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Re:	Enhancement of IEEE 802.16e Sleep mode operation
Abstract	This document presents the enhancement of sleeping mode that has been approved into the baseline document of the IEEE802.16e standard. In order to reduce the power consumption of the MSS, provide synchronization of the data transmission, define the MSS operation at the maximum window value and provide the call flow, we propose the functionalities can enhance the current sleeping mode operation. The contribution provides a general description of the proposed technique and the exact addition required to add this mode to the standard.
Purpose	Present how the IEEE802.16a can be enhanced in order to support mobility.
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IEEE802.16e Sleep Mode Enhancement

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1 Introduction

This document presents the enhancement of sleeping mode that has been approved into the baseline document of the IEEE802.16e standard. In order to reduce the power consumption of the MSS, provide synchronization of the data transmission, define MSS operation at the maximum window value and provide the call flow, we propose the functionalities can enhance the current sleeping mode operation (IEEEC802.16e-03/15r1). The contribution provides a general description of the proposed technique and the exact addition required to add this mode to the standard.

2 Proposed Enhancements of Sleep mode

2.1 Purpose of Sleep mode

Sleep mode operation can have some benefits in terms of the MSS and BS operation. Especially, from point of MSS operation, it can be able to provide the reduction of the battery consumption and this would be the aim of the current sleep mode operation. However, the sleep mode operation can have another tangible benefits from cell control of the BS. In addition to, it requires that the Rx power consumption of MSS should be taken into account to the potential factors for the sleep mode operation. The basic purposes of sleeping mode operation are followings

- MSS battery saving
  - MSS Tx power saving : the MSS would be the traffic generator and the only MSS itself can control or request the Sleep mode transition to save its Tx power according to the traffic pattern (4IPP model described in IEEEC80216-03/15r1).
  - MSS Rx power saving : the BS would be the traffic generator and the only BS itself can control the traffic flow based on its Tx buffer which would be given by the network congestions, such as WEB downloading, and indicate the Sleep mode transition to save MSS's power.
- BS control

  The BS, based on the current call admission and cell loading status, should achieve the call control and load balancing. In order to regularize cell loading and provide the call admission control efficiently, it should be allowed that the BS intentionally indicate and deny the mode changes to and from the MSS. This kind of operation would definitely provide the effective call control and increasing of the cell capacity.

2.2 Proposed Functionality

We propose some tangible functionality as followings

- PDU sequence number indication
- The MSS operation at the Maximum window value
- The number of max-window retry

- Sleep and Awake mode change approval
- Control signal and data traffic indication

2.2.1 PDU sequence number indication

When the MSS and BS enter the awake mode from the sleep mode in order to re-initiate PDU transmission, the both sides need to justify the PDU sequence number which has already been transmitted or is to be transmitted in order to avoid undesirable retransmission by duplicate transmission or protect the undesirable PDU loss. Therefore we propose the new information element, 8bits(exact number may be TBD) on the BSTRF-IND message and MSSTRF-IND message that has been newly created or re-named for the transition to awake-mode from sleep mode.

2.2.2 Maximum window operation

There was no exact description of the MSS operation when reached the maximum window size of the sleeping interval. Current draft is just mentioning as follows

" **This procedure shall be repeated as long as the resulting sleep interval does not exceed the max-window value**." in 6.2.16.2.

Therefore, it can give some confusion and unclear operation between the MSS and BS when the window size reaches the maximum value. Thus, it requires that the exact explanation of the MSS operation on the last window size increment should be described. We propose following operation and description.

" This procedures shall be repeated as long as the resulting sleep interval does not exceed the max-window value and the MSS shall send SLP_REQ message when it reaches the last increment of max-window value."

This kind of double check operation for the sleeping interval clarification by the signaling will be useful for link maintenance and synchronization in good environment of between BS and MSS.

2.2.3 The number of max-window retry

Relevant with 2.2.1, if the BS knows how many times MSS reached the last increment of max-window value, it can be able to re-allocate appropriate min-window and max-window values to the MSS when it sends SLP_RSP message corresponding to SLP_REQ message. Therefore, we propose the new information element, 6bits (exact number may be TBD), which indicates the number of retry on the max-window value, on the SLP_REQ message generated from the MSS. This information element definitely provides the flexibility of the MSS' s sleeping interval that consists of min-window and max-window values. And also, the BS can be able to allocate the initial sleeping interval based on the status of the MSS. Furthermore the MSS can save the battery consumption for monitoring the Traffic-Indication message in the listening interval due to higher min-window value.

2.2.4 Mode change approval

Current draft text, there is 1bit approval IE and 7bits reservation IE in SLP_RSP message to be used for the mode changes, awake to sleep mode initiated by the MSS. We propose the some functionality diverted from the reservation fields as followings. The operation as shown in the table 1 shows the some alternative when the MSS receives the SLP-RSP message with "Sleep Approved == 0" from the BS. When "Sleep Approved" field in the SLP-RSP message is set to 1, the following command would not be activated. In the table 1, if After-REQ-Action is set to "001", 4bits REQ-duration bits will be added to indicate that how long the MSS shall be back off. In other cases, the 4bits will be kept as a reserved field. Therefore, total 7bits are still maintained.

Table 1. Proposed information elements for mode change approval (Awake to Sleep)

After-REQ-Action	Sleep Approved == 0 (Deny)	Comments
000	The MSS may retransmit the SLP-REQ message at any time	As it is current operation described in the draft text
001	The MSS shall retransmit the SLP-REQ message after the time duration given by the BS in this message	The BS can control the load balancing and manage the MSS's request by this command
010	The MSS shall not retransmit the SLP-REQ and shall wait the SLP-REQ message from the BS	The BS accepts the request from the MSS and can decide the transition points. Furthermore this command would give the benefits that the MSS saves the battery consumption due to retransmission of SLP-REQ message and the BS reduces the cell interference
011 – 111	Reserved	

We also propose and apply this kind of logic to the TRF-CFN message which is used for the mode changes to awake mode from sleep mode initiated by the MSS. All of operation and IE are the same as the case of SLP-RSP message, but the name of IE have been changed in order to discriminate from it. Table 2 shows the command and operation of the MSS when the MSS receives the TRF-CFN message with "Awake Approved ==0". Similar to SLP-RSP message case, if After-IND-Action is set to "001", 4bits IND-duration bits will be added to indicate that how long the MSS shall be back off. In other cases, the 4bits will be kept as a reserved field.

Table 2. Proposed information elements for mode change approval (Sleep to Awake)

After-IND-Action	Awake Approved == 0 (Deny)	Comments
000	The MSS may retransmit the MSSTRF-IND message at any time	As it is
001	The MSS shall retransmit the MSSTRF-IND message after the time duration given by the BS in this message	The BS can control the load balancing and manage the MSS's request by this command

010	The MSS shall not retransmit the MSSTRF-IND message and shall wait the BSTRF-IND message from the BS	The BS accepts the request from the MSS and can decide the transition points. Furthermore this command would give the benefits that the MSS save the battery consumption due to retransmission of MSSTRF-IND message and the BS reduce the cell interference
011 – 111	Reserved	

2.2.5 Traffic type indicator

We propose the 1bit traffic type indicator to the MSSTRF-IND message, which has been newly proposed for the enhancement of sleep mode operation, in order to indicate the type of traffic to the BS. This indicator will be used for examining the traffic type (control signaling or user packet data) the MSS wants to transmit after entering the awake mode. As we proposed above, the BS may reject the MSSTRF-IND message to control the cell capacity and load balancing since the BS implicitly recognize that the MSS wants to transit to the Awake-mode for transmitting packet data even though the MSS wants to transmit the control signaling such as ranging signaling or other signaling purpose, etc. If the MSS is going to transmit the control signaling while in awake mode, the BS should allow that the MSS goes to awake mode. In opposite case, however, it may not allow that the MSS goes to awake mode, because of load balancing and cell capacity government. Therefore, to identify and guarantee the control packet transmission from the MSS side, 1bit indicator on the MSSTRF-IND message will be useful.

2.3 Proposed and Modified MAC Messages

As we explained the purpose of sleeping mode operation, we propose and modify some messages including the proposed functionalities described above. Some messages for the current sleeping mode operation and proposed message for the enhancements of sleeping mode are depicted in table 1. As shown in table 1, there are no messages and procedures for the BS initiated Sleep to Awake mode transition and the MSS initiated Awake to sleep mode transition. Table 1 also shows the some modifications and creations for the enhancement of the Sleep mode operation.

Table 1. Comparison of messages defined for Sleep mode operation

Mode	Initialization	Required messages	Current	Proposed	Modifications
Sleep to Awake mode	MSS initiated	SLP_REQ (MSS to BS)	O		Slightly modified (Start time decision point)
		SLP_RSP (BS to MSS)	O		Slightly modified (Start time decision point)
	BS initiated	SLP_REQ (BS to MSS)	X	O	“Unsolicited Instruction (?)” Proposed
		SLP_RSP (MSS to BS)	X	O	Refine the SLP_RSP in terms of direction

Awake to Sleep mode	MSS initiated	TRF_IND (MSS to BS)	X	O	Proposed message with functionalities
		TRF_CFN (BS to MSS)	X	O	Proposed with functionalities
	BS initiated	TRF_IND (BS to MSS)	O		Renamed as BSTRF_IND with new IE
		TRF_CFN (MSS to BS)	X	O	Proposed with functionalities

2.3.1 SLP-REQ message (MSS to BS)

Request of the MSS is to enter sleep mode. The message will include the requested *sleep-interval* parameters (e.g. *min-window*, *max-window* and *listening-interval*) and the number of max-window retrials. "Start time" field will be disabled when the MSS transmits this message and "Num-max-window-retry" field will be enabled when the MSS transmits this message. Modification of the existing field and new functionality proposed are in this existing message as followings.

- Modify the start time activation point: the only BS can know the system status and time to be referred and scheduled with all of MSS in the cell. Therefore, the start time should be allocated and indicated by the BS
- Propose the Num-max-window-retrial: refer to 2.2.2 and 2.2.3

2.3.2 SLP-RSP message (BS to MSS)

Authorization from the BS is to allow MSS to enter *sleep-mode.* The message includes the requested *sleep-interval* parameters (e.g. *min-window, max-window and listening-interval*), a reference time for starting the process and sleep-approval parameters. This message is sent in response to ***Sleep-Request*** from the MSS. "Sleep-approved" field and its related fields exist only when the BS transmits this message corresponding to the SLP-REQ message from the MSS. And also, "Start time" field will be enabled. Modification of the existing field and new functionality proposed are in this existing message as followings.

- Modify and propose the sleep-approved and its related fields (After-REQ-action): refer to 2.2.4
- Modify the start time activation point: refer to 2.3.1

2.3.3 SLP-REQ message (BS to MSS)

There was no this direction, BS to MSS, to request the mode changes in the current specification. But we are not sure whether or not an "Unsolicited Instruction" of SLP-RSP message can achieve this operation. However, it would be better description and standardization that the naming and the meaning of the message should be clearly and properly defined. In addition, for increasing the cell capacity and providing call admission control and load balancing, it should be supported that the BS intentionally give an indication to the MSS to be transited into sleep mode. Furthermore, battery saving should be taken into account for Rx power as well as Tx power. From point of traffic source direction, when the BS does not have something to send to the MSS, the BS can indicate the mode transition to the MSS, Awake to Sleep mode. For example, in case of WEB downloading or something like that, if the BS has been held to transmit the traffic due to network congestion or packet inter-arrival time, etc., the BS wants to hold the

transmission. This proposed SLP-REQ message transmission, BS to MSS SLP-REQ message transmission, would be useful and required for the mode changes.

It is proposed that the BS can transmit this existing message to the MSS in order to indicate the sleep mode transition. The contents of message are the same as described in 2.3.1, but descriptions for the some fields are different. "Start time" field will be enabled when the BS transmits this message, but "Num-max-window-retry" field will be disabled when the BS transmits this message. Modification of the existing field and new functionality proposed are in this existing message as followings.

- Propose the message direction to be transmitted
- Modify the start time activation: refer to 2.3.1
- Propose the Num-max-window-retry: refer to 2.2.2 and 2.2.3

2.3.4 SLP-RSP message (MSS to BS)

Authorization from the MSS is to allow *sleep-mode* transition. The message includes the requested *sleep-interval* parameters (e.g. *min-window, max-window and listening-interval*). This message is sent in response to ***Sleep-Request*** from the BS. "Sleep-approved" field and its related fields will be disabled when the MSS transmits this message corresponding to the SLP-REQ message from the BS. And also, "Start time" field will be disabled. Modification of the existing field and new functionality proposed are in this existing message as followings.

- Modify and propose the sleep-approved and its related fields (After-REQ-action): refer to 2.2.4
- Modify the start time activation point: refer to 2.3.1

2.3.5 MSSTRF-IND message (MSS to BS)

It is proposed that the MSS transmits this message that there have been PDUs or control signal addressed for it. The message will include the lastly transmitted PDU sequence number and packet type indicator. An MSS may terminate *sleep-mode* and return to *awake-mode* anytime to send this message.

- Propose this message
- Propose the PDU sequence number: refer to 2.2.1
- Propose the traffic type indicator: refer to 2.2.5

2.3.6 TRF-CFN message (BS to MSS)

Authorization from the BS is to allow entering *awake-mode.* The message includes awake-approved and its related fields, lastly received PDU sequence number, a reference time for starting the process. "Awake-approved" field and its related fields will be enabled when the BS transmits this message corresponding to the MSSTRF-IND message from the MSS. And also, "Start time" field will be enabled when the BS transmits this message. This message is sent in response to ***MSSTRF-Indication***.

- Propose this message
- Propose the awake-approved and its related fields (After-IND-action): refer to 2.2.4
- Propose the start time activation point: refer to 2.3.1
- Propose the PDU sequence number: refer to 2.2.1

2.3.7 BSTRF-IND message (BS to MSS)

Indication of the BS to an MSS is one of the frames during the *listening-interval*, that there have been PDUs addressed for it. For efficiency reasons, this message is a broadcast message. The

message will include the lastly transmitted PDU sequence number and a reference time for starting the process. Modification of the existing field and new functionality proposed are in this existing message as followings.

- TRF-IND message is renamed as BSTRF-IND message
- Propose the PDU sequence number: refer to 2.2.1
- Propose the start time activation point: refer to 2.3.1

2.3.8 TRF-CFN message (MSS to BS)

Authorization from the BS is to allow entering *awake-mode.* The message will include the lastly received PDU sequence number, a reference time for starting the process and awake-approval parameters. "Awake-approved" field and its related fields will be disabled when the MSS transmits this message corresponding to the BSTRF-IND message from the BS. And also, "Start time" field will be disabled when the MSS transmits this message. This message is sent in response to ***BSTRF-Indication***.

- Propose this message
- Propose the PDU sequence number: refer to 2.2.1

3 Text to be inserted into standard

6.2.2.3.40 Sleep Request message (SLP-REQ)

MSS supporting sleep-mode uses the SLP-REQ message to request permission from the BS to enter sleep-mode. And BS supporting sleep-mode uses the SLP-REQ message to indicate to the MSS to enter sleep-mode. The SLP-REQ message is sent from MSS/BS to the BS/MSS on the MSS's basic CID. The message includes sleep-mode parameters as requested by the MSS and indicated by the BS.

Table xxx: Sleep-Request (SLP-REQ) message format

Syntax	Size	Notes
SLP-REQ_Message_Format() {		
Management message type = 45	8 bit	
Start time	7bit	This parameter exists only when the message is sent by the BS
min-window	6 bit	
Max-window	10 bit	
listening interval	8 bit	
Num-max-window-retry	6 bit	This parameter exists only when the message is sent by the MSS
}		

Parameters shall be as follows:

Start-time

The number of frames (not including the frame in which the message has been received) until the MSS shall enter the first sleep-interval. This parameter exists only when the message is sent by the BS.

Min window

Requested start value for the sleep interval (measured in frames).

Max window

Requested stop value for the sleep interval (measured in frames).

Listening interval

Requested listening interval (measured in frames)

Num-max-window-retry

The number of max-window retries (including the current retry in which the message has been transmitted) after the MSS enter the first sleep-interval. This parameter exists only when the message is sent by the MSS.

6.2.2.3.41 Sleep Response message (SLP-RSP)

The SLP-RSP message shall be sent from BS/MSS to a MSS/BS on the MSS's basic CID in response to an SLP-REQ message. The MSS and BS shall enter sleep-mode using the parameters indicated in the message.

Table xxx: Sleep-Response (SLP-RSP) message format

Syntax	Size	Notes
SLP-RSP_Message_Format() {		
Management message type = 46	8 bit	
Sleep-approved	1 bit	0: Sleep-mode request denied 1: Sleep-mode request approved This parameter exists only when the message is sent by the BSS
If (Sleep-approved == 0) {		
~~**Reserved**~~	~~7 bit~~	
After-REQ-action	3 bit	000: The MSS may retransmit the SLP-REQ message at any time 001: The MSS shall retransmit the SLP-REQ message after the time duration(REQ-duration) given by the BS in this message 010: The MSS shall not retransmit the SLP-REQ message and wait the SLP-REQ message from the BS 011-111: Reserved
If (After-REQ-action == 001) {		
REQ-duration	4 bit	
} else {		
Reserved	4 bit	
}		
} else {		
Start-time	7 bit	This parameter exists only when the message is sent by the BS
Min-window	6 bit	
Max-window	10 bit	
listening interval	8 bit	
}		
}		

Parameters shall be as follows:

Sleep approved

Defines whether or not the request to enter sleep-mode has been approved by the BS. This parameter exists only when the message is sent by the BS

After-REQ-action

The activation indication of the MSS when the MSS receives this message from the BS

REQ-duration

Waiting value for the SLP-REQ message re-transmission (measured in frames)

Start-time

The number of frames (not including the frame in which the message has been received) until the MSS shall enter the first sleep-interval. This parameter exists only when the message is sent by the BS

Min window

Start value for the sleep interval (measured in frames).

Max window

Stop value for the sleep interval (measured in frames).

Listening interval

Value for the listening interval (measured in frames).

6.2.2.3.42 BS-Traffic Indication message (BSTRF-IND)

This message is sent from BS to MSS on the broadcast CID. The message is intended for MSS that are in sleep-mode, and is sent during those MSS listening-interval. The message indicates whether there has been traffic addressed to each MSS that is in sleep-mode. A MSS that is in sleep-mode~~m~~, during its listening-interval, shall decode this message seek an indication addressed to itself.

When ~~S~~BS awakens, it will check the frame number to ensure that it did not lost frame synchronization with the ~~B~~MSS, and MSS will check PDU sequence number lastly received before entering sleep-mode and PDU sequence number indicated in this message. ~~,~~ ~~i~~If it does not find any positive indication in the BSTRF-IND message (or the message does not exists), it will consider this as a negative indication and shall return to sleep mode.

Table xxx: BS-Traffic-Indication (BSTRF-IND) message format

Syntax	Size	Notes
BSTRF-IND_Message_Format() {		
Management message type = 47	8 bit	
Positive_Indication_List() {		Traffic has been addressed to these MSS
Num-positive	8 bit	
for (i=0; i< Num-positive; i++) {		
CID	16 bit	Basic CID of the MSS
PDU sequence	8 bit	The PDU sequence number which has been lastly transmitted before entering the sleep- mode
Start time		
}		
}		

Parameters shall be as follows:

Num-positive

Number of CIDs on the positive indication list.

PDU sequence number

The PDU sequence number that has been lastly transmitted before entering the sleep-mode

Start-time

The number of frames (not including the frame in which the message has been received) until the MSS shall enter the awake-mode

6.2.2.3.43 MSS-Traffic Indication message (MSSTRF-IND)

This message is sent from MSS to BS on the MSS's basic CID. The message is intended for BS that is in sleep-mode. The message indicates whether there has been traffic addressed to BS that is in sleep-mode. When MSS awakens, it will check the frame number to ensure that it did not lost frame synchronization with the BS, and MSS will check PDU sequence number lastly transmitted before entering sleep-mode and PDU sequence number indicated in this message. And the message also indicates whether has been control signal addressed to BS that is in sleep-mode.

Table xxx: MSS-Traffic-Indication (MSSTRF-IND) message format

Syntax	Size	Notes
MSSTRF-IND_Message_Format() {		
Management message type = 48	8 bit	
CID	16 bit	Basic CID of the MSS
PDU sequence	8 bit	The PDU sequence number which has been lastly transmitted before entering the sleep-mode
Packet indicator	1 bit	The indicator of the packet type which will be transmitted after entering the awake-mode 0: User packet 1: Control packet
}		

Parameters shall be as follows:

PDU sequence number

The PDU sequence number that has been lastly transmitted before entering the sleep-mode

Start-time

The number of frames (not including the frame in which the message has been received) until the MSS shall enter the awake-mode

Packet indicator

The indicator of the packet type that will be transmitted after entering the awake-mode

6.2.2.3.44 Traffic Confirm message (TRF-CFN)

The TRF-CFN message shall be sent from BS/MSS to a MSS/BS on the MSS's basic CID in response to an MSSTRF-IND and BSTRF-IND message, respectively. The MSS and BS shall enter awake-mode using the parameters indicated in the message.

Table xxx: Traffic-Confirmation (TRF-CFN) message format

Syntax	Size	Notes
TRF-CFN_Message_Format() {		

Management message type = 49	8 bit	
Awake-approved	1 bit	0: Awake-mode request denied 1: Awake-mode request approved This parameter exists only when the message is sent by the BS
If (Awake-approved == 0) {		
After-IND-action	3 bit	000: The MSS may retransmit the MSSTRF-IND message at any time 001: The MSS shall retransmit the MSSTRF-IND message after the time duration(IND-duration) given by the BS in this message 010: The MSS shall not retransmit the MSSTRF-IND message and wait the BSTRF-IND message from the BS 011-111: Reserved
If (After-IND-action == 001) {		
IND-duration	4 bit	
} else {		
Reserved	4 bit	
}		
}else {		
CID	16 bit	Basic CID of the MSS
PDU sequence	8 bit	The PDU sequence number which has been lastly received before entering the sleep-mode
Start-time	7 bit	This parameter exists only when the message is sent by the BS
}		
}		

Parameters shall be as follows:

Awake approved
Defines whether or not the request to enter awake-mode has been approved by the BS. This parameter exists only when the message is sent by the BS
PDU sequence number
After-IND-action
The activation indication of the MSS when the MSS receives this message from the BS
IND-duration
Waiting value for the MSSTRF-IND message re-transmission(measured in frames)
PDU sequence number
The PDU sequence number that has been lastly received before entering the sleep-mode
Start-time
The number of frames (not including the frame in which the message has been received) until the MSS shall enter the awake mode. This parameter exists only when the message is sent by the BS

6.2.16 Sleep-mode for mobility-supporting MSS

6.2.16.1 Introduction

Sleep-mode is a mode in which MSS supporting mobility may power down. Sleep-mode is intended to enable mobility-supporting MSS to minimize their energy usage while staying connected to the network. Implementation of power-save mode is optional.

A MSS and BS that supports sleep-mode can be in one of two modes:

- Awake
- Sleep

When MSS and BS are ~~is~~ in awake-mode, they are exchanging ~~it is receiving and transmitting~~ PDUs in a normal fashion. When MSS and BS are ~~is~~ in a sleep-mode, they do ~~it does~~ not exchange ~~send or receive~~ PDUs. In sleep-mode the MSS may power down.

Two intervals are defined:
Sleep-interval – A time duration, measured in whole frames, where the MSS is in sleep-mode. During consecutive sleep periods the sleep-interval shall be updated using an exponentially increasing algorithm with adjustable minimum and maximum limits.

Listening-interval – A time duration, measured in whole frames, during which the MSS, shall be able to demodulate downlink transmissions. During this interval the MSS shall decides whether to stay awake or go back to sleep based on an indication from the BS. The Listening-interval is agreed between the BS and the MSS and is adjustable.

At the MSS side, ~~B~~before entering sleep-mode the MSS shall inform the BS and obtain its approval. On the other side, before entering sleep-mode, the BS shall inform the MSS. The BS and MSS may buffer (or they ~~it~~ may drop) incoming PDUs addressed to the sleeping MSS and BS, and shall ~~a~~ send a notification to the MSS and BS in it's awakening periods about whether data has been addressed for it.

At the MSS side, before entering awake-mode the MSS shall inform the BS and obtain its approval. On the other side, before entering awake-mode, the BS shall inform the MSS. The BS and MSS may buffer (or they may drop) incoming PDUs addressed to the awakening MSS and BS, and shall send a notification to the MSS and BS in it's sleeping periods about whether data or control signal has been addressed for it.

A MSS shall awake according to the sleep-interval and check whether there were PDUs addressed for it. If such PDUs exist, it shall remain awake. A MSS may terminate sleep-mode and ~~return to awake-mode anytime~~ transmit the MSSTRF-IND message to return to awake-mode(i.e. there is no need to wait until the sleep-interval is over) when the MSS has PDUs or control signal to transmit to the BS. If the BS receives MSSTRF-IND message from the MSS, the BS shall respond the TRF-CFN message to indicate whether or not the BS approved the request. ~~data from a SS that is supposed to be in sleep-mode, the BS shall assume that the SS is no longer in sleep-mode.~~

6.2.16.2 Sleep-interval update algorithm

A MSS shall enter sleep-mode after receiving an SLP-RSP message from the BS. In the first time it enters sleep-mode, it shall use the min-window value for the sleep interval. If during the following listening interval the BS has not signaled that traffic has been addressed for the MSS,

the MSS shall re-enter sleep-mode an double the duration of the sleep-interval. This procedure shall be repeated as long as the resulting sleep-interval does not exceed the max-window value and the MSS shall send an SLP-REQ message with Num-max-window-retry which is set to how many times the MSS reached the last increment of max-window value when the MSS reaches the last increment of max-window value.

6.2.16.3 Traffic indication signaling

The BS shall indicate for each MSS in sleep-mode, during its listening-interval, whether traffic has been addressed to it. The indication is sent on the BSTRF-IND broadcast message. The MSS shall examine the both PDU sequence number from this message and frame number from the PHY Synchronization Field, and shall verify its synchronization with the BS. If such synchronization is lost, i.e. expected frame number is different than found frame number, the MSS shall return into awake-mode. The MSS shall send the TRF-CFN message to the BS on the MSS's basic CID in response to a BSTRF-IND message.

If the MSS did not find any BSTRF-IND message, or did not find any positive indication with it's CID in the BSTRF-IND, it shall consider this as a negative indication and shall return into sleep mode.

The MSS shall indicate for the BS in sleep-mode whether traffic or control signal has been addressed to it. The indication is sent by the MSSTRF-IND message on the MSS's basic CID. The BS shall examine the PDU sequence number from this message and frame number from the PHY Synchronization Field, and shall verify its synchronization with the MSS. If such synchronization is lost, i .e. the expected frame number is different than found frame number, the BS shall return into awake-mode. The BS shall send the TRF-CFN message to the MSS on the MSS's basic CID in response to an MSSTRF-IND message. If the BS did not find any MSSTRF-IND message with MSS's basic CID, it shall consider this is in a sleep-mode and shall return into sleep mode.

6.2.16.4 Example of sleep-mode operation

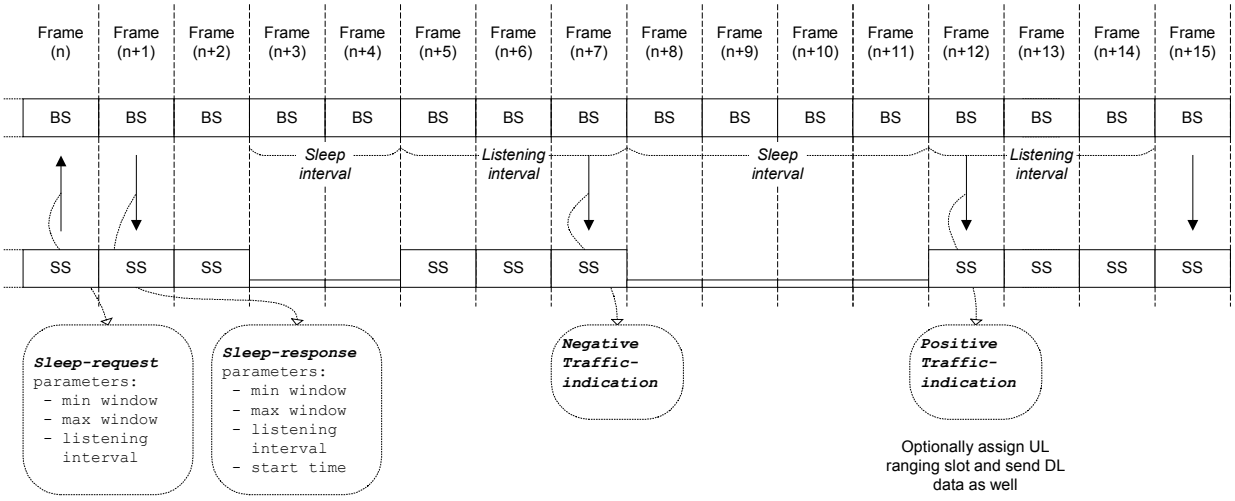

Figure xxx: Example of sleep-mode operation

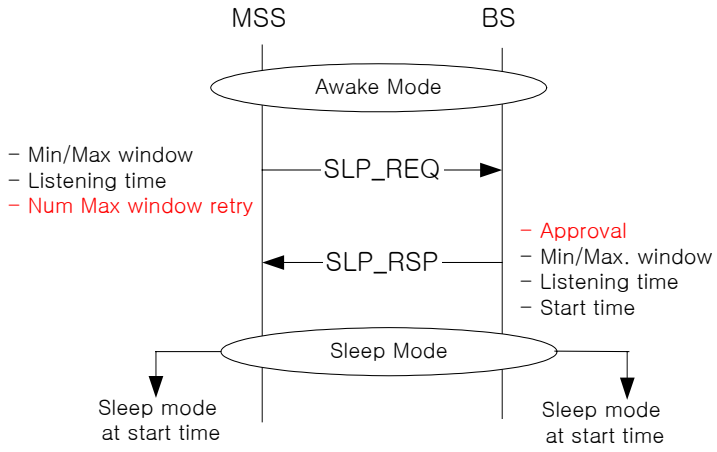

Figure xxx. Call flow diagram of MSS initiated awake to sleep-mode transition

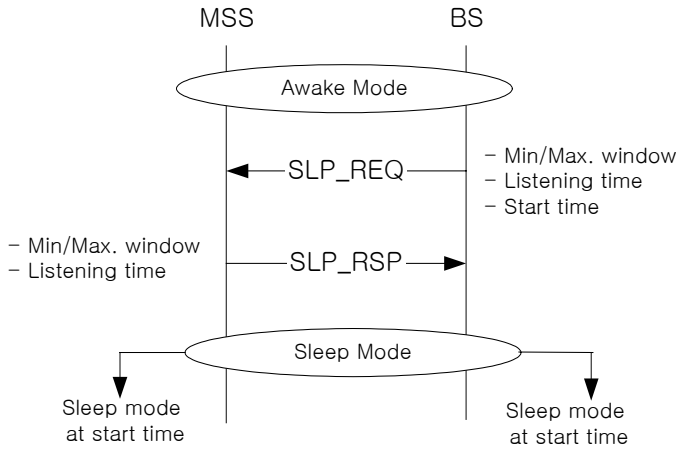

Figure xxx. Call flow diagram of BS initiated awake to sleep mode transition

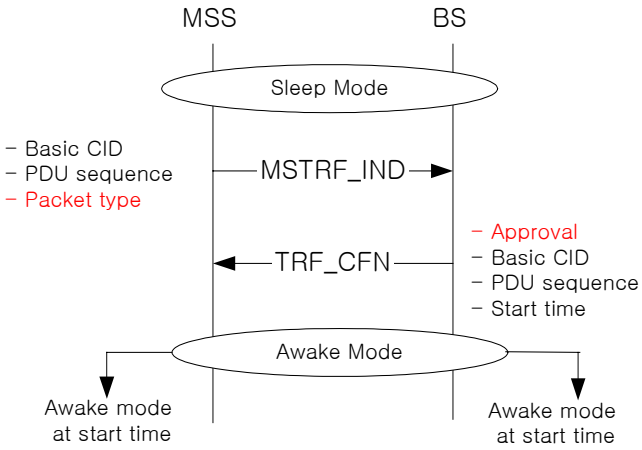

Figure xxx. Call flow diagram of MSS initiated sleep to awake mode transition

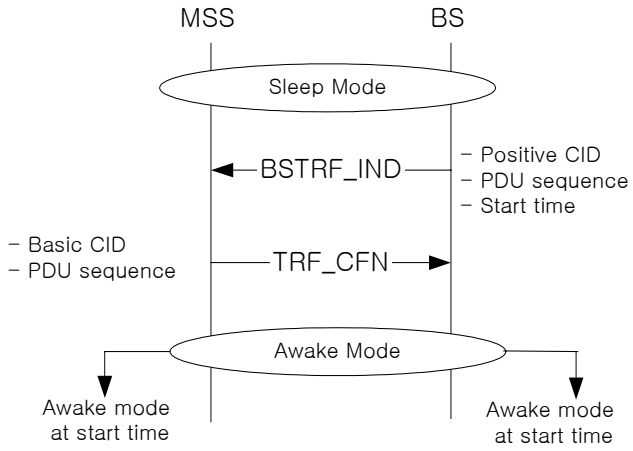

Figure xxx. Call flow diagram of BS initiated sleep to awake mode transition

10.1 Global Values

Add the following values to table 118:

Table 118: Parameters and Constants

System	Name	Time Reference	Minimum Value	Default Value	Maximum Value
MSS	Min_Sleep_Interval	Minimum sleeping time allowed to MSS	2ms		
MSS	Max_Sleep_Interval	Maximum sleeping time allowed to MSS			5s
MSS	Listening_Interval	The time duration during which the MSS, after waking up and synchronizing with the DL transmissions, can demodulate downlink transmissions and decides whether to stay awake or go back to sleep			
MSS	REQ_Duration	The time duration during which the MSS, after receiving the SLP-RSP message, shall wait to retransmit the SLP-REQ message			
MSS	IND_Duration	The time duration during which the MSS, after receiving the TRF-CFN message, shall wait to retransmit the MSSTRF-IND message			

References

[1] IEEE Std 802.16-2001 “Part 16: Air Interface for Fixed Broadband Wireless Access Systems”
[2] IEEE P802.16a/D7-2002 “Part 16: Air Interface for Fixed Broadband Wireless Access Systems – Medium Access Control Modifications and Additional Physical Layer Specifications for 2-11 GHz”
[3] IEEE 802.16.3c-01/30r1 “Traffic Model for 802.16 TG3 MAC/PHY Simulations”
[4] IEEE 80216e-02_01 “Call for Contributions on Project 802.16e”
[5] IEEE 802.16e-03/02, “Call for Proposals on IEEE Project 802.16e: Mobility Enhancements to IEEE Standard 802.16/802.16a”