<table>
<thead>
<tr>
<th>Project</th>
<th>IEEE 802.16 Broadband Wireless Access Working Group  &lt;<a href="http://ieee802.org/16">http://ieee802.org/16</a>&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Sleep Mode and Handoff corrections for Task Group e</td>
</tr>
<tr>
<td>Date Submitted</td>
<td>2003-09-05</td>
</tr>
</tbody>
</table>
| Source(s) | Itzik Kitroser  Runcom  itzikk@runcom.co.il  
Yigal Leiba  Runcom  yigall@runcom.co.il  
Ken Stanwood  Ensemble  ken@ensemble.com  
Vladimir Yanover  Alvarion  vladimir.yanover@alvarion.com  |
| Re: | Task Group Review of IEEE 802.16e-03/07r3 IEEE 802.16 Task Group e |
| Abstract  | This document provide corrections per given actions points given at session #26 |
| Purpose  | |
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Sleep Mode and Handoff corrections for Task Group e

Itzik Kitroser  
Yigal Leiba  
Runcom Technologies Ltd.

Ken Stanwood  
Ensemble Communications

Vladimir Yanover  
Alvarion

1. General

This document contains modified text as per action points given at meeting #26.

2. Proposed changes:

1.3.1.2.3.1.3 Ranging and uplink parameters adjustment

For MSS’s that have used their scanning interval to do ranging with target BS this stage should be immediate. Otherwise, this stage is similar to the one performed at an initial network entry as specified in 6.2.9. During this stage the MSS is assigned a new basic and primary management CID in the target BS. If the MSS has used scanning interval(s) to do preliminary ranging with target BS, and if the target BS received HO-notification message that contains the MAC address of the MSS, (see section C.2.4 "Backbone network HO procedures") the BS may choose, instead of waiting for initial ranging request in MAINT region, to allocate non-contention transmission opportunity for the MSS.

As opposed to initial regular network entry, where this stage initial ranging is performed on contention basis, here the ranging opportunity may be allocated individually by the BS based on an MSS’s 48-bit MAC address identifier. This identifier is assuming this identifier was forwarded to the target BS via the backbone network (see section Backbone network - HO procedures). Allocation of non-contention ranging opportunity is done using the Fast_UL_ranging_IE() (see Fast ranging (Paging) Information Element) in the UL-MAP. When an initial ranging opportunity is not allocated individually, this procedure defaults to the one specified for initial network entry.
6. MAC CPS

6.4 Data/Control Plane

6.4.2 MAC PDU formats

6.4.2.3 MAC Management messages

Change Sections 6.4.2.3.40 as follows:

6.4.2.3.40 Sleep Request message (MOB_SLP-REQ)

SS supporting sleep-mode uses the MOB_SLP-REQ message to request permission from the BS to enter sleep-mode. The MOB_SLP-REQ message is sent from the SS to the BS on the SS’s basic CID.

Table 56aa—Sleep-Request (MOB_SLP-REQ) message format

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLP-REQ_Message_Format() {</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management message type = 45</td>
<td>8 bit</td>
<td></td>
</tr>
<tr>
<td>initial-sleep window</td>
<td>6 bit</td>
<td></td>
</tr>
<tr>
<td>final-sleep window</td>
<td>10 bit</td>
<td></td>
</tr>
<tr>
<td>listening interval</td>
<td>8 bit</td>
<td></td>
</tr>
<tr>
<td>}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Parameters shall be as follows:

\[\text{MinInitial-sleep window}\]

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

\[\text{MaxFinal-sleep window}\]

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

\[\text{Listening interval}\]

Requested listening interval (measured in frames).

Change Sections 6.4.2.3.41 as follows:

6.4.2.3.41 Sleep Response message (M0B_SLP-RSP)

The MOB_SLP-RSP message shall be sent from BS to a MSS on the SS’s basic CID in response to an MOB_SLP-REQ message, or may be sent unsolicited. The SS shall enter sleep-mode using the parameters indicated in the message.

Table 56ab—Sleep-Response (MOB_SLP-RSP) message format
Parameters shall be as follows:

**Sleep approved**
Defines whether or not the request to enter sleep-mode has been approved by the BS.

**Start-time**
The number of frames (not including the frame in which the message has been received) until the SS shall enter the first sleep-interval.

**MinInitial-sleep window**
Start value for the sleep interval (measured in frames).

**MaxFinal-sleep window**
Stop value for the sleep interval (measured in frames).

**Listening interval**
Value for the listening interval (measured in frames).

### Change Sections 6.4.2.3.48 as follows:

#### 6.4.2.3.48 BS HO Response (MOB_BSHO-RSP) message

Either an MSS or a The BS shall transmit an MOB_BSHO-RSP message upon reception of MOB_HO-REQ message or in an unsolicited manner. The message shall be transmitted on the basic CID.

#### Table 56ai—MOB_BSHO-RSP Message Format

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOB_BSHO-RSP_Message_Format()</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management message type = 46</td>
<td>8 bit</td>
<td></td>
</tr>
</tbody>
</table>
| Sleep-approved             | 1 bit | 0: Sleep-mode request denied
1: Sleep-mode request approved |
| Reserved                   | 7 bit |                                                 |
| start frame                | 7 bit | lower byte of the frame number, in which the SS shall enter into sleep mode |
| initial-sleep window       | 6 bit |                                                 |
| final-sleep window         | 10 bit |                                                |
| listening interval         | 8-bit |                                                |
A BS or MSS shall generate MOB_BSRO-RSP messages in the format shown in Table 56ai. The following parameters shall be included in the MOB_BSRO-RSP message,

**Estimated HO time** – Estimated number of frames starting from the frame following the reception of the MOB_BSRO-RSP message until the HO may take place. A value of zero in this parameter signifies that this parameter should be ignored.

**N_Recommended** – Number of recommended neighbor BS

For each recommended neighbor BS, the following parameters shall be included,

**Neighbor BS-ID** – Same as the Base Station ID parameter in the DL-MAP message of neighbor BS

**Service level prediction** – This value indicates the level of service the MSS can expect from this BS. the following encodings apply:

0 = No service possible for this MSS.

1 = Some service is available for the MSS.

2 = Service with QoS specified at ASA server (for the MSS identified by the 48-bit MAC address) is available.

**Renumber section 6.4.2.3.49 as 6.4.2.3.50, change ‘Management Message Type’ to 55 in table 56aj and insert new section 6.4.2.3.49 as follows:**

### 6.4.2.3.49 MSS HO Response (MOB_MSSHO-RSP) message

An MSS shall transmit an MOB_MSSHO-RSP message upon reception of MOB_MSSHO-REQ message. The message shall be transmitted on the basic CID.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOB_MSSHO-RSP_Message_Format()</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Message Type = 54</td>
<td>8 bits</td>
<td></td>
</tr>
</tbody>
</table>
A MSS shall generate MOB_MSSHO-RSP messages in the format shown in Table 56ai. The following parameters shall be included in the MOB_MSSHO-RSP message,

**Estimated HO time** – Estimated number of frames starting from the frame following the reception of the MOB_BSHO-RSP message until the HO may take place. A value of zero in this parameter signifies that this parameter should be ignored.

**N_Recommended** – Number of recommended neighbor BS

For each recommended neighbor BS, the following parameters shall be included,

**Neighbor BS-ID** – Same as the Base Station ID parameter in the DL-MAP message of neighbor BS

---

Change Sections 6.4.16.1 - 6.4.16.3 as follows:

### 6.4.16 Sleep-mode for mobility-supporting SS

#### 6.4.16.1 Introduction

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

An SS that supports sleep-mode can be in one of two modes:

— **Awake**
— **Sleep**

When an SS is in awake-mode, it is receiving and transmitting PDUs in a normal fashion. When the SS is in a sleep-mode, it does not send or receive PDUs. In sleep-mode the SS may power down.

Two intervals are defined:

**Sleep-interval**

A time duration, measured in whole frames, where the SS 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**

Length, measured in whole frames, of the listening interval. During this interval the SS shall decide whether to stay awake or go back to sleep based on an indication from the BS. The Listening-interval duration is negotiated between the BS and the SS.
Before entering sleep-mode the SS shall inform the BS and obtain its approval. The BS may buffer (or it may drop) incoming PDUs addressed to the sleeping SS, and shall a send notification to the SS in its awakening periods about whether data has been addressed for it.

An SS shall awake according to the sleep-interval and check whether there were PDUs addressed for it. If such PDUs exist, it shall remain awake. An SS may terminate sleep-mode and return to awake-mode anytime (i.e. there is no need to wait until the sleep-interval is over). If the BS receives an MPDU from an SS that is supposed to be in sleep-mode, the BS shall assume that the SS is no longer in sleep-mode.

Traffic indication message (TRF-IND) shall be sent by the BS on the broadcast CID periodically. If the number of positive indications is zero, the BS sends an empty indication message, that is, TRF-IND message with num-positive=0.

When its sleep-interval timeouts, the SS shall awake to listen to the DL transmissions until it receives a TRF-IND message. If there is a positive indication to the SS, it shall remain awake. Otherwise, the SS may return to its sleep-mode. The listening-interval parameter defines the number of frames the SS shall remain awake waiting for the TRF-IND message.

In this way, the listening interval parameter is no longer needed to be negotiated between SS and BS in the SLP-REQ and SLP-RSP messages. The interval between two TRF-IND messages sent by the BS is the maximum listening interval for all SS's supporting sleep-mode. It can be sent in the SLP-RSP message only.

Figure 123a shows the SDL for the SS in the awake state.

**Figure 123a—SS Awaiting Sleep Response SDL Diagram**

Figure 123b shows the SDL for the SS after it has sent an MOB_SLP-REQ message and is awaiting a response.
Figure 123c shows the SDL for the SS while in sleep-mode.
Figure 123d shows the SDL for when the SS is listening for an MOB_TRF-IND message from the BS.

Figure 123d—SS Listening SDL Diagram
Figure 123e shows the SDL for when the SS has awakened prematurely.

Figure 123f shows the SDL for the BS when an SS is in awake mode.
Figure 123g shows the SDL for the BS when the SS is in sleep mode.

Figure 123f—BS – SS Awake Mode SDL Diagram
Figure 123h shows the BS SDL for when the SS is awakening.

Figure 123g—BS – SS Sleep Mode SDL Diagram
6.4.16.2 Sleep-interval update algorithm

An 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 initial-sleep 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 final-sleep window value. The following formula defines the calculation of the duration of the k\textsuperscript{th} sleep-interval - $I_k$:

$$
\begin{align*}
I_0 &= \text{initial-sleep window} \\
I_k &= \min\{2 \cdot I_{k-1}, \text{final-sleep window}\} \quad k > 0
\end{align*}
$$

(1)

When the MSS has reached the final-sleep window size, it shall continue in sleep mode without further increasing the sleep-interval.
6.4.16.3 Traffic indication signaling

A BS shall notify each SS in sleep-mode, during its listening-interval, if traffic has been addressed to it. The indication is sent on the TRF-IND broadcast message. The SS shall examine the frame number from the PHY Synchronization Field and shall verify its synchronization with the BS. If the expected frame number is different than found frame number, the SS shall return into awake mode.

If the SS did not find any positive indication with its CID the TRF-IND message, if the SS receives a TRF-IND message with ‘num-positive’ field = 0, or no CID in the TRF-IND message matches the SS’s basic CID, it shall consider this as a negative indication and shall continue in sleep mode. For an example of sleep mode operation, see Annex D.

11. TLV Encodings

11.1 MAC management message encodings

11.1.4 REG-RSP TLVs for connection re-establishment

*Change in table 127b:*

<table>
<thead>
<tr>
<th>Name</th>
<th>Type (1 byte)</th>
<th>Length (1 byte)</th>
<th>Value (Variable-length)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CID_updateCID</td>
<td>TBD</td>
<td>16-bits</td>
<td>CID in the previous serving BS, New CID after handover to new BS.</td>
</tr>
<tr>
<td>OLD CID</td>
<td>TBD</td>
<td>16-bits</td>
<td>Replacement CID in the current serving BS, Old CID before handover from old BS.</td>
</tr>
<tr>
<td>Connection_Info</td>
<td>TBD</td>
<td>Variable</td>
<td>The Connection_Info is a compound TLV value that encapsulates the Service Flow Parameters and the CS Parameter Encodings TLVs allowed on the DSA-RSP message that have changed for the service. All the rules and settings that apply to the TLV parameters when used in the DSAC-RSP message apply to the contents encapsulated in this TLV.</td>
</tr>
</tbody>
</table>

11.4 Common encodings

*Add to Table 278:*

<table>
<thead>
<tr>
<th>Type</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>Mobility support capabilities</td>
</tr>
</tbody>
</table>

11.4.2 SS Capabilities encoding

*Add to Table 279*
Table 279—SS Capability encodings

<table>
<thead>
<tr>
<th>Type</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Mobility parameters support</td>
</tr>
</tbody>
</table>

Insert new sections 11.4.2.11, 11.4.2.11.1 and 11.4.2.11.2

11.4.2.11 MSS Mobility parameters support

This field defines the parameters associated with the mobility support capabilities of the MSS.

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Value</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.24</td>
<td>n</td>
<td></td>
<td>REG- REQ</td>
</tr>
</tbody>
</table>

11.4.2.11.1 Sleep-mode supported

This field indicates whether the MSS supports sleep-mode. A bit value of 0 indicates not supported while 1 indicates supported.

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Value</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.24 .1</td>
<td>1</td>
<td>Bit #0: Sleep-mode support Bits #1-7: Reserved, shall be set to zero</td>
<td>REG- REQ</td>
</tr>
</tbody>
</table>

11.4.2.11.2 Sleep-mode recovery time

This field indicates the time requires for an MSS which is in a sleep-mode to return to awake-mode. This parameter is optional and may be used by the BS to determine the sleep interval windows sizes when initiating sleep-mode with an MSS.

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Value</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.24 .2</td>
<td>1</td>
<td>Number of frames required for the MSS to switch from sleep-mode to awake-mode</td>
<td>REG- REQ</td>
</tr>
</tbody>
</table>

Insert new sections 11.4.14
11.4.14 Mobility support capabilities

This field defines common parameters for mobility support..

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>n</td>
<td>-</td>
</tr>
</tbody>
</table>

11.4.14.1 Listening Interval

This field indicates the length in frames of listening interval for sleep-mode operation.

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Value</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.1</td>
<td>1</td>
<td>Length in frames of listening interval</td>
<td>REG- RSP</td>
</tr>
</tbody>
</table>