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Re:	Response to IEEE 802.16e-4/06 (Call for Contributions on IEEE 80.16e/D1)	
Abstract	MSS Idle Mode	
Purpose	Provide for a mechanism for MSS to be detached from active Normal Operation service with a BS, but available to periodic broadcast messaging to prompt MSS to return to Normal Operation service	
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MSS Idle Mode

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Problem:
The current mobility model for 16e, in common with contemporary IP networks, requires constant Normal Operation connectivity, persistent connection, of an MSS to Serving BS as the MSS traverses the RF geography. Even 'Sleep Mode', during portions of which the MSS has no DL listening/response requirements, is a 'Normal Operation' operational state requiring that the MSS be currently attached to a specific Serving BS with which the MSS has a negotiated 'Sleep Mode' operation. Given that the vast majority of devices in current mobile networks are typically inactive while attached to the mobile network, requiring these inactive MSS to conduct active HO transactions creates non-productive overhead. Eliminating non-productive HO traffic would likely result in a 90%+ reduction in all HO traffic, and a significant savings in total overhead.

Remedy:
Borrowing 'Area Paging' or 'Zone Paging' concepts and mechanisms from the cellular world provides a ready solution mechanism to enable MSS periodic 'availability' to DL traffic 'tickler' messages without requiring active UL connectivity to specific BS. The lack of transmission synchronization among BS creates some difficulty in crafting a solution. But options exist to overcome this obstacle.

It is possible to extend 'Sleep Mode' to accomplish our paging goals. It initially seems a ready choice given its already defined function as a negotiated MSS 'unavailable' mode of operation with a constructed method of MSS active recovery. However, due to the fact that 'Sleep Mode' has negotiated intervals of DL 'unavailability' interleaved with intervals of DL 'listening' and that these negotiated intervals are negotiated specific to a certain Serving BS, MSS and BS would have a difficult time negotiating and coordinating intervals between an MSS and several BS, especially given the lack of BS transmission synchronization.

Another, simpler mechanism presents itself. By creating a new 'IDLE Mode' that operates as a network pre-reentry state we can more easily provide a solution. And we can leave 'Sleep Mode' alone. 'IDLE Mode' would operate outside Normal Operations, pre-Initial Ranging in the registration process. 'IDLE Mode' would be passive only; any MSS UL traffic would discontinue the mode, though the MSS might immediately return to 'IDLE Mode'. 'IDLE Mode' would use fixed, not negotiated Paging Broadcast Message Listening Intervals. With these intervals being consistently located within the frame timing of individual BS, coordination between BS and synchronous Paging Broadcast Messages would be unnecessary. Overall, a properly constructed solution mechanism should reduce non-productive overhead while minimizing multimedia session initiation latency. And of course accomplish this with a minimum of new constructs and mechanisms.

Remedy 1:

*[Add new sub-section to section **6.4 Data/Control Plane**; editor will make appropriate allocation of numbering (??) for subsection, page 17, line 28]:*

6.4.?? MSS Idle Mode

Idle Mode is intended as a mechanism to allow MSS to become periodically available for DL broadcast traffic messaging without requiring the MSS establish a UL traffic relationship with each BS as the MSS traverses an air link environment populated by multiple BS, typically over a large geographic area. Idle Mode benefits MSS by removing the active requirement for HO, and all Normal Operation requirements. By restricting MSS activity to scanning at discrete intervals, Idle Mode allows the MSS to conserve power and operational resources.

Idle Mode benefits the network and BS by providing a simple and timely method for alerting the MSS to pending DL traffic directed toward the MSS, and by eliminating air interface and network HO traffic from essentially inactive MSS.

Idle Mode is an optional mode.

The BS are divided into logical groups called paging groups. The purpose of these groups is to offer a contiguous coverage region in which the MSS does not need to transmit in the UL, yet can be paged in the DL if there is traffic targeted at it. The paging groups should be large enough so that most MSS will remain most of the time within the same paging group, and small enough such that the paging overhead is reasonable. Figure 2 shows an example of four paging groups defined over multiple BS arranged in a hexagonal grid. A BS may be a member of one or more Paging Groups.

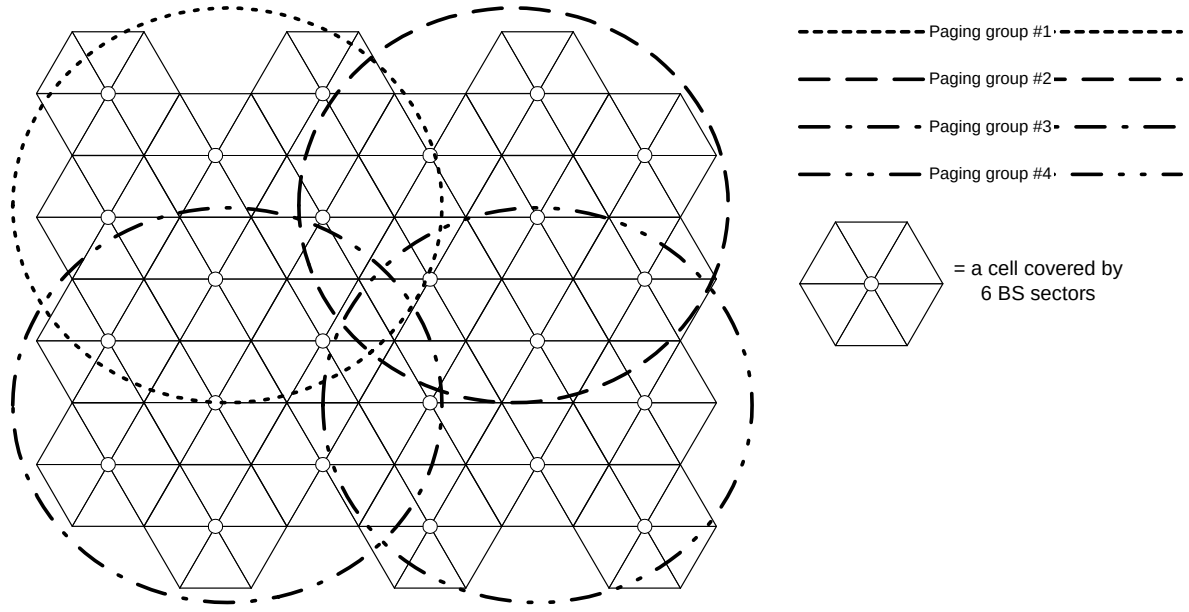

Figure 1: Paging-groups example

The paging-groups are defined in the management system. One possible method of definition is by using the **paging-group-action** backbone message. Another backbone message, **paging-announce**, is used to initiate paging of the MSS on all BS belonging to the paging group.

Idle is comprised of the following activities/stages:

6.4.??.1 MSS Idle Mode Initiation

Idle Mode Initiation may begin after MSS de-registration. During Normal Operation with its Serving BS, an MSS may signal intent to begin Idle Mode by sending a DREG-REQ with a De-registration_Request_Code = 0x01; request for MSS de-registration from Serving BS and initiation of MSS Idle Mode. Similarly, a Serving BS may signal for an MSS to begin Idle Mode by sending a DREG-CMD with an Action Code = 0x05; require MSS de-registration from Serving BS and request initiation of MSS Idle Mode.

6.4.??.2 Cell Selection

At MSS Idle Mode Initiation, an MSS may engage in Cell Selection to obtain a new Preferred BS. A Preferred BS is a Neighbor BS that the MSS evaluates and selects as the BS with the best air interface DL properties. An MSS previous Serving BS may be the Preferred BS. In all other respects, Cell Selection is similar to 6.4.??.1 Cell Selection in HO Process.

6.4.??.3 MSS Broadcast Paging Message time synchronization

At evaluation and selection of the Preferred BS, the MSS shall synchronize and decode the DCD and DL-MAP for the Preferred BS, extracting the frame size and frame number. The MSS shall evaluate the frame size and frame number and use them to determine time until next regular BS Broadcast Paging message Transmission Interval for the Preferred BS. The calculated time until the next regular BS Broadcast Paging message Transmission Interval, less any MSS DL scanning, decoding, and synchronization time requirements, shall be the MSS Paging Unavailable Interval.

6.4.??.4 MSS Paging Unavailable Interval

During MSS Paging Unavailable Interval, the MSS may power down, scan Neighbor BSs, re-select a Preferred BS, conduct ranging, or perform other activities for which the MSS will not guarantee availability to any BS for DL traffic. Should the MSS re-select a Preferred BS during the MSS Paging Unavailable Interval, then the MSS shall return to the MSS Broadcast Paging Message time synchronization stage.

6.4.??.5 MSS Paging Listening Interval

The MSS shall scan, decode the DCD and DL-MAP, and synchronize on the DL for the Preferred BS in time for the MSS to begin decoding any BS Broadcast Paging message during the entire BS Broadcast Paging message Transmission Interval. At the end of MSS Paging Listening Interval, providing that the MSS does not elect to terminate the MSS Idle Mode, the MSS may return to MSS Paging Unavailable Interval.

6.4.??.6 BS Broadcast Paging message Transmission Interval

A BS Broadcast Paging message Transmission Interval shall occur during the five frames beginning with the frame whose frame number, N_{frame}, meets the condition

$$N_{frame} \textbf{ modulu } PAGING\_CYCLE == 0$$

on each BS. BS receive notification of active PAGING_CYCLEs through backbone messages. PAGING_CYCLE shall be the exponential of 2. A BS may broadcast one or more BS Broadcast Paging messages during the Transmission Interval. Different BS may, but need not synchronize their Transmission Intervals.

6.4.??.7 BS Broadcast Paging message

A BS Broadcast Paging message is an MSS notification message indicating the presence of DL traffic pending, through the BS or some network entity, for the specified MSS. The BS Broadcast Paging message shall be sent on the Broadcast CID during the BS Broadcast Paging message Transmission Interval. A paging message shall be transmitted during the Transmission Interval regardless of the number of MSS that need paging.

The BS Broadcast Paging message shall include one or more Paging Group IDs identifying the logical affiliations of the transmitting BS.

MSS are identified in the BS Broadcast Paging message by their MSS MAC Address hash. A single BS Broadcast Paging message may include multiple MAC Addresses. For a given BS Broadcast Paging message in a specific BS Broadcast Paging message Transmission Interval, the BS shall include only those MSS MAC Address hash particular to the PAGING_CYCLE.

The BS Broadcast Paging message shall also include an Action Code directing each MSS notified via the inclusion of its MSS MAC Address hash to either:

00) no action required
01) perform Ranging to establish location and acknowledge message
10) perform initial network entry
11) reserved

6.4.??.8 Paging Availability Mode Termination
6.4.?.?.8.1 MSS side

An MSS may terminate MSS Idle Mode at any time.

An MSS shall terminate Idle Mode and re-enter the network if it decodes a BS Broadcast Paging message that contains the MSS own MSS MAC Address hash and an Action Code of 10, enter network. In the event that an MSS decodes a BS Broadcast Paging message that contains the MSS own MSS MAC Address hash and an Action Code of 01, Perform Ranging, the MSS shall conduct and complete Initial Ranging to establish location to the network and acknowledge message decoding. Similarly, the MSS shall conduct and complete Initial Ranging to establish location to the network and acknowledge message decoding in the event that it fails to find the MSS own Paging Group ID in the Broadcast Paging message. In either instance of required Initial Ranging, upon completion of the Ranging procedure the MSS shall assume the Paging Group ID of the Preferred BS.

The MSS shall exit Idle mode if it has lost synchronization with the paging message. When re-entering the network, the MSS may use the short network re-entry sequence similar to the behavior after HO or drop event.

To prevent collisions from multiple MSS trying to wake from Idle mode at the same time, the MSS shall use special initial-ranging back-off values that will be advertised in the UCD message.

6.4.?.?.8.2 BS side
The BS at which the MSS entered the network may report to the BS that initiated the paging about the MSS network re-entry, using the backbone message. If the BS that has initiated the paging is not informed about MSS reentry into the network, it shall initiate another paging sequence for the MSS. The backbone message

may also be used to inform the BS at which the MSS has entered IDLE mode that the MSS has transitioned to a different Paging Group.

Remedy 2:
[In page 25, line 41, insert following sentence to assistance efficient idle mode operation]:

6.4.2.3.45 Neighbor Advertisement (MOB_NBR-ADV) message

For each advertised Neighbor BS, the following TLV parameters may be include.

Mode Supported : Same with 11.4.2.13.1.

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

Paging Group ID (16 bit) : One or more logical affiliation groupings of BS

Remedy 3:
[Modify 6.4.2.3.?? SS De-registration Request (DREG-REQ) message, contribution item to 6.4.2.3 MAC Management Message, page 60, line 33]:

Table *nn*—De-registration Request (DREG-REQ) message format

Syntax	Size	Notes
DREG-REQ_Message_Format() {		
Management Message Type=??	8 bits	
De-registration_Request_Code	8 bits	0x00 = SS de-registration request from BS and network 0x01 = request for MSS de-registration from Serving BS and initiation of MSS Paging Availability Mode ~~0x01~~0x02-0xFF = reserved
Paging Cycle Request	16 bits	Only valid if De-Registration_Request_Code=0x01
TLV encoded parameters	Variable	
}		

An SS shall generate SS DREG-REQs including the following parameters:

De-registration_Request_Code

Request code identifying the type of de-registration request:

0x00 = SS de-registration request for de-registration from BS

0x01 = request for MSS de-registration from Serving BS and initiation of MSS Paging Availability Mode

~~0x01~~ 0x02 – 0xFF = reserved

Paging Cycle Request

PAGING_CYCLE requested by MSS. Only valid if De-Registration_Request_Code=0x01

The DREG-REQ shall include the following parameters encoded as TLV tuples:

HMAC Tuple (see 11.1.2)

The HMAC Tuple shall be the last attribute in the message.

Remedy 4:
[Modify 6.4.2.3.26 De/Re-register Command (DREG-CMD) message, Table 55—Action Codes and actions, page 93, lines 12-28]:

Table 54—DREG-CMD message format

Syntax	Size	Notes
DREG-CMD_Message_Format() {		
Management Message Type = 29	8 bits	
Action Code	8 bits	
TLV encoded parameters	Variable	
}		

Table 55—Action Codes and actions

Action Code	Action
0x00	SS shall leave the current channel and attempt to access another channel
0x01	SS shall listen to the current channel but shall not transmit until an RES-CMD message or DREG_CMD with Action Code 0x00 is received.
0x02	SS shall listen to the current channel but only transmit on the Basic, Primary Management, and Secondary Management Connections.
0x03	SS shall return to normal operation and may transmit on any of its active connections.
0x04	SS shall terminate current Normal Operations with the BS; the BS shall transmit this action code only in response to any SS DREG-REQ
0x05	require MSS de-registration from Serving BS and request initiation of MSS Idle Mode
0x06	The MSS may retransmit the DREG-REQ message after the time duration (REQ-duration) given by the BS in this message
0x07	The MSS shall not retransmit the DREG-REQ message and shall wait the DREG-CMD message
~~0x05~~ 0x08 – 0xFF	Reserved

An SS shall generate BS DREG-CMD including the following parameters:

The DREG-CMD shall include the following parameters encoded as TLV tuples:

HMAC Tuple (see 11.1.2)

The HMAC Tuple shall be the last attribute in the message.

When the DREG-CMD message is sent with Action Code = 0x05, the following TLV shall be included:

Paging Information (see 11.?)

The Paging Information TLV defines the **Paging Group ID,** the **PAGING_CYCLE** and the **START_FRAME_OFFSET** parameters to be used by the MSS in IDLE mode

The DREG-CMD may include the following parameters encoded as TLV tuples:

REQ-duration

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

Remedy 5:

*[Add MAC Management message to **6.4.2.3 MAC Management messages**, page 18, line 1; editor will make appropriate allocation of numbering for subsection and Management Message Type, set appropriate Table number nn, and adjust referenced Table 14a to include new Management Message Type reference]:*

6.4.2.3.?? BS Broadcast Paging (MOB_PAG-ADV) message

The MOB_PAG-ADV message shall be sent on the Broadcast CID during the BS Broadcast Paging message Transmission Interval.

The MAC Management Message Type for this message is given in Table 14a. The format of the message is shown in Table *nn*.

Table *nn*—BS Broadcast Paging (MOB_PAG-ADV) message format

Syntax	Size	Notes
MOB_PAG-ADV_Message_Format() {		
Management Message Type=??	8 bits	
Num_Paging Group IDs	8 bits	Number of Paging Group IDs in this message
For (i=0; i<Num_Paging Group IDs; i++) {		
Paging Group ID	8 bits	
}		
For (j=0; j<Num_MACs; j++) {		Number of MSS MAC Addresses in message can be determined from the length of the message (found in the generic MAC header).
MSS MAC Address hash	24 bits	The hash is obtained by computing a CRC24 on the MSS 48-bit MAC address. The polynomial for the calculation is 0x864CFB
Action Code	2 bit	Paging action instruction to MSS 00=No Action Required 01=Perform Ranging to establish location and

		acknowledge message 10=Enter Network 11=reserved
Reserved	6 bits	
}		
}		

A BS shall generate MOB_PAG-ADV including the following parameters:

MSS MAC Address hash

This is a 24-bit field used to hash the MSS 48-bit MAC address. The hash value shall be the remainder of the division (Modulo 2) of the 48-bit MAC address by the generator polynomial g(D)= D16 + D12 + D5 + 1 of the polynomial D16 multiplied by the content of the MSS 48-bit MAC address. (Example: [MSS 48-bit MAC address]= 00:D0:59:0F:E2:2E, hash should then be set to TBD).

Action Code

Paging action instruction to MSS to perform the following action:
00=No Action Required
01=Perform Ranging to establish location and acknowledge message
10=Enter Network
11=reserved

Remedy 6:
[Add the following text after section 11.12]:

11.13 DREG-CMD message encodings

Name	**Type**	**Length**	**Value**
Paging Information	?	4	**Bits 15:0 - PAGING_CYCLE** - Cycle in which the paging message is transmitted within the paging group **Bits ~~31~~23:16 - Paging-group-ID** - ID of the paging group the MSS is assigned to **Bits 31:24 – Start-Frame-Offset** – Starting value for N_{frame}

Remedy 7:
[In 11.4.2.13.1 Sleep-mode supported, page 63, line 42, Modify the following table]:

This field indicates whether the MSS supports mobility hand-over, ~~a~~ sleep-mode and ~~i~~Idle-mode. A bit value of 0 indicates “not supported” while 1 indicates “supported”.

Type	Length	Value	Scope
5.24.1	1	Bit #0: Mobility (handover)	REG- REQ

		support Bit #1: Sleep-mode support Bit #2 : Idle-mode support	REG-RSP

Remedy 8:
[Modify Table C3 in section C.2.1. as shown below]:

Field	Size	Notes
Global header	152-bit	
Num Records	4-bit	Number of paging-group-ID records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS on initial network Entry
Action flag	8-bit	0 – Request information 1 – MSS arrived from hibernate mode 2 – MSS has transitioned to another paging group
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

Remedy 9:
[Add new sections C.2.8, C.2.9 and rename the existing C.2.8. The sections will include the following text]:

C.2.8 Paging-group-action message

This message is sent from BS to BS (or the ASA server) to indicate that the recipient BS is either added or removed from a paging group. The message can also be used to query whether the recipient BS is part of a paging group, or inform that the sender BS is part of a paging group.
The message contains the following information,

Field	Size	Notes
Message Type = ?	8-bit	
Sender BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Target BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Time Stamp	32-bit	Number of milliseconds since midnight GMT (set to 0xffffffff to ignore)
Action	4-bit	0 – Assign target BS to paging groups 1 – Remove target BS from paging groups 2 – Query (which paging groups target BS belongs to?) 3 – Information (paging groups sender BS belongs to)
Num Records	4-bit	Number of paging-group-ID records
For (j=0; j<Num Records; j++) {		
Paging-group-ID	16-bit	Paging-group-ID
PAGING_CYCLE	16-bit	Cycle in which the paging message is transmitted within the paging group
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

Table xxx: Paging-group-action message

C.2.9 Paging-announce message

This message is sent from BS to BS (or the ASA server) to announce that the recipient BS should page the provided list of MSS at certain frames, according to their PAGING CYCLE.

The message contains the following information,

Field	Size	Notes
Message Type = ?	8-bit	
Sender BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Target BS-ID	48-bit	Set to 0xffffff to indicate broadcast
Time Stamp	32-bit	Number of milliseconds since midnight GMT (set to 0xffffffff to ignore)
Num MSS	8-bit	Number MSS to page
For (j=0; j<Num MSS; j++) {		
MSS 48-bit MAC address	48-bit	-
PAGING CYCLE	16-bit	MSS PAGING CYCLE parameter
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

Table yyy: Paging-announce message