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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 MR\_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 MR\_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 MR\_SLP-INFO to RS on RS' basic CID to inform the RS the corresponding MS sleep-mode information. If RS receives the MR\_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 MR\_SLP-INFO messages in an MR network. Furthermore, the design of MR\_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
<del>67-255</del>		<del>Reserved</del>	
<u>67</u>	<u>MR_SLP-INFO</u>	<u>MS sleep mode information</u>	<u>Basic</u>
<u>68</u>	<u>SLP_INF-ACK</u>	<u>MS Sleep mode acknowledge</u>	<u>Basic</u>
<u>69-255</u>	=	<u>Reserved</u>	=

##### 6.3.2.3.62 MS sleep mode information message (MR\_SLP-INFO)

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

An MR-BS sends the MR\_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 MR\_SLP-INFO with Definition=0 and Operation=0 for that particular CID. This removes only the corresponding sleep information from the RS.

<u>Syntax</u>	<u>Size</u>	<u>Notes</u>
<u>MR_SLP-INFO Message format() {</u>	=	=
<u>Management message type = xx</u>	<u>8 bits</u>	=
<u>Transaction ID</u>	<u>16 bits</u>	

<u>Number of MS</u>	<u>8 bits</u>	<u>Number of MSs included in the message.</u>
<u>for (i=0; i&lt;Number of MS; i++) {</u>		
<u>MS Basic CID</u>	<u>16 bits</u>	<u>Identification of an MS</u>
<u>Number of Classes</u>	<u>8 bits</u>	<u>Number of power saving classes</u>
<u>for (i=0; i&lt;Number of Classes; i++) {</u>	=	=
<u>Definition</u>	<u>1 bit</u>	=
<u>Operation</u>	<u>1 bit</u>	=
<u>Power Saving Class ID</u>	<u>6 bits</u>	=
<u>if (Operation = 1) {</u>	=	=
<u>Start frame number</u>	<u>6 bits</u>	=
<u>Reserved</u>	<u>2 bits</u>	=
<u>}</u>	=	=
<u>If (Definition = 1) {</u>	=	=
<u>Power Saving Class Type</u>	<u>2 bits</u>	
<u>Direction</u>	<u>2 bits</u>	
<u>Traffic triggered waking flag</u>	<u>1 bit</u>	
<u>TRF_IND required</u>	<u>1 bit</u>	
<u>Reserved</u>	<u>2 bits</u>	
<u>Initial sleep window</u>	<u>8 bits</u>	
<u>Listening window</u>	<u>8 bits</u>	
<u>Final-sleep window base</u>	<u>10 bits</u>	
<u>Final-sleep window exponent</u>	<u>3 bits</u>	
<u>Number of Sleep CIDs</u>	<u>3 bits</u>	

<u>for (i=0; i&lt;Number of Sleep CIDs; i++ {</u>		
<u>CID</u>		
<u>}</u>	<u>16 bits</u>	
<u>  If (TRF-IND required) {</u>		
<u>    SLPID</u>	<u>10 bits</u>	
<u>    Reserved</u>	<u>6 bits</u>	
<u>  }</u>		
<u>}</u>		
<u>TLV encoded information</u>	<u>variable</u>	<u>TLV specific</u>
<u>}</u>		

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.DirectionDefined 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 waking 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\_RequiredFor 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 windowAssigned 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 windowAssigned 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 baseAssigned 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 exponentAssigned 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  $\times$  2<sup>(final-sleep window exponent)</sup>For Power Saving Class type III, it is the exponent for the duration of single sleep window requested by the message.SLP\_IDThis is a number assigned by the BS whenever an MS is instructed to enter sleep mode.The MR\_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.

<u>Syntax</u>	<u>Size</u>	<u>Note</u>
<u>SLP_INF-ACK Message format(){</u>		
<u>Management message type = xx</u>	<u>8bits</u>	
<u>Transaction ID</u>	<u>16bits</u>	
<u>TLV encoded information</u>	<u>Variable</u>	<u>TLV specific</u>
<u>}</u>		

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 MR\_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 MR\_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 MR\_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]*

<u>System</u>	<u>Name</u>	<u>Time reference</u>	<u>Minimum value</u>	<u>Default value</u>	<u>Maximum value</u>
<u>MR-BS</u>	<u>T49</u>	<u>Time the MR-BS waits _____ for SLP_INF-ACK from RS</u>	=	=	=
<u>MR-BS</u>	<u>MS SLP INFO retry count</u>	<u>Number of retries on _____ MR SLP-INFO transmission</u>			