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Re:	Call for inputs for commentary of p802.16e/D1

Abstract	This contribution describes paging procedure in idle mode for IEEE P802.16e/D1-2004.

Purpose	Discuss and Adopt enhanced feature of p802.16e/D1

Paging Procedure in Idle mode for IEEE802.16e

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1. Problem Statements

– Absence of paging procedures

By adopting idle mode in the 802.16e standard, we have to define the paging procedures for the BSS to send a message to the MSS while it stays in idle mode. 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. For power conservation, the MSS shall monitor only the down link at a specific time and then go back to sleep for a predetermined interval. Therefore the BS must know when the MSS will 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. In this document, we introduce efficient monitoring & paging procedures to achieve those requirements. This proposal also provides a paging frame determination algorithm.

2. Overview of Proposed Solutions

Upon entering idle mode from awake mode, the MSS and the BS shall negotiate the paging parameters. This enables the BS and MSS to determine the exact time of monitoring and paging a message on the downlink.

The BS shall send the paging message in one of a monitoring frame set of the MSS while it stays in idle mode. The BS can send the paging message with each different purpose and for each case, different paging procedure is applied. We can classify the different paging purposes of the BS as following :

1. Triggering the MSS to perform the network re-entry and initialization
2. Transmitting a paging message to an upper layer or application without the acknowledgment(no **MOB_PAG-RSP** message)
3. Transmitting a paging message to an upper layer or application and Requesting the acknowledgement(**MOB_PAG-RSP** message)
4. Changing the rest interval and the timer-based registration interval
5. Requesting the zone-based registration.

The MSS shall only monitor one monitoring frame on the broadcast CID. During the frames of the rest interval, in which the MSS is not being monitored can suspend or stop its processing for power conservation.

When the MSS receives a paging message, it determines whether there is any paging information directed to itself or not by matching its MSS address. Otherwise, the MSS shall perform the overhead update procedure if a received message is one of configuration messages.

If there is no paging message in a monitoring frame, the MSS shall ignore simply and then gets into idle mode for another interval if needed.

3. Proposed Text Change

Accept following section 6.4.18xx paging procedure in idle mode as whole.

6.4.18.3 Paging procedure in idle mode

Upon entering idle mode from awake mode, the MSS and the BS shall negotiate the paging parameters. This enables the BS and MSS to determine the exact time of monitoring and paging a message on the downlink.

- *Monitoring & Paging*

    The BS shall send the paging message in one of a monitoring frame set of the MSS while it stays in idle mode.

- *Monitoring broadcast CID*

    The downlink is divided into the frame. Each frame has its own number from 0 to 2^{24}-1. One paging cycle consists of 2^{24} frames and the frame number starts again counting from 0 after reaching the maximum (2^{24}-1).

The MSS shall only monitor one monitoring frame on the broadcast CID. During the frames of *the rest interval*, in which the MSS is not being monitored can suspend or stop its processing for power conservation.

If the BS broadcasts its idle mode supporting capability using SUPPORTED_MODE field of on a **MOB_NBR-ADV** message, the MSS can specify its preferred rest interval index using PREF_REST_INTERVAL_INDEX field of **REG-REQ** or **MOB_IDL-REQ** message and the BS can specify its selected rest interval index using SEL_REST_INTERVAL_INDEX field of **REG-RSP or MOB_IDL-RSP** message.

In idle mode, the MSS shall only receive the MAC messages that have been transmitted in a monitoring frame on broadcast CID. Therefore the BS shall send a page message on broadcast CID if it has something to send to the MSS. The BS may contain multiple pieces of paging information in one page message designated to multiple MSS(s). When the MSS receives a paging message, it determines whether there is any paging information directed to itself or not by matching its MSS address.

If there is no paging message in a monitoring frame, the MSS shall ignore simply and then gets into idle mode for another interval if needed.

The MSS may monitor more frames if needed and may stop monitoring consecutive frames if the one of the following conditions is met.

- If the MSS receives a valid message completely in one or more frames, the BS shall perform processing the procedures directed in the message.
- The network re-activation is initiated by an user or upper layer. The MSS shall try to enter awake mode by performing the network re-entry and the initialization procedure.

6.4.18.3.1 Frame determination

To determine the MSS's monitoring frame with the rest interval index and the MSS MAC Address, the BS shall use the algorithm described below.

The MSS shall propose its preferred rest interval, REST_INTERVAL, during the registration process. The MSS obtains the frame offset, FRAME_OFFSET by performing the hash function with the input and the MSS MAC Address. The frames monitored by the MSS are as the following :

F0: the frame offset mod Y

Fn: frame number for nth monitoring element

Monitoring frame set : Fn+1 = (Fn + D) mod Y

, where n is an integer, D is the rest interval and Y is the maximum number of frames, 224 , in one paging cycle.

D is given by

$$D = (2^i * \delta) < Y, \text{ where } \delta = 2^j \quad (j = 0, \textbf{recommended})$$

and *i* is the REST_INTERVAL_INDEX.

When the BS is able to determine that the MSS is in idle mode and the BS knows the selected rest interval index, the BS uses that to determine the monitoring frame set.

When the network requests to the BS for transmitting the paging messages, it has to inform the BS of the MSS's location.

The BS shall schedule which paging messages (*designated to many MSSs*) are included in the **MOB_PAG-REQ** message of a downlink frame when paging is permitted. If the BS can not be able to send all paging messages supposed to be transmitted on a coming paging frame, the BS may schedule not to send some paging messages and then the BS may re-schedule them to be transmitted on their next paging frame. Usually, the BS may schedule a delayed paging message to be included in the **MOB_PAG-REQ** message at first comparing to non-delayed paging messages. The BS may maintain a delay count of each paging message and it is incremented whenever paging is delayed. The BS may build the **MOB_PAG-REQ** message with paging messages in their descending order of a delay count. A delay count may be initialized with 0 when a paging message is created.

The **MOB_PAG-REQ** shall be used to send a paging message that contains paging messages designated to MSS(s) in one paging frame. According to the purpose of paging, the BS may request the MSS to respond with the **MOB_PAG-RSP** message or not, using PAG_PURPOSE field of the **MOB_PAG-REQ** message.

The following sub clause explains paging procedures of all paging cases.
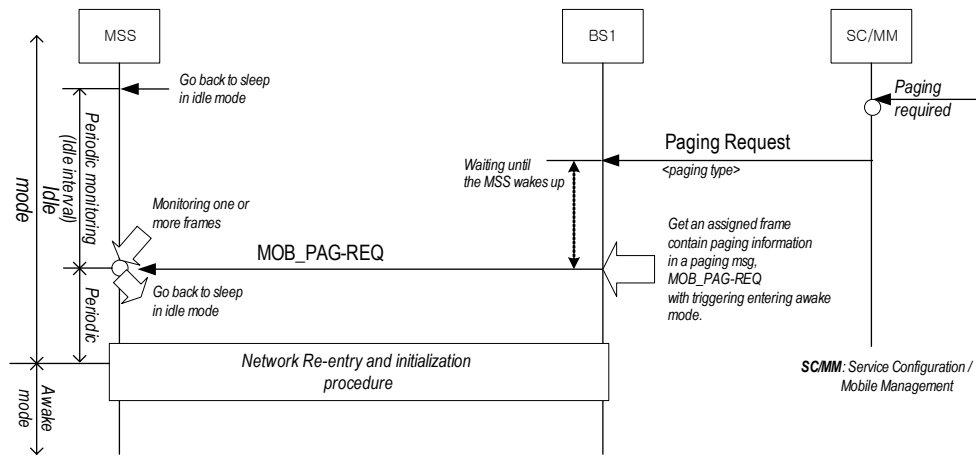
6.4.18.3.2 Paging procedure

The BS can trigger paging with different purpose and it can make different paging sub procedures. There are 5 different case of paging procedure with different purpose. Those are classified as paging procedure No.1 ~ paging procedure No.5

The MSS shall enter awake mode in response to the paging procedures No.1, No.3 and No.5, and remains in the idle mode in response to the procedures No.2 and No.4. Particularly, the BS may trigger No. 5 case to check the correctness of the latest location information of the MSS.

6.4.18.3.2.1 Paging Procedure No. 1.

This paging procedure is for the case that BS want to trigger the MSS to perform the network re-entry and initialization. At this case, after receiving paging message, the MSS shall enter awake mode

The figure shows the overview of performing paging procedure No.1 while the MSS is in idle mode.
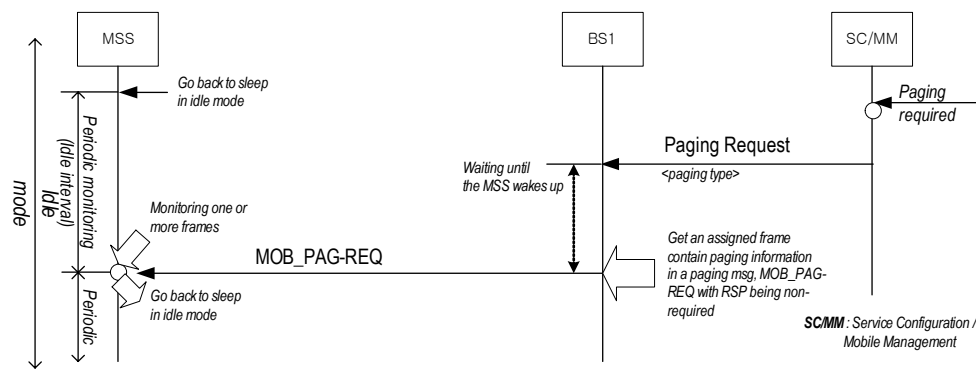
Figure Paging procedure of No. 1

The BS can request the MSS to enter awake mode by performing the network re-entry and initialization procedure. Usually, the network can trigger this paging event when there is DL user traffic arrival to be transmitted on the downlink.

6.4.18.3.2.2 Paging Procedure No. 2.

This paging procedure is for the case that BS want to transmit a paging message without the acknowledgment(no **MOB_PAG-RSP** message)

The following figure shows overview of performing paging No.2 case while the MSS is in idle mode. Since the BS doesn't request the MSS to send a response, the MSS shall transfer a received message to an upper layer or application and continues to stay in idle mode.
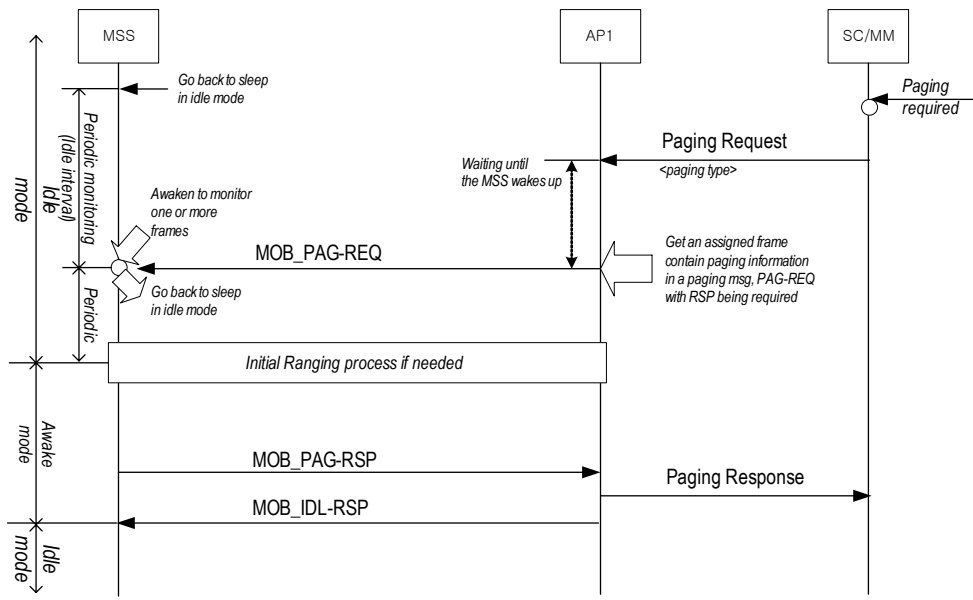

Figure Paging procedure of No. 2

The BS may invoke this paging event when it has only one shot paging message.

6.4.18.3.2.3 Paging Procedure No. 3.

This paging procedure is for the case that BS want to transmit a paging message to an upper layer or application and request the acknowledgement(**MOB_PAG-RSP** message)

The following figure shows overview of performing paging No.3 while the MSS is in idle mode. Since the BS requests the MSS to send a response, the MSS shall transfer a received message to the higher layer or application and wait until it receives a response from the higher layer or application. When the MS receives a response, it sends it to the BS. Otherwise, when the MS fails to a response, it informs the BS of its failure of receiving a response using the CAUSE field of the **MOB_PAG-RSP** message. The MSS may enter awake mode to be able to access the UL to send the response.

Figure Paging procedure of No 3 (one cell).

After successfully sending the **MOB_PAG-RSP** message, the MSS or the BS can trigger entering idle mode by sending a **MOB_IDL-REQ** or **MOB_IDL-RSP** message respectively. The following figure shows also No.3 case when there are multiple BSs where the paging is performed.
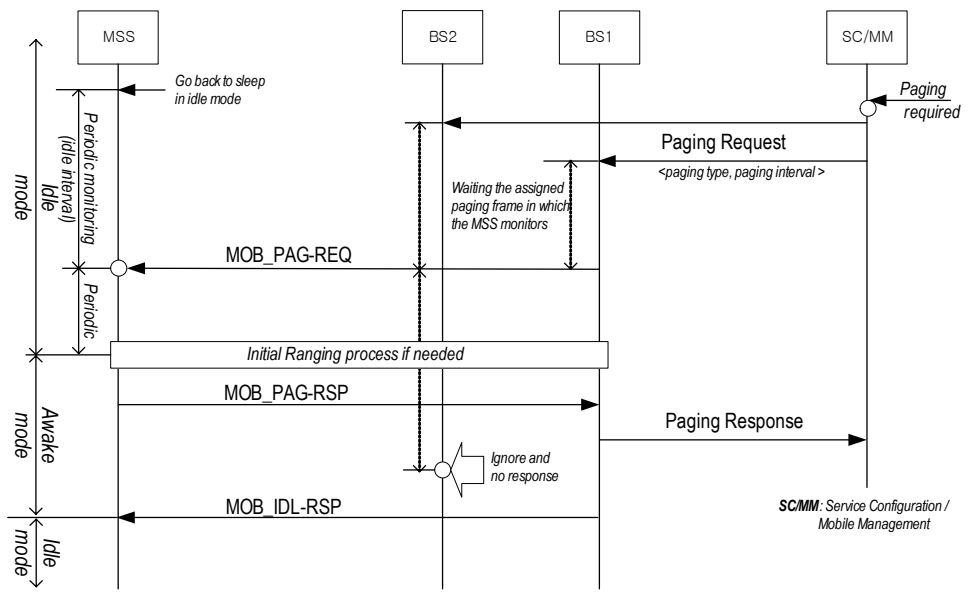
Figure Paging procedure of No 3 (multiple cells).

6.4.18.3.2.4 Paging Procedure No. 4.

This paging procedure is for the case that BS want to change the rest interval and the timer-based registration interval

The following figure shows overview of performing paging No. 4 while the MSS is in idle mode.
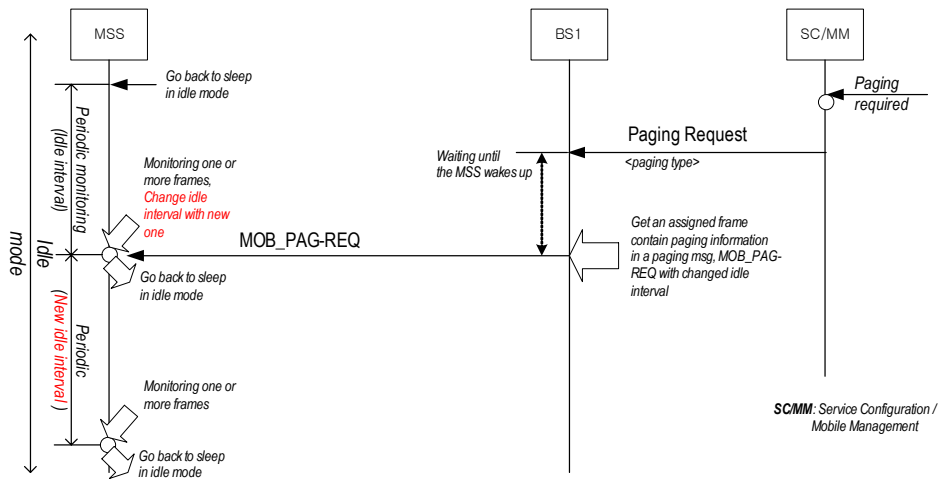
Figure Paging procedure of No 4.

The BS shall request the MSS to change its rest interval in idle mode. It can be used for the BS to control the rest interval of the MSS. When the MSS receives this paging, it shall update the rest interval and also the timer-based registration interval if the timer-based registration is supported. In this case, there will be no mode transition after changing the rest interval.

6.4.18.3.2.5 Paging Procedure No. 5.

This paging procedure is for the case that BS want to request the zone-based registration.

The following figure shows overview of performing paging No. 5 case while the MSS staying in idle mode.

Figure Paging Case of No 5.

The BS can send the **MOB_PAG-REQ** message to request the MSS to perform the location update procedure. The BS may trigger this event to investigate the correctness of the last location update. Therefore, the BS may page multiple BS at the same time. It also requires the MSS to enter awake mode for a while and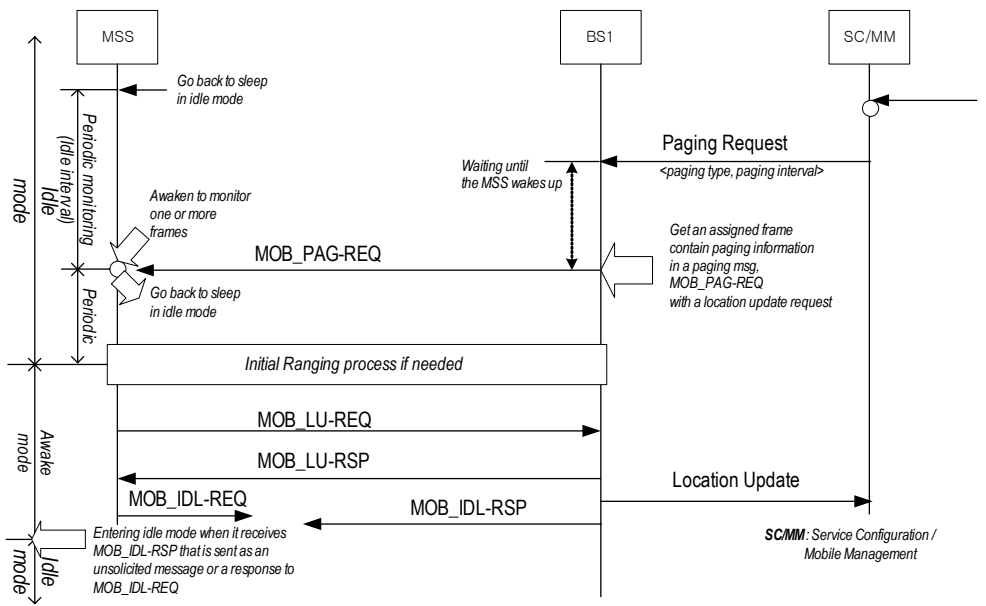 after then, the MSS after which, BS may trigger entering idle mode again by sending a **MOB_IDL-REQ** and **MOB_IDL-RSP** message respectively.

Accept following MAC Management Message

6.4.2.3 MAC Management Messages

Table 14b. MAC Management Messages

Type	Message Name	Message Description	Connection
??	MOB_IDL-REQ	Idle request message	basic
??	MOB_IDL-RSP	Idle response message	basic
??	MOB_PAG-REQ	Paging request message	broadcast
??	MOB_PAG-RSP	Paging response message	primary
38, 57-255		Reserved	

6.4.2.3.55 Paging Request (MOB_PAG-REQ) Message

This message is sent from BS to MSS on the broadcast CID. The message is intended for MSS's that are in idle-mode, and is sent at a MSS's monitoring frame. The message indicates whether there has been traffic addressed to each MSS that is in idle-mode. An MSS that is in idle-mode at its monitoring frame shall decode this message to seek paging messages those are designated to itself by the MAC Address matching..

When an MSS monitors a frame in idle mode, it will check the frame number to ensure that it does not lose frame synchronization with the BS, if it finds neither the **MOB_PAG-REQ** message nor its own MAC address in the **MOB_PAG-REQ** message, it ignores the frame and then it may perform idle procedures of idle mode.

Table MOB_PAG-REQ Message Format

Syntax	Size	Notes
MOB_PAG-REQ_Message_Format() {		
Management message type = ??	8 bits	
Number of paged terminals	8 bits	
For (j=0; j<Number of paged terminals; j++) {		
MAC_ADDRESS	48 bits	48bit_MSS_unique_MAC address
PAG_PURPOSE	8bits	
LENGTH	6 bits	The length of the payload, units of bytes
PAYLOAD	8 x LENGTH bits	Paging information.
}		
}		

Parameters shall be as follows:

Number of paged terminals

The number of paging messages inside this message

MAC_ADDRESS

MAC address of the designated MSS that is supposed to receive this paging message.

PAG_PURPOSE

This field represents the purpose of paging.

Table PAG_PURPOSE

value	Description

00000000	Reserved
00000001	Performing the network re-entry and initialization.
00000010	No ack. required. (no MOB_PAG-RSP)
00000011	Ack. required. (no MOB_PAG-RSP)
00000100	Change rest interval
00000101	Requesting the location update
00000110 ~ 0xff	Reserved

LENGTH

The length of the payload..

PAYLOAD

This has a different message structure according to the PAG_PURPOSE. *The* PAG_PURPOSE *1, 4 and 5 are mapped with the payload type 1, 4 and 5 respectively. Therefore, When the BS tries to sending the* MOB_IDL-REQ *message,   the BS shall set this field to the corresponding octet of* 'PL_TYPE_1_Format' *of the payload type 1. The same rule is also applied to* PAG_PURPOSE *4 and 5. When the* PAG_PURPOSE *is either 2 or 3, the payload shall be omitted. See the* 'PL_TYPE' *explanation described at 6.4.2.3.56 sub clause.*

6.4.2.3.56 Paging Response (MOB_PAG-RSP) Message

The **MOB_PAG-RSP** message shall be sent from an MSS to the BS on the MSS's primary CID in response to an **MOB_PAG-REQ** message which requires the acknowledgement message of the **MOB_PAG-REQ**.

Table MOB_PAG-RSP Message Format

Syntax	Size	Notes
MOB_PAG-RSP_Message_Format() {		
Management message type = ??	8 bits	
Cause	2 bits	00 & 11: reserved 01 : MOB_PAG-REQ accepted 10 : MOB_PAG-REQ rejected
PL_TYPE	8bits	Refer to MOB_PAG-RSP. *PL_TYPE 0 (dummy) recommended.*
LENGTH	6 bits	if, PL_TYPE == 0, this field is set to 0 also.
PAYLOAD	8 x LENGTH bits	
}		

PL_TYPE

The type of the payload

Table payload type

PL_Type value	Purpose
00000000	Dummy
00000001	Request the MSS to enter awake mode
00000010	Reserved
00000011	Reserved
00000100	Request to change rest interval
00000101	Request the MSS to perform the location registration.
00000110 ~ 0xff	Reserved

● *A Request of entering awake mode*

Syntax	Size	Notes

Syntax	Size	Notes
PL_TYPE_1_Format() {		
reason	8 bits	value 0 : DL User data buffered 1~0xff : reserved

● *A Request of changing rest interval*

Syntax	Size	Notes
PL_TYPE_4_Format() {		
rest interval index	4 bits	
reserved	4 bits	

● *Location Registration Request*

Syntax	Size	Notes
PL_TYPE_5_Format() {		
reserved	8 bits	