Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>	
Title	RS Sleep Mode	
Date Submitted	2007-1-8	
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Re:	IEEE802.16j-06/034: “Call for Technical Proposals regarding IEEEP802.16j”	
Abstract	This contribution proposes procedures for RS sleep mode procedure.	
Purpose	Text proposal for 802.16j Baseline Document	
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RS Sleep Mode

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1 Introduction

Sleep mode is essential for power saving. RS is a relay which responses for traffic sent from MR-BS to MSs and vice versa. Considering the deployment issues, RS may be installed without wired power line. The fix/nomadic RS may rely on battery or solar power as backup power source, and the mobile RS may only rely on battery power. This contribution is mainly aimed at RS sleep mode which not only supports RS power saving, but also releases the air interface resources to the other active RSs.

1.1 RS Sleep Mode

This contribution adopts the MR-BS centralized control mechanism and introduces a sleep mode procedure for power constrained RS. The sleep mode feature of RS is useful for providing power efficiency, especially in the mobile RS with battery power source or low-power fixed RS powered by the solar power or battery. Also, such feature is also applicable to nomadic RS and client owned RS. In these cases, RS is installed without power line. As RS enters sleep mode, its power resource could be conserved and the air interface resources could be released further.

1.1.1 Broadcast in RS Sleep Mode

Depending on RS type, an RS either relays or generates broadcast messages such as FCH, DCD, UCD, DL_MAP and UL_MAP. If RS relays broadcast messages, then the MR-BS needs to coordinate the broadcast message intervals with the RS, such that the RS stays in the active mode during the broadcast message relay period. If RS generates its own broadcast messages, then there is no need for the coordination.

In order to facilitate network-entry/network-re-entry/handover for the associated MS staying in sleep mode, two RS sleep modes, the Full RS Sleep Mode and the Partial RS Sleep Mode, are defined,.

1.1.2 Full RS Sleep Mode

There is no traffic at relay link and access link during RS staying in sleep mode. In this mode, the MR-BS ceases sending traffic to RS, and RS also stops serving all associated downstream RSs and MSs.

1.1.3 Partial RS Sleep Mode

There is no traffic at relay link or access link except that the DL Start Frame Preamble, FCH, DCD, UCD, DL_MAP, UL_MAP, and broadcast messages periodically sent from the RS at predefined intervals for supporting the message exchanges for the events of MS network entry/re-entry/handover. Attached MSs that stay in sleep mode could send the MOB_SCN-REQ, MOB_MSHO-REQ, and MOB_SCN-REP management messages on the UL location allocated in the UL_MAP if the enabled-action-triggered events are permitted and

corresponding events are triggered. The interval of RS broadcasting and allocating the UL bandwidth for bandwidth request messages for exchanging such managements should be less than the time MS searches for decodable UL_MAP.

1.1.4 RS Sleep Mode in Centralized Scheduling

It is noteworthy that the proposed RS Sleep Mode does not cause any change to the MS sleep mode, it works on top of the MS sleep mode.

In centralized scheduling MR-BS controls all the schedulings and MAP allocations for all MSs and RSs even parts of them are staying in sleep mode. First, the MR-BS informs MS and RS in proper sequences about the listening and sleep windows. Then, the RS could enter into the sleep mode with the sleeping pattern which is consistent to the listening and sleep windows of all attached MSs. As all attached MSs are in sleep mode, the RS(s) on the relay path could enter into sleep mode for power conservation. The activation of RS sleep mode is fully managed by MR-BS. Alternatively, a RS can request the activation of RS sleep mode (e.g., due to backup power source is activated) by sending RS_SLP-REQ message with MR-BS. RS will obtain the sleep pattern from RS_SLP-RSP message sent from MR-BS.

1.1.5 RS Sleep Mode in Distributed Scheduling

The assumption of the distributed scheduling is that the all RS are capable of performing scheduling functions. For centralized control and distributed scheduling system, the access RS of the access link shall have the information of sleep patterns of associated MSs. After RS is notified the sleep mode information of its subordinate MSs, it will generate the listening and sleep windows for itself and issue an RS_SLP-REQ carrying the sleep parameters to the MR-BS. RS could enter sleep mode after it receives the RS_SLP-RSP message sent from MR-BS. This procedure is optional and independent of the MS sleep mode.

2 Spec Changes

This section contains the suggested text for the 802.16 specification changes.

Change Table 14 as indicated:

Type	Message name	Message description	Connection
~~67–255~~		~~Reserved~~	-
xx	RS_SLP-REQ	RS Sleep Request	Basic
xx	RS_SLP-RSP	RS Sleep Response	Basic
xx-255		Reserved	-

6.3.21.7 Relay sleep mode support for mobility supporting MS

6.3.21.7.3 RS sleep mode

In MR-BS centralized control mechanism, the sleep mode feature of RS is useful for providing power efficiency, especially in the mobile RS with battery power source or low-power fixed RS powered by the solar power or battery. Also, such feature is also applicable to nomadic RS and client owned RS. In these cases, RS is installed without power line. As RS enters sleep mode, its power resource could be conserved and the air interface resources could be released further.

In centralized control and centralized scheduling system, MR-BS controls all the schedulings and MAP allocations for all MSs and RSs even parts of them are staying in sleep mode. First, the MR-BS informs MS and RS in proper sequences about the listening and sleep windows. Then, the RS could enter into the sleep mode with the sleeping pattern which is consistent to the listening and sleep windows of all attached MSs. As all attached MSs are in sleep mode, the RS(s) on the relay path could enter into sleep mode for power conservation. The activation of RS sleep mode is fully managed by MR-BS. Alternatively, a RS can request the activation of RS sleep mode (e.g., due to backup power source is activated) by sending RS_SLP-REQ message with MR-BS. RS will obtain the sleep pattern from RS_SLP-RSP message sent from MR-BS.

For centralized control and distributed scheduling system, the access RS of the access link shall have the information of sleep patterns of associated MSs. After RS is notified the sleep mode information of its subordinate MSs, it will generate the listening and sleep windows for itself and issue an RS_SLP-REQ carrying the sleep parameters to the MR-BS. RS could enter sleep mode after it receives the RS_SLP-RSP message sent from MR-BS. This procedure is optional and independent of the MS sleep mode.

6.3.21.7.3.1 Full RS Sleep Mode

There is no traffic at relay link and access link during RS staying in sleep mode. In this mode, the MR-BS ceases sending traffic to RS, and RS also stops serving all associated downstream RSs and MSs.

6.3.21.7.3.2 Partial RS Sleep Mode

There is no traffic at relay link or access link except that the DL Start Frame Preamble, FCH, DCD, UCD, DL_MAP, UL_MAP, and broadcast messages periodically sent from the RS at predefined intervals for supporting the message exchanges for the events of MS network entry/re-entry/handover. Attached MSs that stay in sleep mode could send the MOB_SCN-REQ, MOB_MSHO-REQ, and MOB_SCN-REP management messages on the UL location allocated in the UL_MAP if the enabled-action-triggered events are permitted and corresponding events are triggered. The interval of RS broadcasting and allocating the UL bandwidth for bandwidth request messages for exchanging such managements should be less than the time MS searches for decodable UL_MAP.

6.3.2.3.64 RS_SLP-REQ message

An RS supporting sleep mode uses the RS_SLP-REQ message to request activation of RS sleep mode. The RS_SLP-REQ message is sent from the RS to the MR-BS on the RS's basic CID. The RS_Sleep_Mode bit indicates what kind of RS sleep mode is requested.

Syntax	Size	Notes
RS_SLP-REQ_Message_format() {	-	-

Management message type = xx	8 bits	-
RS_Sleep_Mode	1 bit	Value=0 – Full RS Sleep Mode Value=1 – Partial RS Sleep Mode
Support_Enabled-Action-Triggered	1 bits	
RS_start_frame_number	6 bits	
RS_initial-sleep_window	8 bits	
RS_listening-window	8 bits	
RS_final-sleep_window_base_	10 bits	
RS_final-sleep_window_exponent	3 bits	
RS_traffic_triggered_wakening_flag	1 bits	
Reserved	2 bits	
}		

Parameters shall be as follows:

RS_Sleep_Mode
0 = Full RS Sleep Mode
1 = Partial RS Sleep Mode

Support_Enabled-Action-Triggered
This field is present when Enabled Action Trigger Included flag is included. This field possible is performed action upon reaching trigger condition. RS needs this information for allowing relay of the event related message.

RS_start_frame_number
Start frame number for the sleep window.

RS_initial-sleep_window
Assigned Duration of RS listening window (measured in frames).

RS_listening-window
Assigned initial duration for the RS sleep window (measured in frames).

RS_final-sleep_window_base_
Assigned final value for the RS sleep interval (measured in frames).

RS_final-sleep_window_exponent
Assigned factor by which the final-sleep window base is multiplied in order to calculate the RS_final-sleep window. The following formula is used:
RS_final-sleep window = RS_final-sleep window base $\times 2^{(\text{RS\_final-sleep window exponent})}$

RS_traffic_triggered_wakening_flag
0 = be activated if traffic appears at the connection activate
1= be deactivated if traffic appears at the connectiondeactivate

6.3.2.3.64 RS_SLP-RSP message

The RS_SLP-RSP message shall be sent from MR-BS to an RS on the RS's basic CID in response to an RS_SLP-REQ message, or may be sent unsolicited. The RS_Sleep_Mode bit indicates what kind of RS sleep mode is allowed.

Syntax	Size	Notes
RS_SLP-RSP_Message_format() {	-	-
Management message type = xx	8 bits	-
RS_Operation	1 bit	Value=0 – Deactivate. Value=1 – Activate.
if (RS_Operation = 1) {		
RS_Sleep_Mode	1 bit	Value=0 – Full RS Power Sleep Mode Value=1 – Partial RS Power Sleep Mode
RS_start_frame_number	6 bits	
RS_initial-sleep_window	8 bits	
RS_listening-window	8 bits	
RS_final-sleep_window_base_	10 bits	
RS_final-sleep_window_exponent	3 bits	
RS_traffic_triggered_wakening_flag	1 bits	
Support_Enabled-Action-Triggered	1 bits	
Reserved	1 bits	
RS_SLPID	10 bits	
REQ-duration	8 bits	
Reserved	6 bits	
}		
else{		
Reserved	7 bits	

}		
}		

Parameters shall be as follows:

RS_Operation
0= Deactivation of RS Sleep Mode
1= Activation of RS Sleep Mode
RS_Sleep_Mode
0 = Full RS Sleep Mode
1 = Partial RS Sleep Mode
Support_Enabled-Action-Triggered
This field is present when Enabled Action Trigger Included flag is included. This field possible is performed action upon reaching trigger condition. RS needs this information for allowing relay of the event related message.
RS_start_frame_number
Start frame number for the sleep window.
RS_direction
0b00 = Both
0b01 = Downlink direction only
0b10 = Uplink direction only
0b11 = Reserved
RS_traffic_triggered_wakening_flag
0 = be activated if traffic appears at the connection activate
1= be deactivated if traffic appears at the connection deactivate
RS_initial-sleep_window
Assigned Duration of RS listening window (measured in frames).
RS_listening-window
Assigned initial duration for the RS sleep window (measured in frames).
RS_final-sleep_window_base_
Assigned final value for the RS sleep interval (measured in frames).
RS_final-sleep_window_exponent
Assigned factor by which the final-sleep window base is multiplied in order to calculate the RS_final-sleep window. The following formula is used:
RS_final-sleep window = RS_final-sleep window base $\times 2^{(\text{RS\_final-sleep window exponent})}$
Scheduling_type
0 = Centralized Scheduling
1 = Distributed Scheduling
RS_SLPID
This is a number assigned by the MR-BS whenever an RS is instructed to enter sleep mode. This number shall be unique in the sense that it is assigned to a single RS that is instructed to enter sleep mode. No other RS shall be assigned the same number while the first RS is still in sleep mode
REQ-duration

Waiting value for the RS_SLP-REQ message re-transmission (measured in MAC frames): the RS may retransmit the RS_SLP-REQ message after the time duration (REQ-duration) provided in the message.

Change the subclause 11.7.15:

11.7.15 Sleep mode recovery time

The 'Sleep mode recovery time' field indicates the time required for an MS or an RS that is in a sleep mode to return to awake-mode. This parameter is optional and may be used by the MR-BS to determine sleep interval window sizes when initiating sleep mode with an MS or an RS.

Type	Length	Value	Scope
32	1	Number of frames required for the MS or the RS to switch from sleep mode to awake-mode	REG-REQ

Insert new figures in annex D:

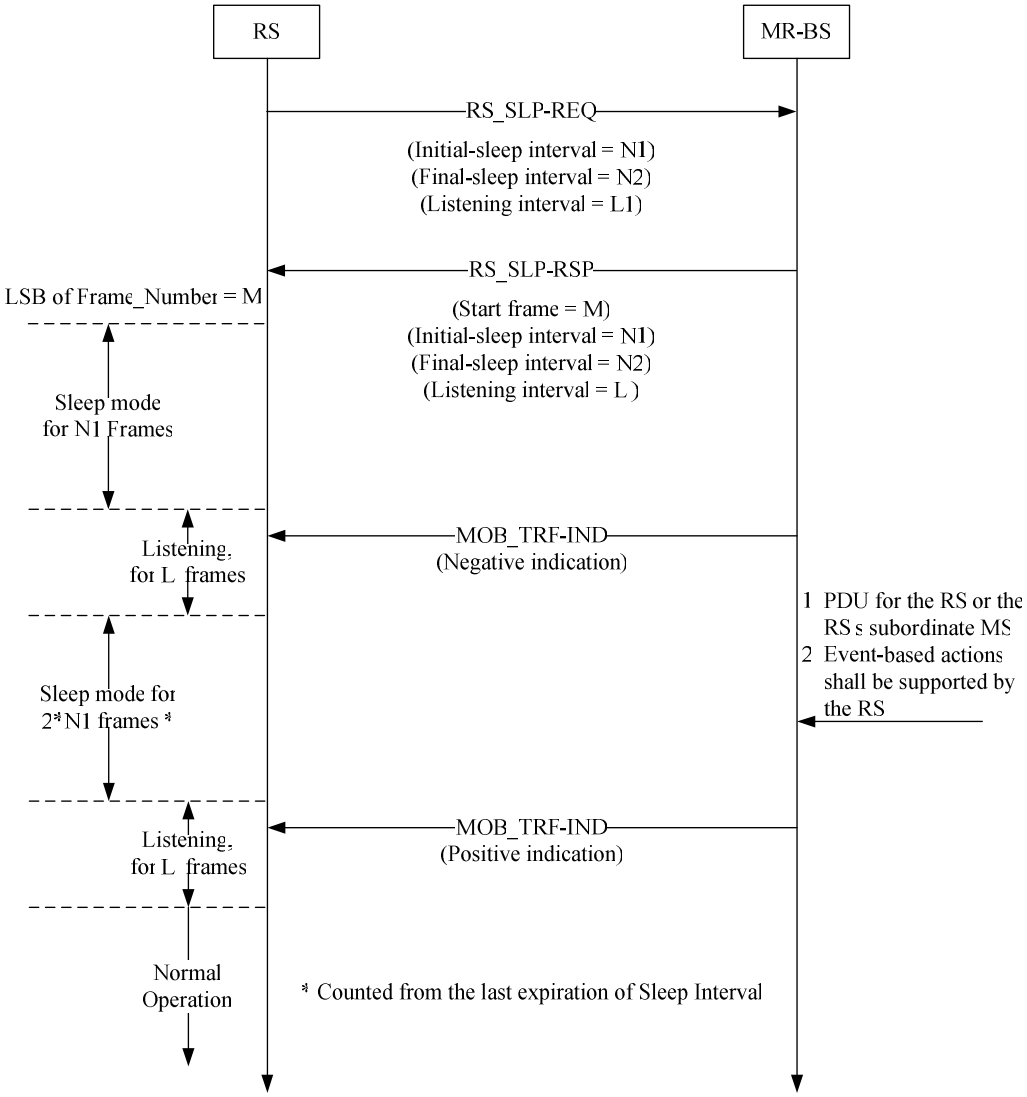

Figure D. 10--Example RS sleep mode — RS initiated

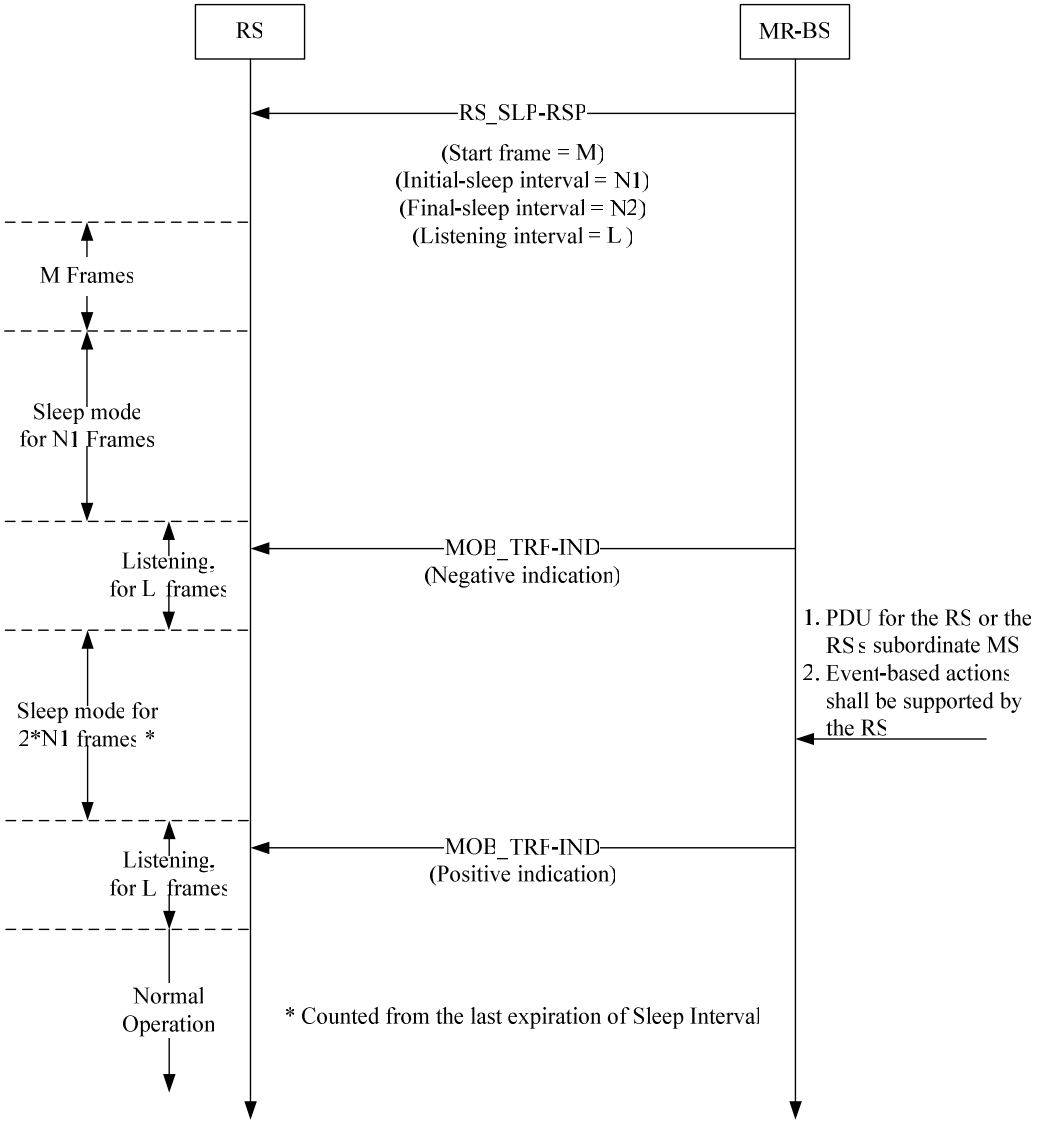

Figure D. 11--Example RS sleep mode — MR-BS initiated

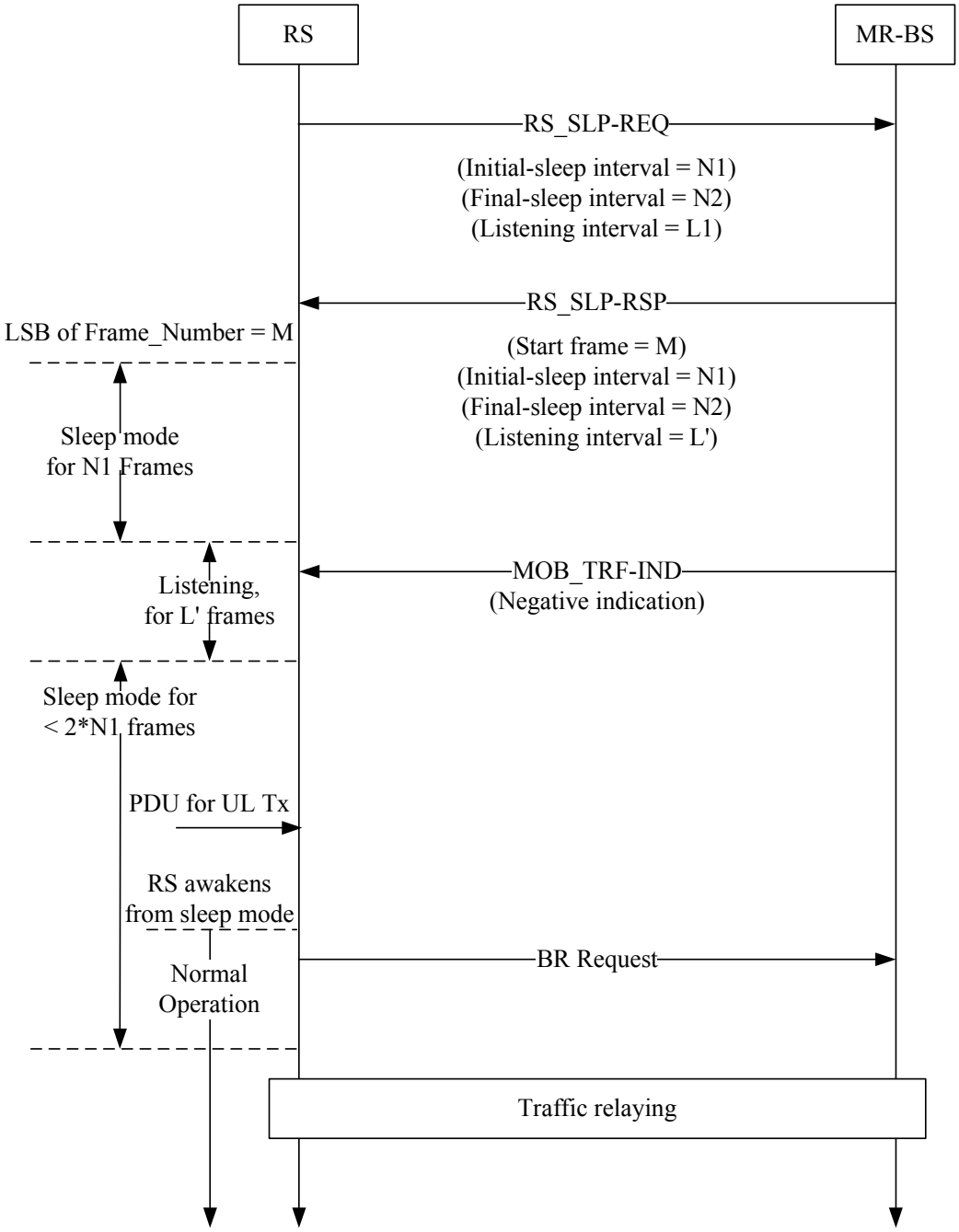

Figure D. 12-- Example RS Sleep mode— RS initiating awakening