 1 and 2 only).
1 = Activation of Power Saving Class.
Power_Saving_Class_ID
Assigned Power Saving Class identifier. The ID shall be unique within the group of Power Saving Classes associated with the MS. This ID may be used in further MOB_SLP-REQ/RSP messages for activation / deactivation of Power Saving Class.
Start_frame_number
Start frame number for first sleep window.
Power Saving Class Type

Power Saving Class Type of a connection.

Direction

Defined the directions of the class's CIDs.
0b00 = Unspecified. Each CID has its own direction assign in its connection creation. Can be DL, UL, or both (in the case of management connections).
0b01 = Downlink direction only.
0b10 = Uplink direction only.
0b11 = Reserved.

Traffic_triggered_wakening_flag (for Type I only)

0 = Power Saving Class shall not be deactivated if traffic appears at the connection as described in 6.3.19.2.
1 = Power Saving Class shall be deactivated if traffic appears at the connection as described in 6.3.19.2.

TRF-IND_Required

For Power Saving Class Type I only.
1 = BS shall transmit at least one TRF-IND message during each listening window of the Power Saving Class.
This bit shall be set to 0 for other types.

Initial-sleep window

Assigned initial duration for the sleep window (measured in frames). For Power Saving Class type III, it is not relevant and shall be encoded as 0.

Listening window

Assigned Duration of MS listening window (measured in frames). For Power Saving Class type III, it is not relevant and shall be encoded as 0.

Final-sleep window base

Assigned final value for the sleep interval (measured in frames). For Power Saving Class type II, it is not relevant and must be encoded as 0. For Power Saving Class type III, it is the base for duration of single sleep window requested by the message.

Final-sleep window exponent

Assigned factor by which the final-sleep window base is multiplied in order to calculate the final-sleep window. The following formula is used:
final-sleep window = final-sleep window base × 2(final-sleep window exponent)
For Power Saving Class type III, it is the exponent for the duration of single sleep window requested by the message.

SLP_ID

This is a number assigned by the BS whenever an MS is instructed to enter sleep mode.

The MS_SLP-INFO message shall include the following parameters encoded as TLV tuples:
HMAC/CMAC Tuple (see 11.1.2)
The HMAC/CMAC Tuple shall be the last attribute in the message.

[***Insert a new subclause after 6.3.2.3.62***]

6.3.2.3.63 SLP_INF-ACK message

After successfully receiving the a MS-SLP-INF message sent by MR-BS on RS' basic CID, the RS shall transmit SLP_INF-ACK message on its basic CID to MR-BS to acknowledge that it got the information about the sleep context of the CIDs indicated.

Syntax	Size	Note
SLP_INF-ACK_Message_format(){		
Management message type = xx	8bits	
Transaction ID	16bits	
TLV encoded information	Variable	TLV specific
}		

The following parameters shall be included in the message:

Transaction ID

Transaction ID from corresponding MOB_SLP-RSP message.

All other parameters are coded as tuples:

HMAC/CMAC Tuple (see 11.1.2)

The HMAC/CMAC Tuple attribute contains a keyed message digest (to authenticate the sender). The HMAC Tuple attribute shall be the final attribute in the DSx message's attribute list.

[Insert a new subclause after 6.3.21.7]

6.3.21.7.x MS sleep mode support for distributed scheduling approach

In MR networks, the sleep mode of MS shall be centrally controlled by the MR-BS in the presence of distributed scheduling i.e. The MR-BS shall be responsible for generating MOB_SLP-RSP, DL sleep control extended subheader, or RNG-RSP with power-saving class parameters (Table 364a) messages, which will be relayed by RSs.
In the distributed scheduling case, before MR-BS instructing the MS sleep mode parameters by sending MOB_SLP-RSP, DL sleep control extended subheader, or RNG-RSP with power-saving class parameters to the RS' subordinate MSs, the MR-BS shall send an MS_SLP-INFO message to the access RS on the RS's basic CID to inform the RS the corresponding MS sleep mode parameter modifications. After receive this MS_SLP-INFO message, the access RS shall send SLP_INF-ACK message to MR-BS to acknowledge that it got the information about the sleep context of the CIDs indicated. The MB-RS shall retransmit the MS_SLP-INFO message to the access RS on the RS's basic CID, if it does not

receive the SLP_INF-ACK message from the corresponding access RS within the T49 timer. MR-BS may do retransmission for a maximum of SLP-INFO Retry Count.. Once MR-BS receives the SLP_INF-ACK message, it shall send a messages, such as MOB_SLP-RSP, DL sleep control extended subheader, or RNG-RSP with power-saving class parameters, which will be relayed by RSs, to the RS' subordinate MS.

10.1 Global values

[***Add one row in table 342 as indicated***]

System	Name	Time reference	Minimum value	Default value	Maximum value
MR-BS	T49	Time the MR-BS waits for SLP_INF-ACK from RS	-	-	-
MR-BS	MS_SLP_INFO_retry_count	Number of retries on MS_SLP-INFO transmission			