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Re:	This contribution is response to call for contribution about IEEE802.16e-D1
Abstract	This contribution is to propose the MOB_TRF IND message in order to perform the periodic ranging within sleep interval.
Purpose	Discuss and Adopt the advanced feature for periodic ranging in sleep mode in the IEEE802.16e group.
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Periodic Ranging in Sleep mode

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1. Problem Statement

IEEE P802.16-REVd/D3-2004, SS joined to BS shall perform the periodic ranging procedure in order to adjust transmission parameters so that it can maintain its uplink communications with the BS. For backward compatibility, MSS supporting IEEE 802.16e/D1-2004 shall also support the periodic ranging procedure defined in IEEE P802.16e/D1-2004.

For each MSS, a BS shall maintain a T27 timer as defined in IEEE P802.16-REVd/D3-2004. Whenever the timer expires, the BS shall issue a ranging opportunity for an uplink transmission (or uplink burst) to the MSS through a UL-MAP message. This timer is restarted each time a unicast grant is made to the MSS. On the other hand, each MSS shall maintain a T4 timer as defined in IEEE P802.16-REVd/D3-2004. The expiration of this timer indicates to the MSS that it has not been given any opportunity to transmit to the BS during an extended period of time. Under Assuming that its uplink transmission parameters are no longer useable, the MSS initializes its MAC operations.

If MSS supports sleep mode, there is a big problem in performing the periodic ranging. BS has a T27 timer for each MSS irrespective of whether it supports the sleep mode. During a sleep window, MSS does not send or receive PDUs, has no obligation to listen to any DL traffic and may even power down one or more its physical operation components. Thus, BS may allocate an uplink burst (or periodic ranging opportunity) to MSS that is in sleep window, at the expiration of the T27 timer. Since MSS does not know whether it is given any uplink burst during the sleep window, it cannot execute the periodic ranging properly. As a result, MSS may have difficulty in its uplink communication with the BS. In the worst case, MSS may fail to receive any grant of bandwidth at the time of T4 expiration, and reinitiate its MAC operations.

2. Proposed Remedy

For the purpose to resolve the above problems, we propose a modified MOB_TRF-IND message considering both sleep mode and periodic ranging. Currently, the MOB_TRF-IND message contains some parameters including a SLPID bitmap. Each bit of the SLPID bitmap indicates a traffic indication for an MSS in sleep mode represented by a sleep id. The MSS shall decode the MOB_TRF-IND message during its listening intervals in order to check whether it receives a positive indication. It means that MSS checks a single bit mapped to its sleep id.

As a way to support both the periodic ranging and the power saving in sleep mode, we modifies the MOB_TRF-IND message; each SLPID is represented by 2 bits in the SLPID bit-map, and an additional 10-bit frame offset is assigned to each MSS scheduled to have a periodic ranging in the next sleep window. The detailed operation related with the modification is as follows.

- The two bits assigned to an MSS have additional information about Traffic Indication or Periodic Ranging Operation based on its value.
  - The bits have the following meanings respectively
    - ◆ OPR: Occurrence of Periodic Ranging in the next sleep interval; the first bit
    - ◆ TRF_or_MGMI: Indication of Traffic Indication or Management message after Periodic Ranging; the second bit
  - Table 1 explains the MSS operation according to the possible combinations of the two bits

Table 1. Bit Allocation and MSS action

Bit Allocation (OPR:TRF_or_MGMI)	Meaning	MSS Action
0:0	During the next Sleep window, No Periodic Ranging Operation with negative Traffic Indication	May return to Sleep mode.
0:1	During the next Sleep window, No Periodic Ranging Operation with positive Traffic Indication	Shall transit to Awake mode in order to receive DL Traffic.
1:0	During the next Sleep window, Periodic Ranging Operation with no additional MAC Management message after completion of the Periodic Ranging	May return to and remain in sleep mode until the start of periodic Ranging Operation. (The Frame Offset indicates when to awake in the sleep window from the end of listening interval.) After the completion of Periodic ranging Operation, MSS may return to sleep mode.
1:1	During next Sleep window, Periodic Ranging Operation with additional MAC Management message after completion of the Periodic Ranging	May return to and remain in sleep mode until the start of periodic Ranging Operation. (The Frame Offset indicates when to awake in the sleep window from the end of the listening interval.) After the Completion of Periodic ranging Operation, MSS shall wait to receive an additional MAC Management message maintaining awake mode.

- The frame offset(FR_OFFSET-Frame offset used to awake within sleep window for periodic ranging) means
  - If the periodic ranging operation occurs, that is, BS allocates the uplink burst for periodic ranging through UL-MAP message to MSS in sleep mode, MSS shall transit to an awake mode within sleep window in order to get the UL burst for periodic ranging. In that case, MSS has to know when to awaken during the sleep window. For this reason, MSS whose OPR is '1', that is, MSS with periodic ranging operation during sleep window shall refer to FR_OFFSET assigned to itself. Its unit is frame.
  - MSS whose OPR bit is '1' shall read its FR_OFFSET in the order of SLPID among all the MSSs whose OPR bit is '1'. And then, for power saving, MSS may return to and remain in sleep mode until the start of periodic ranging operation apart from the end of the listening interval as FR_OFFSET.

Figure 1 shows the example of the proposed operation of periodic ranging and sleep mode
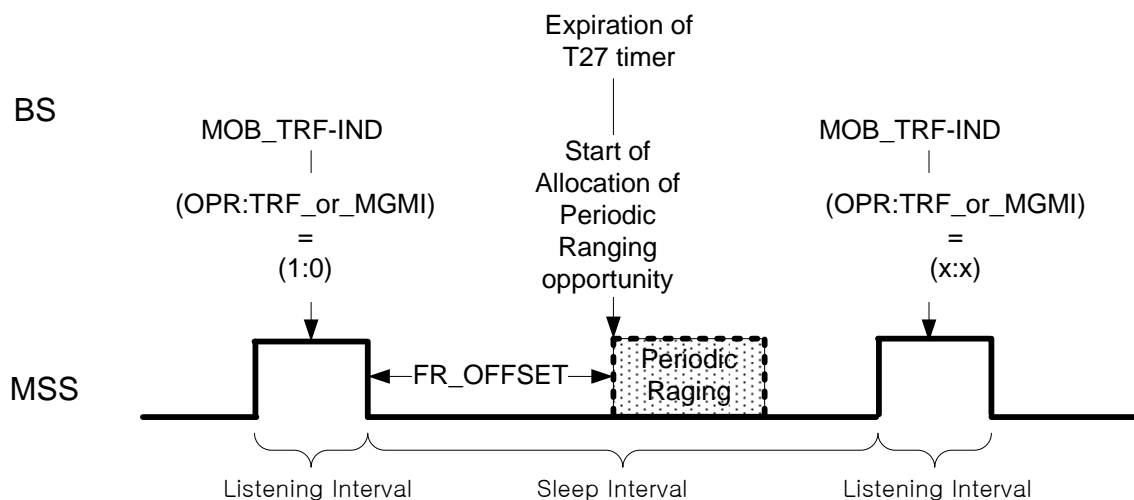
Figure 1. The proposed operation of sleep mode and periodic ranging

3. Proposed Text Changes

[Modify the paragraph of 6.4.2.3.4.44 in Page 23, Line 52 as follows]

6.4.2.3.44 Traffic Indication message (MOB_TRF-IND)

This message is sent from BS to MSS on the broadcast CID. The message is intended for MSS's that are in sleep-mode, and is sent during those MSS's listening-intervals. The message indicates whether there has been traffic addressed to each MSS in sleep-mode and whether Periodic Ranging Operation for each MSS exists or not within its own sleep window. An MSS that is in sleep-mode during its listening interval shall decode this message to seek a 2bit-wise indication addressed to it.

When an MSS awakens, it will check the frame number to ensure that it did not lose frame synchronization with the BS. Then it will read a two-bit indicator assigned to it, and take one of the following actions accordingly.

The indicator with "00" means that the MSS will have neither periodic ranging operation nor DL traffic to receive within the next sleep window. The MSS may return to sleep mode.

The indicator with "01" means that the MSS will have no periodic ranging operation but DL traffic to receive within the next sleep window. The MSS shall stay in awake mode to receive the DL traffic from its BS.

The indicator with "10" means that the MSS will have a periodic ranging operation within the next sleep window, but it will have no additional MAC management message to receive after the successful periodic ranging operation. Therefore, it shall read its 'Frame Offset to Awake for Periodic Ranging' in the order of its SLPID among all the MSSs with their indicator set to '10' or '11'. MSS may return to and remain in sleep mode until the start of periodic ranging operation apart from the end of its listening interval as 'Frame Offset to Awake for Periodic Ranging'. And then, it shall awaken to decode the UL-MAP for periodic ranging opportunity. Upon completion of the periodic ranging operation, it may return to sleep mode, since there is no additional MAC Management message to receive during the remaining sleep interval.

The indicator with "11" means that the MSS will have a periodic ranging operation within the next sleep window, and it will have an additional MAC management message to receive after the periodic ranging operation succeeds. Therefore, it shall do the same operation as the case where the indicator is "10" except for remaining in an awake mode to receive the additional MAC Management message even after the completion of the periodic ranging operation.

If MSS meets another listening interval during the current periodic ranging, it shall monitor and decode MOB_TRF-IND message.

[Modify Table 85c in Page 24, Line 1 – Traffic-Indication(MOB_TRF-IND) message format as follows]

Table 85c --- Traffic-Indication(MOB_TRF-IND) Message format

Syntax	Size	Notes
MOB_TRF-IND_Message_Format() {		
Management message type = 48~~7~~		
Byte of SLPID bit-map	8 bit	
SLPID bit-map	Variable	Two bits are allocated to one MSS 00 : No Periodic Ranging Operation in Sleep Window and No DL Traffic 01 : No Periodic Ranging Operation in Sleep Window and DL Traffic 10 : Periodic Ranging Operation in Sleep Window and Return to Sleep mode after Periodic Ranging 11 : Periodic Ranging Operation in Sleep Window and Maintain Awake mode after Periodic Ranging
NUM_of_MSS_Periodic_Ranging	8 bit	
For(i=0; i<NUM_of_MSS_Periodic_Ranging; i++) {		
Frame Offset to Awake for Periodic Ranging	10 bit	Frame Offset to Awake within sleep window for the MSS with its two-bit indicator in SLPID bit-map set to 10 or 11
}		
Padding	Variable	
}		

Parameters shall be as follows:

Byte of SLPID bit-map

The size of SLPID bit-map field in bytes

SLPID bit-map

The SLPID bit-map is a variable length field with its length determined by the number of SLPID currently assigned by the BS. It requires padding for byte alignment, if needed. The most-significant 2 bits of the first byte in the bit-map is an indicator for the MSS with SLPID=0, and the subsequent 2 bits are for the MSS with SLPID=1, etc.

The MSS with SLPID=n by the SLP-RSP message shall interpret the 2 bit indicator $(b_{2n}b_{2n+1})$ in the SLPID bit-map in the following manner:

b_{2n} means whether a periodic ranging operation exists within the next sleep window

$b_{2n} = 0$ means that a periodic ranging operation is not scheduled within the next sleep window.

$b_{2n} = 1$ means that a periodic ranging operation is scheduled within the next sleep window.

b_{2n+1} has different meanings depending on the b_{2n}

In case of $b_{2n} = 0$

$b_{2n+1} = 0$ means a negative indication of DL Traffic to receive

b_{2n+1} = 1 means a positive indication of DL Traffic to receive

In case of b_{2n} = 1

b_{2n+1} = 0 means that MSS may return to sleep mode after the periodic ranging operation succeeds.

b_{2n+1} = 1 means that MSS shall remain in awake mode after the periodic ranging operation succeeds.

Num_of_MSS_Periodic_Ranging

The number of MSSs with their b_{2n} set to 1. This field indicates how many 'Frame Offset to Awake for Periodic Ranging' fields are appended in this message.

Frame Offset to Awake for Periodic Ranging

This field is valid only for a group of MSSs with the first bit of their two bit indicator set to 1. An MSS in the group shall count the number of MSSs with SLPID lower than its SLPID. The count indicates the position of a 'Frame Offset to Awake for Periodic Ranging' that the MSS should read. After the frame offset apart from the end of its listening interval as this field, the MSS shall awaken to receive UL-MAP containing a grant of bandwidth to it, and execute a periodic ranging operation.

Padding

Padded dummy bits for byte alignment of MOB_TRF-IND message

[Modify the paragraph of 6.4.17.1 in Page 35, Line 22 as follows]

6.4.17.1 Introduction

Sleep-mode is a mode in which MSSs supporting mobility may power down, scan neighbor BSs, range neighbor BSs, conduct hand-over/network re-entry, or perform other activities for which the MSS will be unavailable to the Serving BS for DL or UL traffic. Sleep-mode is intended to enable mobility-supporting MSSs to minimize their power usage and to facilitate hand-over decision and operation while staying connected to the network. Implementation of sleep-mode is optional.

An MSS in sleep-mode shall engage in a sleep-interval, defined as a time duration, measured in whole frames, where the MSS is in sleep-mode. The sleep-interval is constructed of one or more variable-length, consecutive sleep-windows, with interleaved listening-windows, through one or more sleep-window-iterations. During a sleep-window, an MSS does not send or receive PDUs, ~~has no obligation to listen to DL traffic and~~. may powerdown one or more physical operation components, or may awaken for periodic ranging,. During a listening-interval, an MSS shall synchronize with the Serving BS downlink and listen for appropriate MOB_TRF-IND traffic indication message. The MSS shall decide whether to stay awake or go back to sleep based on the value of its own 2-bit indicator in the SLPID bit-map in a ~~positive~~ MOB_TRF-IND from the Serving BS. During consecutive sleep-windows and listening-windows, comprising a single sleep-interval, sleep-window shall be updated using the algorithm as defined in 6.4.17.2 Sleep-window update algorithm.

An MSS shall awaken, enter into an interleaved listening-window according to the sleep-interval, and check whether there were PDUs addressed for it and Periodic Ranging Operation within the next sleep window. The listening-window parameter defines the maximum number of whole frames the MSS shall remain awake waiting for an MOB_TRF-IND message. Traffic indication message (MOB_TRF-IND) shall be sent by the BS on the broadcast CID during each appropriate MSS listening window. If ~~the number of positive indications is zero~~ there is no MSS to be scheduled for receiving its DL traffic or executing periodic ranging during the next sleep window, the BS sends an empty indication message, that is, MOB_TRF-IND message with 'Byte of SLPID bit--map' ~~num_positive~~=0. The BS may buffer (or it may drop) incoming PDUs addressed to the sleeping MSS and shall send notification to the MSS in its listening-window about whether ~~data has been addressed,~~ there is DL traffic or periodic ranging procedure addressed for it during an preceding interval. If DL traffic exists ~~If such PDUs exist~~, or if the listening interval has passed but the MSS didn't receive any TRF-IND message, the MSS shall remain awake, terminating the sleep-interval and re-entering Normal Operation.

If MSS find that there is DL traffic addressed to it, it shall awaken to receive DL Traffic. If MSS finds that there will be a periodic

ranging operation within next sleep window, it shall read its 'Frame Offset to Awake for Periodic Ranging' in the order of SLPID among all the MSSs with the respective periodic ranging from the MOB_TRF-IND message, and return to sleep mode until the start of periodic ranging operation apart from the end of the negotiated listening interval as its own Frame Offset. At expiration of Frame Offset, it shall awaken to decode the UL-MAP for periodic ranging opportunity. Upon completion of Periodic ranging operation, it may return to sleep mode or stay awake based on its two–bit indicator in the SLPID bit-map.

An MSS may terminate sleep-mode and return to Normal Operation anytime (i.e. there is no need to wait until the sleep-interval is over). If a Serving BS receives a PDU from an MSS that is supposed to be in sleep mode, the BS shall assume that the MSS is no longer in sleep-mode. Any UL message from the MSS to the Serving BS shall interrupt the sleep-interval, shall signal the Serving BS that the MSS is still active and connected and has not dropped connection during its sleep-interval.