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Re:	Call for inputs for commentary of p802.16e/D1
Abstract	This contribution describes idle mode for IEEE P802.16e/D1-2004.
Purpose	Discuss and Adopt enhanced feature of p802.16e/D1
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The Concept of Idle Mode Operation in IEEE 802.16e

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1 Introduction

The MAC state machines of the BS and MSS described in the current IEEE 802.16e standard have only AWAKE and SLEEP modes in which the network entities shall always maintain the logical and physical connections. These modes in the MAC state machine in IEEE 802.16e have two major disadvantages as follows.

- **Inefficient usage of air resources**

When an MSS turns on its power, it operates in the awake mode. After some times passed without any valid user traffic in both Uplink and Downlink, the MSS can switch to the sleep mode. But the BS shall maintain these physical and logical resources to provide an always-on service to the MSS after the MSS succeeds network entry and initialization procedures. When the BS has nothing to send for a reasonable time, they switch to the sleep mode. Short sleep mode intervals and occupation of air resources have been regarded as one of the major problems of the present standard. Although a recent proposal IEEE 802.16e/D1-2004 has addressed this issue only by extending the sleep interval to 1024 frames, it did not present any suggestions to address the inefficient usage problem of air resources and the power conservation while the MSS operates in sleep mode

- Absence of a light handover process

In all handover described in the present standard, a MSS should initiate a handover process by sending the MAC message to its current serving BS. The pair of a MSS in sleep mode and its BS usually follows the normal handover procedure, which requires exchanging MAC messages and the network re-initialization procedures since the MSS switches to awake mode before performing a handover process. As per the current IEEE 802.16e standard, in order to reduce the handover overhead, the MSS may ignore the entire handover procedure including the location update procedure. However, without performing the location update procedure or without an appropriate paging algorithm in sleep mode, the network may lose the track of the MSS inadvertently. In addition, since there is no explicit way for the MSS to release CIDs assigned by the old BS in this case, the BS may maintain old CIDs for a while and waste the resources in result.

2 Proposed Idle Mode

This new proposal introduces idle mode that gives the MSS and the BS to operate in a simplified way while minimizing the wasted usage of air resources in the current version. Although implementation of idle mode is optional, it is recommended.

Also, by adopting idle mode in the 802.16e standard, we can simplify the handover, location update and paging procedures of a MSS in idle mode. While in performing the handover in idle mode, the MSS is only required to receive new configuration messages without transacting with the BS. In addition, the MSS may register the location information if needed. Comparing to handover taken place in awake or sleep mode, the MSS and BS does not require exchanging handover related MAC messages. The BS can efficiently allocate CIDs because assigned CIDs to the MSS can be reused immediately as soon as the BS and MSS

enter to idle mode.

The 802.16e MAC state machine should be in one of the following modes,

- ***Awake mode*** : In this mode, the MSS and BS continuously shall process DL and/or UL traffics. It also performs handover to support the mobility.
- ***Sleep mode*** : In this mode, the MSS may power down, scan neighbor BS, conduct hand-over/network re-entry or listen the serving DL periodically.
- ***Idle mode*** : In this mode, the MSS and BS shall close all connections, all air resources (i.e. CIDs, UL/DL Bursts and so on) for MSS, but the MSS monitors the serving DL periodically.

2.1 New Mode Transition Diagram

The following figure 1 provides the overview of the MSS and BS modes and mode transitions.

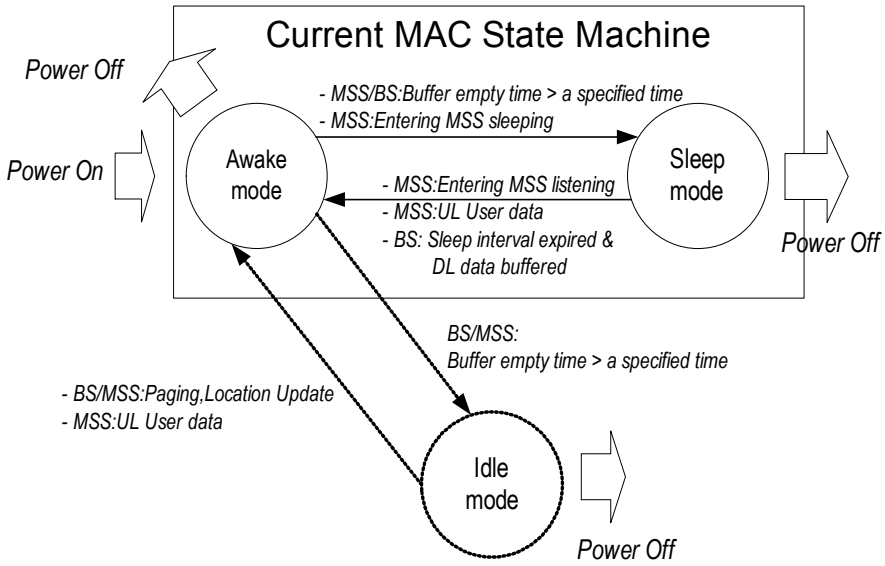

Figure 1 Mode Transition diagram of MAC state machine

2.1.1 Awake mode

Before entering this mode, the MSS shall perform cell selection, network entry and initialization procedures with the BS as illustrated in Figure 58 of the 802.16D standard. In this mode, the MSS and BS shall process normal operations of the Data/Control planes of the MAC. Refer to the 802.16e standards. If the MSS and the BS stay in awake mode and both can support idle mode, either of them decides to enter idle mode by a specified decision algorithm [*see Appendix A*] and triggers transition to idle mode

2.1.2 Sleep mode

Sleep mode is a mode in which MSS supporting mobility shall maintain all connections but is obligated to listen to DL traffic during the sleeping interval. However, the BS can terminate sleep mode by sending traffic indication message to MSS in sleep mode during it's listening interval. The MSS can terminate operating in sleep mode and return to awake mode if there is no need to wait until the sleeping interval is over.

2.1.3 Idle mode

Idle mode is a mode in which MSSs supporting mobility shall close all connections and only maintain its registered location. Idle mode is intended not only to conserve power of the MSSs but also to facilitate a light handover procedure while still staying disconnected to the network. Upon entering this mode from awake-mode, the MSS and BS shall perform the following procedures :

- Synchronizing the paging parameters and other parameters for idle mode.
  - The paging parameters
    - The rest interval (with the rest interval index)
    - The location information and parameters
  - Other parameters
    - Idle handover parameters

In this mode, the MSS may maintain the upper layer connections like an IP connection with the network, but all air resources of the MSS and BS shall be released when entering this mode.

Idle mode performs the following procedures while it is in idle mode and it may trigger entering awake mode if needed. Otherwise, it shall go back.

- The MSS shall perform the broadcast CID monitoring procedures.
- The MSS shall perform the idle handover procedures.
- The MSS shall perform the overhead update procedures.
- The MSS shall perform processing directed messages from the BS.
- The MSS shall perform the MSS Power-Off operation if directed by the user to power down.

2.2 The Requirement for Idle mode

To support idle mode, the MAC layers of an MSS and a BS should satisfy the following requirements.

- Requirement 1: A BS and an MSS should be able to negotiate the capability of supporting idle mode.

  [Solution] Advertise the system information and perform negotiation.

  In this proposal we add more fields for idle mode parameters in the Neighbor Advertisement Message, MOB_NBR-ADV and an MSS shall receive this message while in idle mode. Using MOB_NBR-ADV, a BS informs its MSS of its idle mode supporting capability. The MSS shall propose supporting idle mode using MODE_SUPPORTED (IDLE_SUPPORTED) using the REG-REQ message, and then the BS shall inform the MSS of whether idle mode is supported or not in the REG-RSP message.

- Requirement 2: The new proposal must provide explicit conditions when and how an MSS and a BS can trigger their mode transition from awake to idle.

  [Solution] Detect and Request the mode transition

In this proposal we define new MAC messages, the Idle Mode Transition Request / Response, MOB_IDL-REQ/MOB_IDL-RSP and the MSS supporting idle mode uses the MOB_IDL-REQ messages to obtain the BS's approval for entering idle mode and the BS shall respond with an MOB_IDL-RSP message that shall contain its response, either rejection or approval. The BS may send an unsolicited MOB_IDL-RSP message to the MSS in order for the MSS to get into idle mode.

This proposal introduces an idle mode transition algorithm at the *Appendix A*.

- Requirement 3: If a BS has messages or events to send to an MSS in idle mode, the BS shall send MAC messages on the broadcast CID.

[Solution] Page messages on broadcast CID and register the location.

Upon entering idle mode from awake mode, the MSS and the BS should agree with the paging parameters. For power conservation, the MSS shall monitor only the down link at a specific time and then go back to sleep for a rest interval. Therefore the BS must know when the MSS will awaken and monitor the down link if it has messages to send to the MSS. In addition, the BS has to know the location of the MSS. The parameters required for supporting paging are called the paging parameters. The MSS can propose its preferred paging parameters in the REG-REQ message and the BS can inform the negotiated paging parameters in the REG-RSP message. If needed, the MSS can perform the location registration after the idle handover is completed.

- Requirement 4: While in idle mode, the MSS shall perform the following procedures.
  - Monitoring broadcast CID
  - Idle handover if the MSS moves from one BS to another
  - Overhead update
  - Processing the directed messages from the BS.
  - MSS Power-Off operation if directed by the user to power down.

The 'Idle Procedure' sub clause introduces the detailed solutions for Requirement 4 and we introduce the overhead update and the directed message processing procedures in this document and other procedures, paging, location update and idle handover are introduced at different documents.

First of all, this new proposal has revised a present standard so that the 802.16e MAC state machine has three modes: awake, sleep, and idle. After the MSS is turned on, it shall enter awake mode if it succeeds in performing the cell selection, the network entry, and the initialization procedures.In this document, we assume that an MSS can scan neighbor BS while in processing DL/UL user traffic in parallel. This is a reasonable assumption since it is possible if either the MSS has an alternative module to measure the neighbor BS or a frequency reuse factor is 1.

In other documents, we introduce an efficient idle handover in order to reduce the handover budget. The proposal shall also provide an idle handover determination algorithm. In addition, it also introduces paging and location update procedures to support the mobility while the MSS stays in idle mode. Refer to two documents, *'idle handover & Location Update in the IEEE 802.16e'* and *'paging in the IEEE 802.16e'*.

3 Change of Text

[In Page 43, Line 26, Append new sections after 6.4.17.3 Traffic indication signaling as follows]

6.4.18 Idle Mode for mobility-supporting MSS(Optional)

6.4.18.1 Introduction

Idle mode is a mode in which MSSs supporting mobility shall close all the connections and maintain only its registered location. Idle mode is intended not only to conserve power of the MSSs but also to facilitate a light handover procedure while still staying disconnected to the network. Unlike in the sleep mode, the air resources such as CIDs and Traffic Service scheduling are not used in idle mode and idle mode also serves as a power conserving mode.

During idle mode, the MSS may perform an idle handover when an MSS in idle mode moves from the coverage area of the current serving BS to the coverage area of another BS. During the idle handover, the MSS may also perform the location registration using the location information fields in the MOB_LU-REQ message if needed. The MSS in idle mode shall periodically search for the strongest BS, which is obtained from MOB_NBR-ADV message, on the corresponding frequency.

The BS shall transmit MOB_NBR-ADV message to inform an MSS of the system information that is used for performing the idle procedures. MSS in idle mode updated the system parameter when the received MOB_NBR-ADV message has any changes of operational parameter

6.4.18.2 Mode Transition

The 802.16e MAC state machine should be in one of the following modes.

- *Awake mode*: In this mode, the MSS and BS continuously shall process DL and/or UL traffics. It also performs hand-over to support the mobility.
- *Sleep mode*: In this mode, the MSS may power down, scan neighbor BS, conduct hand-over/network re-entry or listen the serving DL periodically.
- *Idle mode*: In this mode, the MSS and BS shall close all connections, all air resources, but the MSS monitors the serving DL periodically.

The following figure provides the overview of the MSS and BS modes and mode transitions.

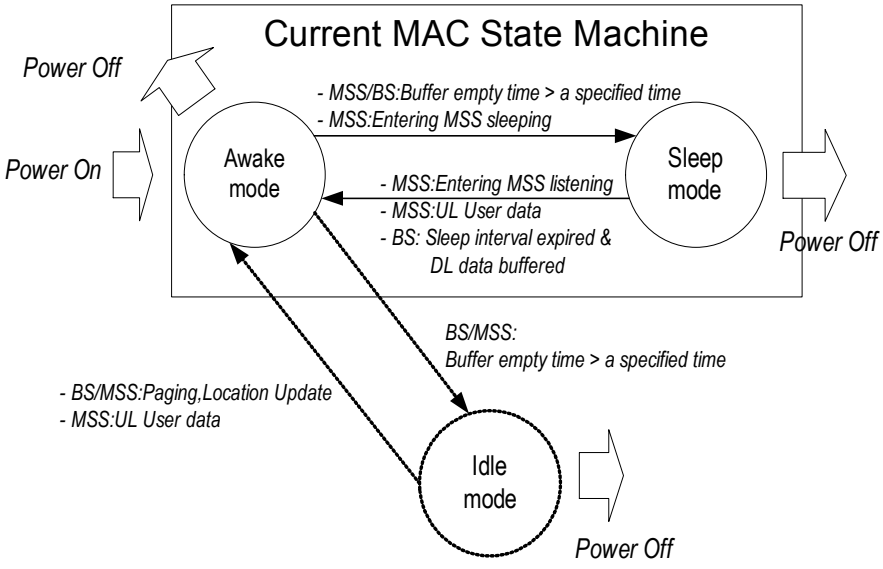

Figure XXX Mode Transition diagram of MAC state machine

6.4.18.2.1 Awake mode

Before entering this mode, the MSS shall perform cell selection, network entry and initialization procedures with the BS as illustrated in Figure 58 of the 802.16D standard.

During performing Registration, the MSS shall inform the BS whether the MSS can support idle mode and what is the preferred rest interval index using PREF_REST_INTERVAL_INDEX field of the REG-REQ message. The BS shall inform the MSS of its response whether idle mode is supported or not by using SUPPORTED_MODE (*setting idle mode supported*) field of a

REG-RSP message. When the BS decides mode transition of an MSS to idle, the BS shall also inform the MSS of the selected rest interval index in the MOB_IDL-RSP message.

In this mode, the MSS and BS shall process normal operations of the Data/Control planes of the MAC. Refer to the 802.16e standards.

If the MSS and the BS stay in Awake mode and both of them can support Idle mode, the MSS or the BS may decide to enter idle mode and triggers transition to idle mode. The MSS supporting idle mode uses the MOB_IDL-REQ messages to obtain the BS's approval for entering idle mode and the BS shall respond with an MOB_IDL-RSP message that shall contain its response, either approval or rejection. In addition, the BS may send an unsolicited MOB_IDL-RSP message to the MSS in order to initiate mode transition of an MSS to idle mode. Otherwise the MSS and BS shall maintain awake mode or try to trigger entering sleep mode if it is supported.

6.4.18.2.2 Sleep mode

Sleep mode is as described earlier. During sleep mode, the MSS can stay at sleep mode or change to Awake mode. If the MSS in sleep mode want to change to idle mode, it shall return to AWAKE mode before entering Idle mode.

6.4.18.2.3 Idle mode

During idle mode, the MSS and BS shall synchronize the paging parameters and other parameters for idle mode.

A. The paging parameters

- The rest interval (with the rest interval index)
- The location information and parameters

B. Other parameters

- Idle handover parameters

During idle mode, the MSS shall perform the following procedures when the MSS awakes to monitor a monitoring frame or when there is a request directed by the user. While the MSS performs the following procedure, it may be triggered to enter awake mode. If it is not, it shall go back to power conserving state in idle mode.

- The MSS shall monitor management message periodically.
- The MSS shall perform the idle handover procedure.
- The MSS shall perform the overhead update procedure.
- The MSS shall perform processing directed messages from the BS.
- The MSS shall perform the MSS Power-Off operation if directed by the user to power down.

On monitoring frame, the MSS shall awake, monitor an interleaved monitoring frame according to the rest-interval , and check whether there are the MAC Management messages with broadcast CID. The respective, fixed and periodic rest-interval for the MSS is obtained by calculating ((2^rest_interval_index) modulo one_paging_cycle). The rest-interval_index is included in the received MOB_IDL-RSP message.

During the monitoring frame, if the MSS receives paging request message (MOB_PAG-REQ) addressed to it from BS, MSS shall enter the awake mode and perform the network re-entry and the initialization procedure.

During idle mode, if the MSS receives the MOB_NBR-ADV message with any changed parameter, then the MSS shall updates the system parameters. The MSS shall maintain the CC_NBR_ADV variable to keep the value of the configuration change count field in the latest received MOB_NBR-ADV message. If the change count value of the received MOB_NBR-ADV is the same as the CC_NBR_ADV value, the MSS may not update overhead messages and otherwise, the MSS shall update the system parameters with the new ones. The MSS shall initialize the CC_NBR_ADV variable and system parameter when it receives the first MOB_NBR-ADV message either after the power is applied or while in performing the idle handover.

The BS uses MOB_NBR-ADV message to inform the MSS of the serving cell's neighbor cells periodically. This message shall also be broadcasted to inform the parameters for paging, idle handover and registration procedures. The BS shall

maintain the configuration change count of MOB_NBR-ADV and shall increment the value modulo 256 whenever the BS modifies one or more fields of the message.

[In Page 37, Line 1, Replace Figure 108a – MSS Awake Mode SDL Diagram with the following]

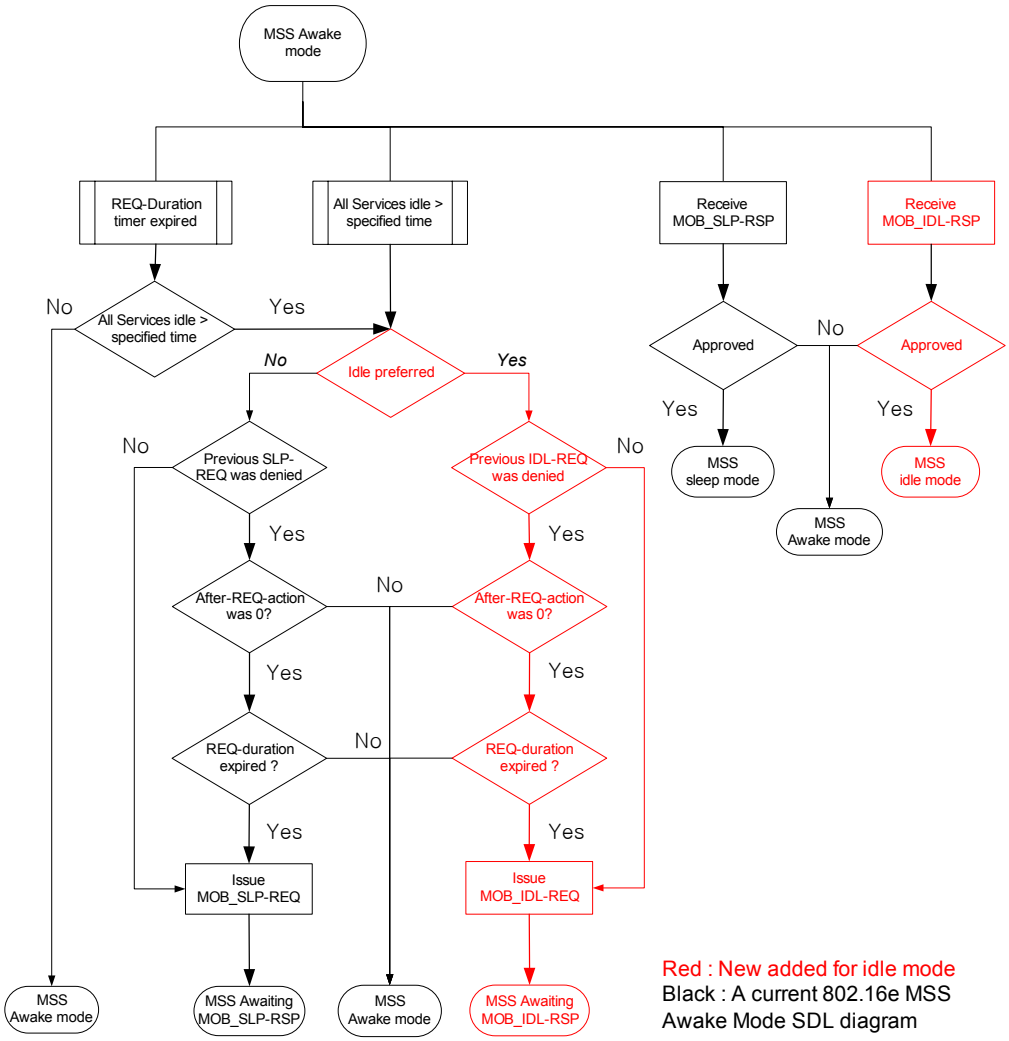

Figure. 108a - MSS Awake Mode SDL Diagram

[In Page 38, Line 1, Replace Figure 108b – MSS Awaiting Sleep Response SDL Diagram with the following]

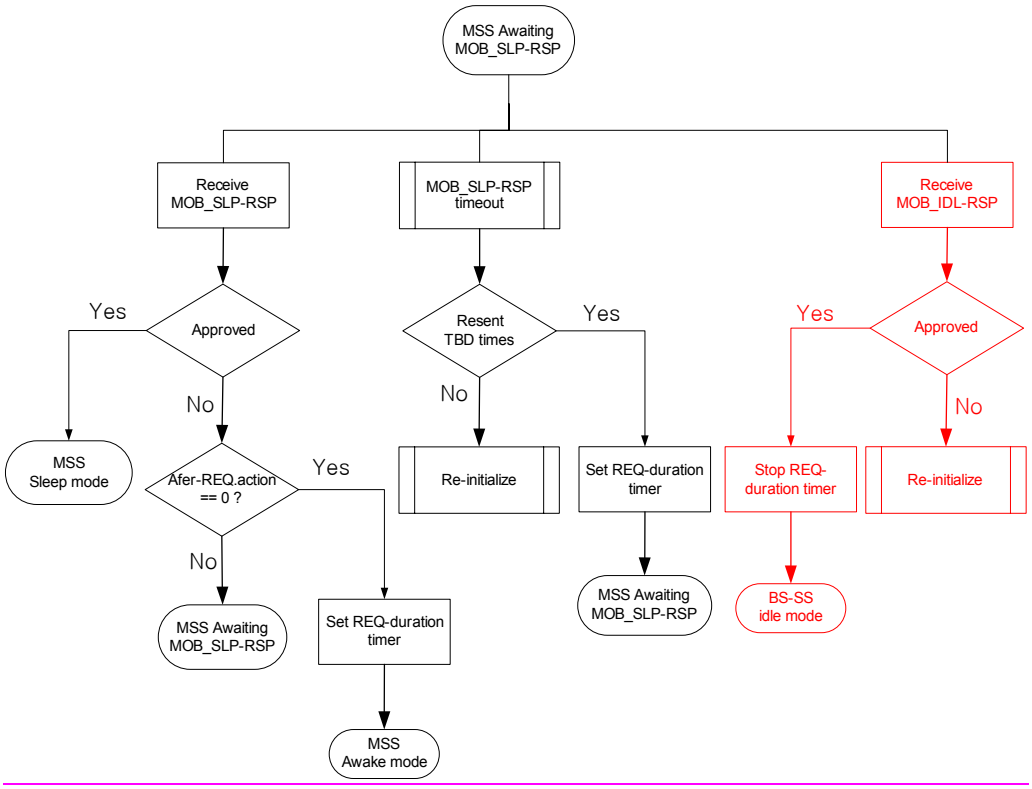

Figure.108b MSS Awaiting Sleep Response SDL Diagram

[In Page 38, Line 1, Replace Figure 108d – Typical MSS Listening SDL Diagram with the following]

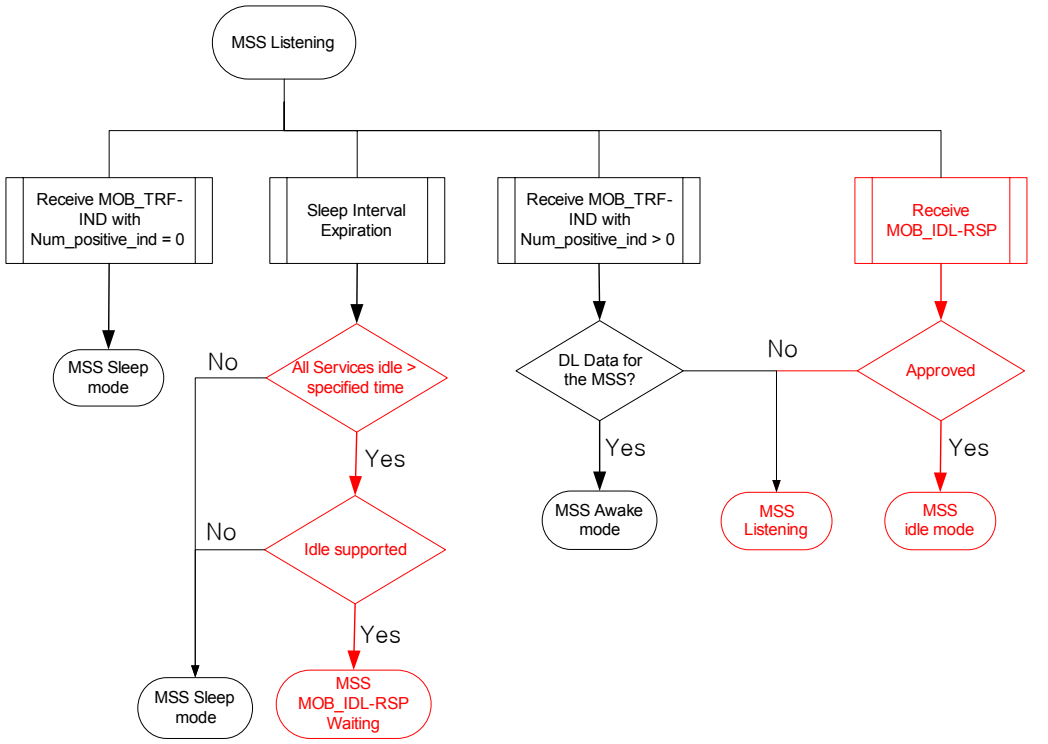

Figure 109d. Typical MSS Listening SDL Diagram

[In Page 43, Line 44, Insert Figures before the section 7.1 Architecture]

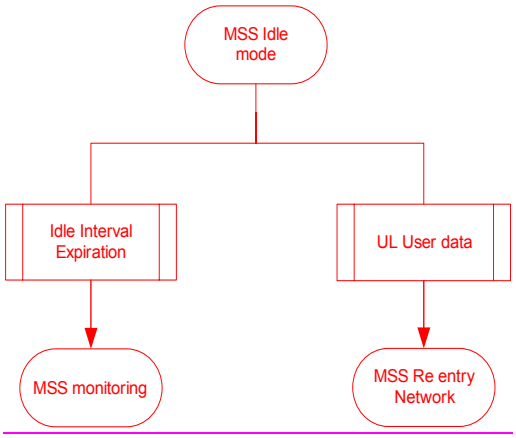

Figure.xxx - MSS Idle Mode SDL Diagram

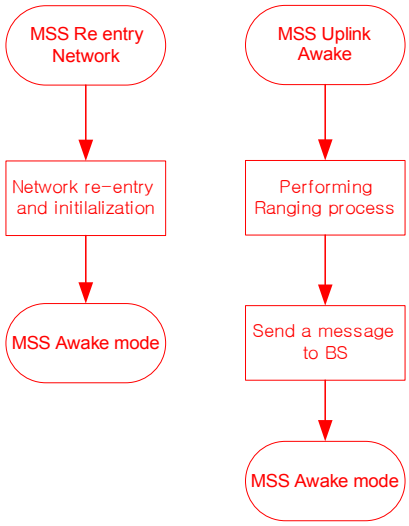

Figure.xxx+1 - MSS Re-entry and Uplink Awake SDL Diagram

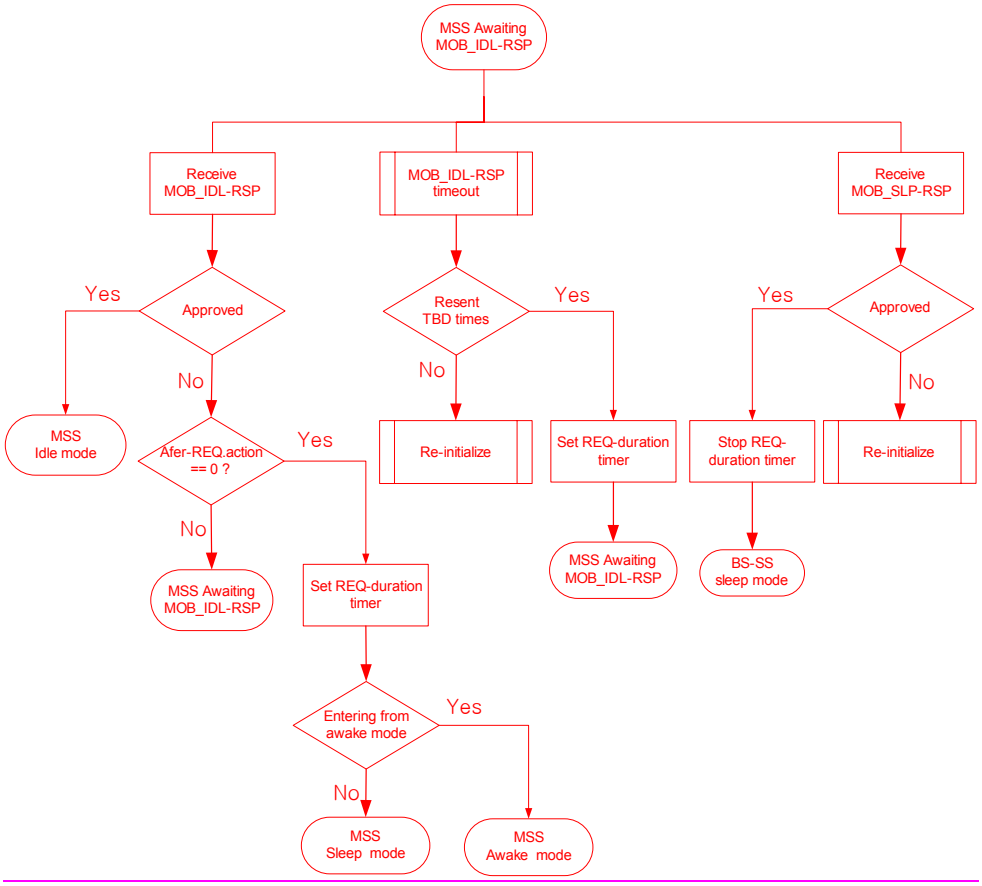

Figure xxx+1 - MSS Awaiting Idle Response SDL Diagram

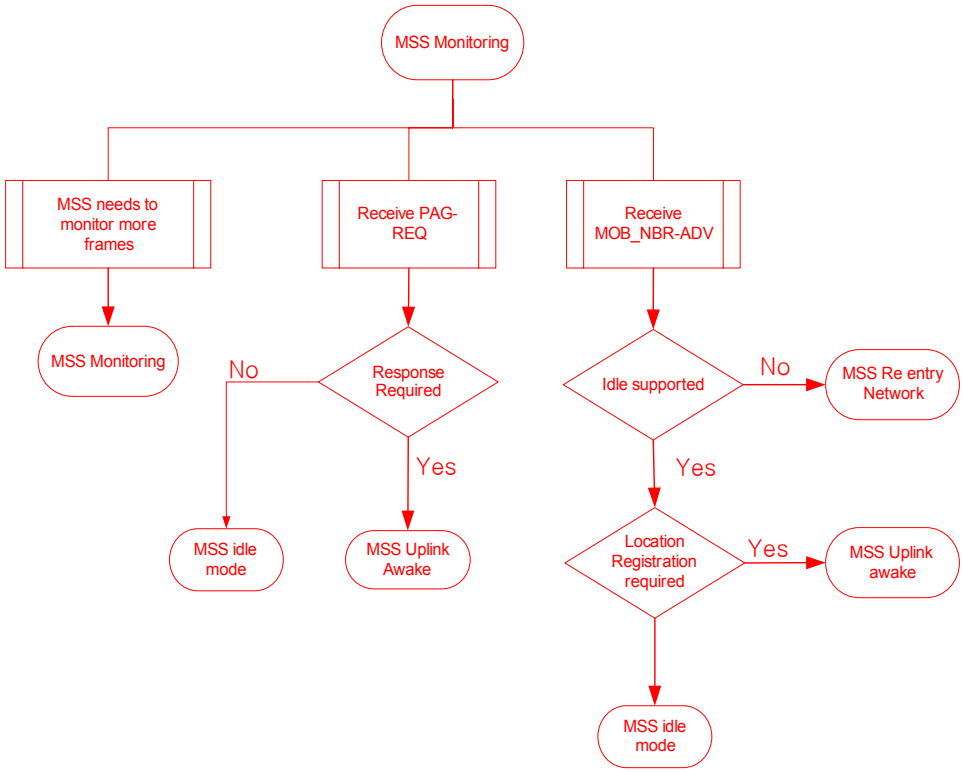

Figure xxx+2. - MSS Monitoring SDL Diagram

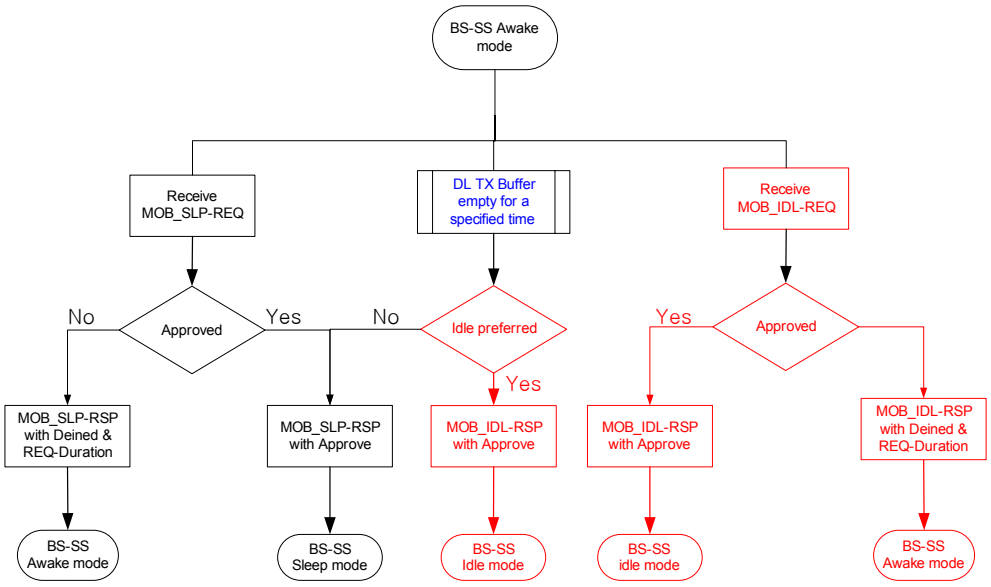

Figure xxx+3 - BS-SS Awake SDL Diagram

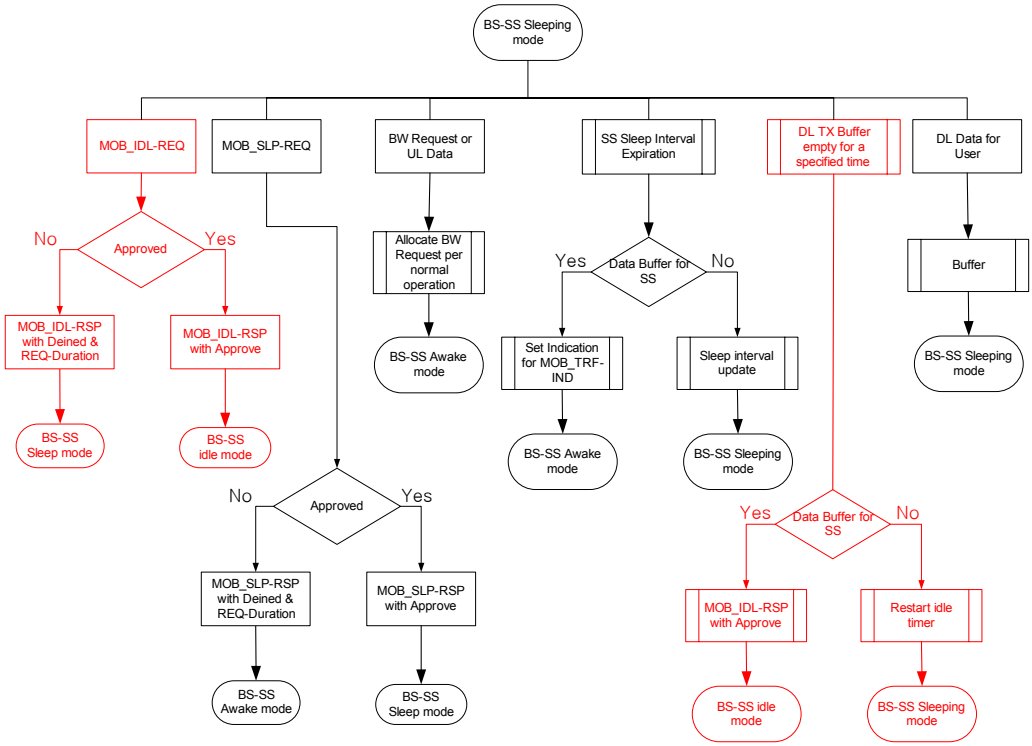

Figure xxx+4 - BS-SS Sleeping SDL Diagram

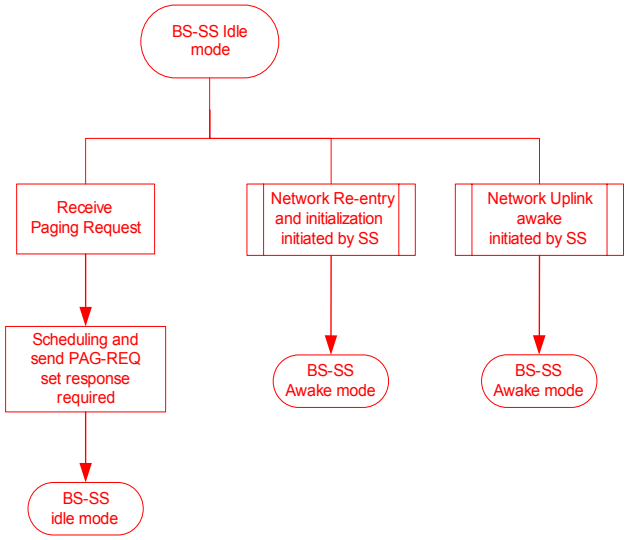

Figure xxx+5 - BS-SS Idle SDL Diagram

[In Page 18, Line 30, Insert new Message type after the Type 56 as follows]

6.4.2.3 MAC Management Messages

Table 14a. MAC Management Messages

Type	Message Name	Message Description	Connection
??	MOB_IDL-REQ	Idle request message	Basic
??	MOB_IDL-RSP	Idle response message	Basic
38, 57-255		Reserved	

[In Page 63. Line 42, Modify as follows]

11.4.2.13.1 Mode Supported

This field indicates whether the MSS supports a several modes for mobility . A bit value of 0 indicates “not supported” while1 indicates “supported”.

Type	Length	Value	Scope
5.24.1	1	Bit #0: Mobility (handover) support	REG- REQ
		Bit #1: Sleep-mode support	REG-RSP
		Bit #2 : Idle-mode support	

6.4.2.3.45 Neighbor Advertisement (MOB_NBR-ADV) message

[In Page 25. Line 24, insert following sentence :

For each advertised Neighbor BS, the following TLV parameters may be include for idle mode supporting neighbor BS.

Mode Supported : Same with 11.4.2.13.1

When Mode Supported bit indicate support idle-mode, following TLV parameters may be included

PZONE-ID (8 bit) : A current serving cell’s packet zone ID

MAX_REST_INTERVAL_INDEX (8bit) : BS (BS) shall set this field to the rest interval index permitted. When the MSS receives this message, the MSS shall compare this with its preferred rest interval index internally saved and select the lesser of the two as its preferred rest interval index.

IH_T (8 bit) : When the MSS finds a target cell at which CINR is greater than a serving cell by IH_T, the MSS shall perform the idle handover procedure.

IH_GUARD(8 bit) : A guard timer for the idle handover,

[In Page 31. Line 4, Insert the following section after 6.4.2.3.52 HO Indication(MOB_HO-IND) message]

6.4.2.3.53 Idle Request (MOB_IDL-REQ) Message

MSS supporting idle-mode uses the MOB_IDL-REQ message to request permission from the BS to enter idle-mode. The MOB_IDL-REQ message is sent from the MSS to the BS on the MSS’s basic CID.

Table 85l - MOB_IDL-REQ Message Format

Syntax	Size	Notes
MOB_IDL-REQ_Message_Format() {		
Management message type = ??	8 bits	

PREF_REST_INTERVAL_INDEX	4 bits	
Reserved	4 bitts	
}		

An MSS shall generate MOB_IDL-REQ messages in the format shown in Table 85l. The following parameters shall be included in the MOB_IDL-REQ message:

PREF_REST_INTERVAL_INDEX - MSS preferred rest interval index. the BS may accept it or propose a different value through a MOB_IDL-RSP message.

6.4.2.3.54 Idle Response (MOB_IDL-RSP) Message

The BS shall send the MOB_IDL-RSP message to a MSS on the basic CID in response to an MOB_IDL-REQ message, or the BS may send unsolicited one. The MSS shall enter idle-mode using the parameters in the message. In the case of idle request being denied (After-REQ-action = 1), it is recommended that the BS provides unsolicited MOB_IDL-RSP message.

Table 85m - MOB_IDL-RSP Message Format

Syntax	Size	Notes
MOB_IDL-RSP_Message_Format() {		
Management message type = ??	8 bits	
Idle approved	1bits	0 : Idle Transition Denied 1 : Idle Transition approved
If(Idle approved == 0){		
After-REQ-action	1 bit	0: The MSS may retransmit the MOB_IDL-REQ after the time duration (REQ-duration) given by the BS in this message 1: The MSS shall not retransmit the MOB_IDL-REQ and shall wait the MOB_IDL-RSP from the BS
REQ-duration	4 bits	Time duration for case where After-REQ-action value is 0.
Reserved	2 bits	
} else{		
SEL_REST_INTERVAL_INDEX	4 bits	
TB_REGI_REQUIRED	1 bits	Timer-base registration required 0 : non-required 1 : required
if(TB_REGI_REQUIRED)		
{		
TB_REGI_INDEX	8bits	0 : reserved 1~255
}		
Reserved	2 bits	
}		

}		

An MSS shall generate MOB_IDL-RSP messages in the format shown in Table 85m. The following parameters shall be included in the MOB_IDL-RSP message:

Idle approved - It is the activation indicator of the MSS when it receives this message from the BS.

After-REQ-action - Indicates resource action on MSS request to enter idle-mode rejected by the BS.

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

SEL_REST_INTERVAL_INDEX - Final Rest interval index (measured in frames). The MSS can only accept or reject.

TB_REGI_REQUIRED - Timer based registration is enabled(0) or disabled (1)

TB_REGI_INDEX - If TB_REGI_REQUIRED is enabled, this value is used to compute the timer-based registration maximum count. Otherwise, this is omitted.