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IEEE 802.16e-03/07

**Draft Amendment to IEEE Standard for  
Local and Metropolitan Area Networks**

# **Part 16: Air Interface for Broadband Wireless Access Systems - Amendment 4: Mobility Enhancements**

Sponsor  
**LAN MAN Standards Committee**  
of the  
**IEEE Computer Society**  
and the  
**IEEE Microwave Theory and Techniques Society**



**Abstract:** This Amendment updates and expands IEEE Std 802.16-2001 to allow for mobility.

**Keywords:** WirelessMAN™ standards, metropolitan area network, broadband wireless access network, millimeter waves, microwaves, mobility

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## Contents

6.2.2.3.37 Mesh Centralized Scheduling (MSH-CSCH) message.....	1
6.2.5.1 Unsolicited Grant Service.....	1
6.2.5.2 Real-Time Polling service.....	1
6.2.5.3 Non-Real-Time Polling service.....	2
6.2.13.2 Service flows.....	2
6.2.13.8.4 Dynamic Service Change (DSC).....	2
8.4.2.2 Derived parameter definitions.....	3
8.4.2.4 Parameters of transmitted signal.....	3
8.4.3.1 Randomization.....	3
8.4.3.2.1 Concatenated Reed-Solomon / convolutional code (RS-CC).....	3
8.4.3.3 Interleaving.....	3
8.4.3.4.1 Data modulation.....	4
8.4.3.5 Example OFDM UL RS-CC encoding.....	4
8.4.3.6 Preamble structure and modulation.....	5
8.4.4.1 PMP.....	5
8.4.5.1 DL-MAP PHY Synchronization Field.....	6
8.5.4.3 DL Frame Prefix.....	6
8.5.5.2 DL-MAP Information Element format.....	7
8.5.5.3 UL-MAP Information Element format.....	8
<b>10.1 Global Values.....</b>	<b>9</b>
11.4.1.2.7 WirelessMAN-OFDM/OFDMA FFT sizes.....	10
11.4.1.2.8 WirelessMAN-OFDM Focused Contention Support.....	10
11.4.8.11 Service flow scheduling type.....	10
11.4.8.12 Request/transmission policy.....	10
11.4.8.15 Fixed-length versus variable-length SDU indicator.....	11
11.4.8.16 SDU size.....	11
11.4.9.4.4 ATM Classifier Error Parameter Set.....	11



## Figures



## Tables

Table 116al—Bit interleaved block sizes.....	4
Table 116am—OFDM PHY synchronization field.....	6
Table 116an—OFDMA DL Frame Prefix.....	7
Table 116ao—OFDMA DL-MAP_Information_Element format.....	8
Table 116bp—OFDMA UL-MAP Information Element format.....	9
Table 118b—Parameters and constants.....	9





1 **Draft Amendment to IEEE Standard for**  
 2 **Local and Metropolitan Area Networks**

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 4  
 5 **Part 16: Air Interface for Broadband**  
 6 **Wireless Access Systems -**  
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 8 **Amendment 4: Mobility Enhancements**  
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16 NOTE-The editing instructions contained in this amendment/corrigendum define how to merge the material  
 17 contained herein into the existing base standard IEEE Standard 802.16-2001 and its amendments IEEE  
 18 802.16a-2003 and 802.16c-2002 to form the comprehensive standard.  
 19

20  
 21 The editing instructions are shown *bold italic*. Four editing instructions are used: *change*, *delete*, *insert*, and  
 22 *replace*. *Change* is used to make small corrections in existing text or tables. The editing instruction specifies  
 23 the location of the change and describes what is being changed by using strike through (to remove old mate-  
 24 rial) and underscore (to add new material). *Delete* removes existing material. *Insert* adds new material with-  
 25 out disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are  
 26 given in the editing instruction. *Replace* is used to make large changes in existing text, subclauses, tables, or  
 27 figures by removing existing material and replacing it with new material. Editorial notes will not be carried  
 28 over into future editions because the changes will be incorporated into the base standard.  
 29  
 30

31  
 32 **3.69 Mobile Subscriber Station (MSS)**

33 SS that supports mobile functionality.  
 34

35  
 36 **3.70 Handoff (HO)**

37 The process in which a MSS migrates from the air-interface provided by one BS to the air-interface  
 38 provided by another BS. Two HO variants are defined:

- 39 — Hard HO: A HO where service with the new BS starts after a disconnection of service with the old BS.
- 40 — Soft HO: A HO where service with the new BS starts before disconnection of the service with the old  
 41 BS.  
 42

43  
 44 **3.71 Serving BS**

45 For any MSS, the serving BS is the BS with which the MSS has recently performed registration at  
 46 initial network-entry or during an HO.  
 47

48  
 49 **3.72 Target BS**

50 The BS that a MSS intends to be registered with at the end of a HO.  
 51

52  
 53 **3.73 Neighbor BS**

54 For any MSS, a neighbor BS is a BS whose downlink transmission can be demodulated by the MSS.  
 55

56  
 57 **3.74 Scanning Interval**

58 A time period intended for monitoring neighbor BS by the MSS, to determine their suitability as tar-  
 59 gets for HO.  
 60

61  
 62 **3.75 Monitored BS**

63 A BS that is monitored by the MSS during its scanning interval.  
 64  
 65

1 **3.76 Selected BS**

2 A subset of Monitored BS, which is selected as potential Target BS.

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6  
7 **6.1.3 MAC Service Definition for Mobility Support**

8  
9 **6.1.3.1 Primitives for Communication Between CS and MA**

10  
11 **6.1.3.1.1 MA to CS: CS\_CREATE\_CONNECTION.request/response**

12  
13  
14 Generated to trigger creation of new connection servicing a newly arrived MSS; specifies classifier(s) to forward data to the connections and QoS parameters for the connection

15  
16  
17 *[TBD Parameters]*

18  
19  
20 **6.1.3.1.2 MA to CS: CS\_TERMINATE\_CONNECTION.request/response**

21  
22 Generated to trigger termination of connection(s) after a MSS leaves the cell

23  
24  
25 *[TBD Parameters]*

26  
27 **6.1.3.1.3 MA to CS: CS\_SDU.request**

28  
29 Generated to send an SDU to backbone connection

30  
31  
32 *[TBD Parameters]*

33  
34 **6.1.3.1.4 CS to MA: CS\_MSS\_ARRIVAL.indication**

35  
36 Signals MSS arrival at the cell

37  
38  
39 *[TBD Parameters]*

40  
41 **6.1.3.1.5 CS to MA: CS\_MS\_DEPARTURE.indication**

42  
43 Signals MSS departure from the cell

44  
45  
46 *[TBD Parameters]*

47  
48 **6.1.3.1.6 CS to MA: CS\_SDU.indication**

49  
50 Generated to signal arrival of an SDU from the backhaul connection

51  
52  
53 *[TBD Parameters]*

54  
55 **6.2.2.3.40 Sleep Request message (SLP-REQ)**

56  
57  
58 SS supporting sleep-mode uses the SLP-REQ message to request permission from the BS to enter sleep-mode. The SLP-REQ message is sent from SS to the BS on the SS's basic CID. The message includes sleep-mode parameters as requested by the SS.

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

Syntax	Size	Notes
SLP-REQ_Message_Format() {		
Management message type = 45	8 bit	
min-window	6 bit	
Max-window	10 bit	
listening interval	8 bit	
}		

Parameters shall be as follows:

**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).

**6.2.2.3.41 Sleep Response message (SLP-RSP)**

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

**Table 56ab—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
If (Sleep-approved == 0) {		
Reserved	7 bit	
} else {		
Start-time	7 bit	
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.

**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.

**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 Traffic Indication message (TRF-IND)**

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

When SS awakens, it will check the frame number to ensure that it did not lost frame synchronization with the BS, if it does not find any positive indication in the TRF-IND message (or the message does not exists), it will consider this as a negative indication and shall return to sleep mode.

**Table 56ac—Traffic-Indication (TRF-IND) message format**

Syntax	Size	Notes
TRF-IND_Message_Format() {		
Management message type = 47	8 bit	
Positive_Indication_List() {		Traffic has been addressed to these SS
Num-positive	8 bit	
for (i=0; i< Num-positive; i++) {		
CID	16 bit	Basic CID of the SS
}		
}		

Parameters shall be as follows:

**Num-positive**

Number of CIDs on the positive indication list.

1 *[This text should be added to section 6.2.2.3.5 in IEEE Std 802.16-2001 “Part 16: Air Interface for Fixed*  
 2 *Broadband Wireless Access Systems”]*  
 3

4 A MSS may use the RNG-REQ message in its scanning interval for associating with a neighbor BS. When  
 5 associating with a neighbor BS, the MSS shall send the RNG-REQ message with the following parameters,  
 6

7  
 8 **Downlink Channel ID** \_ The identifier of the downlink channel on which the MSS received the UCD  
 9 describing the uplink on which this ranging request message is to be transmitted. This is an 8-bit field.  
 10

11 **SS MAC Address** – A 48-bit unique identifier for the MSS.  
 12

13 **CID at MAC Header** – Shall always the Initial Ranging CID.  
 14

15 **MSS Association Channel ID** – An identifier of the downlink channel on which the MSS is currently regis-  
 16 tered. This is an 8-bit field.  
 17

18  
 19 *[This text should be added to section 6.2.2.3.6 in IEEE Std 802.16-2001 “Part 16: Air Interface for Fixed*  
 20 *Broadband Wireless Access Systems”]*  
 21

22  
 23 When a BS sends a RNG-RSP message in response to a RNG-REQ message containing a **MSS Association**  
 24 **Channel ID TLV**, The BS may include the following parameter in the RNG-RSP message,  
 25

26  
 27 **Service Level Prediction** \_ This value indicates the level of service the MSS can expect from this BS. The  
 28 following encodings apply:  
 29

30  
 31 0 = No service possible for this MSS

32 1 = Service requested (as determined by the 48-bit MSS MAC address) is available

33 2 = Service request at requested QoS level is available  
 34

35 This is an 8-bit field.  
 36

37  
 38 The following TLVs shall be included in the REG-RSP for MSS recognized by the BS through their 48-bit  
 39 MAC address (provided in the RNG-REQ message) as MSS that are performing HO,  
 40

41  
 42 **CID\_updtae** – The CID\_update is a TLV value that provides a shorthand method for renewing a connection  
 43 used in the previous serving BS. The TLV specifies a CID in the new serving BS that shall replace a CID  
 44 used in the previous serving BS. All the service flows and parameters associated with the old CID remain  
 45 unchanged. (See ).  
 46

47  
 48 **Connection\_Info** – The Connection\_Info is a compound TLV value that encapsulates the **Service Flow**  
 49 **Parameters** and the **CS Parameter Encodings** TLVs allowed on the DSA-RSP. This TLV enables the new  
 50 serving BS to renew a connection used in the previous serving BS, but with different QoS settings.  
 51

52 *[add the following new MAC messages after section 6.2.2.3.42]*  
 53

#### 54 **6.2.2.3.43 Neighbor Advertisement (NBR-ADV) message**

55  
 56 An NBR-ADV message shall be broadcasted by a BS at a periodic interval () to define the characteristics of  
 57 neighbor BS.  
 58

59  
 60 The message parameters following the configuration change count shall be encoded in a TLV format in  
 61 which the type and length fields are each 1 byte long.  
 62  
 63  
 64  
 65

Table 56ad—NBR-ADV Message Format

Syntax	Size	Notes
NBR-ADV_Message_Format() {		
Management Message Type = ?	8 bits	
N_NEIGHBORS	8 bits	
For (j=0 ; j<N_NEIGHBORS ; j++) {		
Neighbor BS-ID	48 bits	
Configuration Change Count	8 bits	
Physical Frequency	16 bits	
TLV Encoded Neighbor information	Variable	TLV specific
}		
}		

A BS shall generate NBR-ADV messages in the format shown in . The following parameters shall be included in the NBR-ADV message,

**N\_Neighbors** – Number of advertised neighbor BS

For each advertised 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

**Configuration Change Count** – Incremented by one (modulo 256) whenever any of the values relating to this neighbor BS change. If the value of this count in a subsequent NBR-ADV message remains the same, the MSS can quickly to disregard the TLV encoded information

**Physical Frequency** – Physical frequency in multiples of 0.1MHz

All other parameters are coded as TLV value (see ).

For each advertised neighbor BS, the following TLV parameters may be included,

**DCD\_settings** – The DCD\_settings is a compound TLV value that encapsulates a DCD message that may be transmitted in the advertised BS downlink channel. This information is intended to enable fast synchronization of the MSS with the advertised BS downlink.

**UCD\_settings** – The UCD\_settings is a compound TLV value that encapsulates a UCD message that may be transmitted in the advertised BS downlink channel. This information is intended to enable fast synchronization of the MSS with the advertised BS uplink.

1 **6.2.2.3.44 Scanning Interval Allocation Request (SCN-REQ) message**

2  
3 An SCN-REQ message may be transmitted by a MSS to request a scanning interval for the purpose of seek-  
4 ing neighbor BS, and determining their suitability as targets for HO.  
5

6  
7 **Table 56ae—SCN-REQ Message Format**

8

Syntax	Size	Notes
SCN-REQ_Message_Format() {		
Management Message Type = ?	8 bits	
Scan Duration	20 bits	For SCa PHY, units are mini-slots. For OFDM/OFDMA PHY, units are OFDM symbols
}		

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20  
21  
22 A MSS shall generate SCN-REQ messages in the format shown in . The following parameters shall be  
23 included in the SCN-REQ message,  
24  
25

26 **Scan Duration** – The requested period of time for the scan. The units are PHY-dependent, as specified in .  
27  
28

29 **6.2.2.3.45 BS HO Request (BSHO-REQ) message**

30  
31 The BS may transmit a BSHO-REQ message when it wants to initiate an HO. The message shall be trans-  
32 mitted on the basic CID.  
33  
34

35 **Table 56af—BSHO-REQ Message Format**

36

Syntax	Size	Notes
BSHO-REQ_Message_Format() {		
Management Message Type = ?	8 bits	
Estimated HO time	8 bits	
N_Recommended	8 bits	
For (j=0 ; j<N_NEIGHBORS ; j++) {		
Neighbor BS-ID	48 bits	
}		
}		

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57

58 A BS shall generate BSHO-REQ messages in the format shown in . The following parameters shall be  
59 included in the BSHO-REQ message,  
60  
61

62 **Estimated HO time** – Estimated number of frames until the HO will take place. A value of zero in this  
63 parameter signifies that this parameter should be ignored.  
64  
65

1 N\_Recommended – Number of recommended neighbor BS

2  
3 For each recommended neighbor BS, the following parameter shall be included,

4  
5  
6 Neighbor BS-ID – Same as the Base Station ID parameter in the DL-MAP message of neighbor BS

#### 7 8 **6.2.2.3.46 MSS HO Request (MSSHO-REQ) message**

9  
10 The MSS may transmit an MSSHO-REQ message when it wants to initiate an HO. The message shall be  
11 transmitted on the basic CID.  
12

13  
14 **Table 56ag—MSSHO-REQ Message Format**

Syntax	Size	Notes
MSSHO-REQ_Message_Format() {		
Management Message Type = ?	8 bits	
Estimated HO time	8 bits	
N_Recommended	8 bits	
For (j=0 ; j<N_NEIGHBORS ; j++) {		
Neighbor BS-ID	48 bits	
BS S/(N+I)	8 bits	
}		
}		

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39  
40 A MSS shall generate MSSHO-REQ messages in the format shown in . The following parameters shall be  
41 included in the MSSHO-REQ message,

42  
43 **Estimated HO time** – Estimated number of frames until the HO will take place. A value of zero in this  
44 parameter signifies that this parameter should be ignored.

45  
46 **N\_Recommended** – Number of recommended neighbor BS

47  
48 For each recommended neighbor BS, the following parameters shall be included,

49  
50  
51 **Neighbor BS-ID** – Same as the **Base Station ID** parameter in the DL-MAP message of neighbor BS

52  
53  
54 **BS S/(N + I)** –This parameter indicates the signal to noise and interference ratio measured by the MSS from  
55 the particular BS. The value shall be interpreted as an unsigned byte with units of 0.25dB.

#### 56 57 **6.2.2.3.47 HO Response (HO-RSP) message**

58  
59  
60 Either a MSS or a BS shall transmit an HO-RSP message upon reception of HO-REQ message. The message  
61 shall be transmitted on the basic CID.  
62  
63  
64  
65



**Table 56ah—HO-RSP Message Format**

Syntax	Size	Notes
HO-RSP_Message_Format() {		
Management Message Type = ?	8 bits	
Estimated HO time	8 bits	
N_Recommended	8 bits	
For (j=0 ; j<N_NEIGHBORS ; j++) {		
Neighbor BS-ID	48 bits	
BS rating	8 bits	This parameter exists only when the message is sent by the BS
}		
}		

A BS or MSS shall generate HO-RSP messages in the format shown in . The following parameters shall be included in the HO-RSP message,

**Estimated HO time** – Estimated number of frames until the HO will 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

**BS rating** – This parameter exists only when the BS sends the HO-RSP message. The parameter indicates the relative level to which the target BS could meet the MSS QoS requirements. A value of zero in this parameter signifies that this parameter should be ignored.

#### 6.2.2.3.48 HO Indication (HO-IND) message

A MSS shall transmit a HO-IND message for final indication that it is about to perform a HO. The message shall be transmitted on the basic CID.

**Table 56ai—HO-IND Message Format**

Syntax	Size	Notes
HO_IND_Message_Format() {		
Management Message Type = ?	8 bits	
TLV Encoded Information	Variable	TLV specific
}		

1  
2  
3  
4 A MSS shall generate HO-IND messages in the format shown in . If Privacy is enabled, the HO-IND mes-  
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**HMAC Tuple** (see 11.4.10 in IEEE 802.16-2001) – The HMAC Tuple Attribute contains a keyed Message digest (to authenticate the sender).

## 6.2.16 Sleep-mode for mobility-supporting SS

### 6.2.16.1 Introduction

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

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

- Awake
- Sleep

When SS is in awake-mode, it is receiving and transmitting PDUs in a normal fashion. When 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**

A time duration, measured in whole frames, during which the SS, shall be able to demodulate downlink transmissions. 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 is agreed between the BS and the SS and is adjustable.

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 send notification to the SS in its awakening periods about whether data has been addressed for it.

A 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. A 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 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 SS 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 SS, the SS shall re-enter sleep-mode and 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.

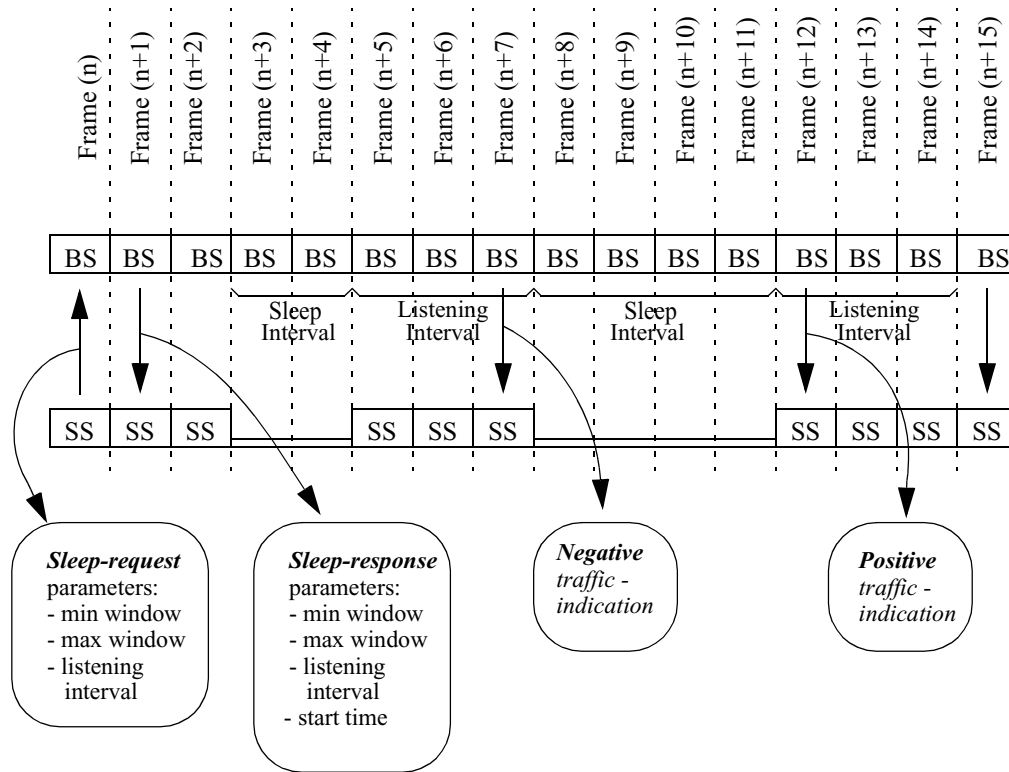
1 **6.2.16.3 Traffic indication signaling**

2  
3  
4 The BS shall indicate for each SS in sleep-mode, during its listening-interval, whether traffic has been  
5 addressed to it. The indication is sent on the TRF-IND broadcast message. The SS shall examine the frame  
6 number from the PHY Synchronization Field and shall verify it synchronization with the BS. If such syn-  
7 chronization is lost, i.e. expected frame number is different than found frame number, the SS shall return  
8 into awake mode.  
9

10  
11 If the SS did not find any TRF-IND message, or did not find any positive indication with it's CID in the  
12 TRF-IND, it shall consider this as a negative indication and shall return into sleep mode.  
13

14 **6.2.16.4 Example of sleep-mode operation**

15  
16 **Figure 59b1—Example of sleep-mode operation**



53 **6.2.17 Handoff Procedures for Mobility Support**

54  
55 **6.2.17.1 Network reference model**

56  
57 **6.2.17.1.1 Entities**

58  
59  
60 The network reference model consists of BS units covering a certain area, and connected by a backbone net-  
61 work. Several such networks, owned by different operators may coexist in the same service area. Each back-  
62 bone network may contain centralized AAA (Authorization, Authentication and Accounting), management,  
63 provisioning or other specialized servers. Specifically, those servers responsible for authentication and ser-  
64  
65

1 vice authorization are collectively referred to as ASA-server(s) and may be single, multiple, centralized or  
 2 distributed. The operation of these servers with the BS and MSS is specified to the extent of defining the  
 3 control messages.  
 4  
 5  
 6  
 7

8 **Table 75a—Mobility Related Entities**

Reference Point	Elements to be Specified by 802.16E
MSS	Mobile Subscriber Station, contains MAC (CS), PHY layers
BS	Base Station Sector: a single MAC entity covers a single sector. BS, at the network side, supports functionality similar to Foreign Agent of Mobile IP working in "foreign agent care-of address" mode.
ASA Server(s)	Authentication and Service Authorization Server servicing the whole operator's network. These servers are optional, and may be implemented as a distributed entity.

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 25 Figure 1: Network model example shows an example of such a network, where two networks operated by  
 26 different operators coexist in the same service area. BS #1 is the serving BS for the depicted MSS. BS #2  
 27 and BS #3 are neighbor BS. Should the depicted MSS move closer to BS #2, as drawn by dotted line BS #2  
 28 might be the target BS for an HO. Should the depicted MSS continue movement  
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**Figure 59b2—Network Model Example**

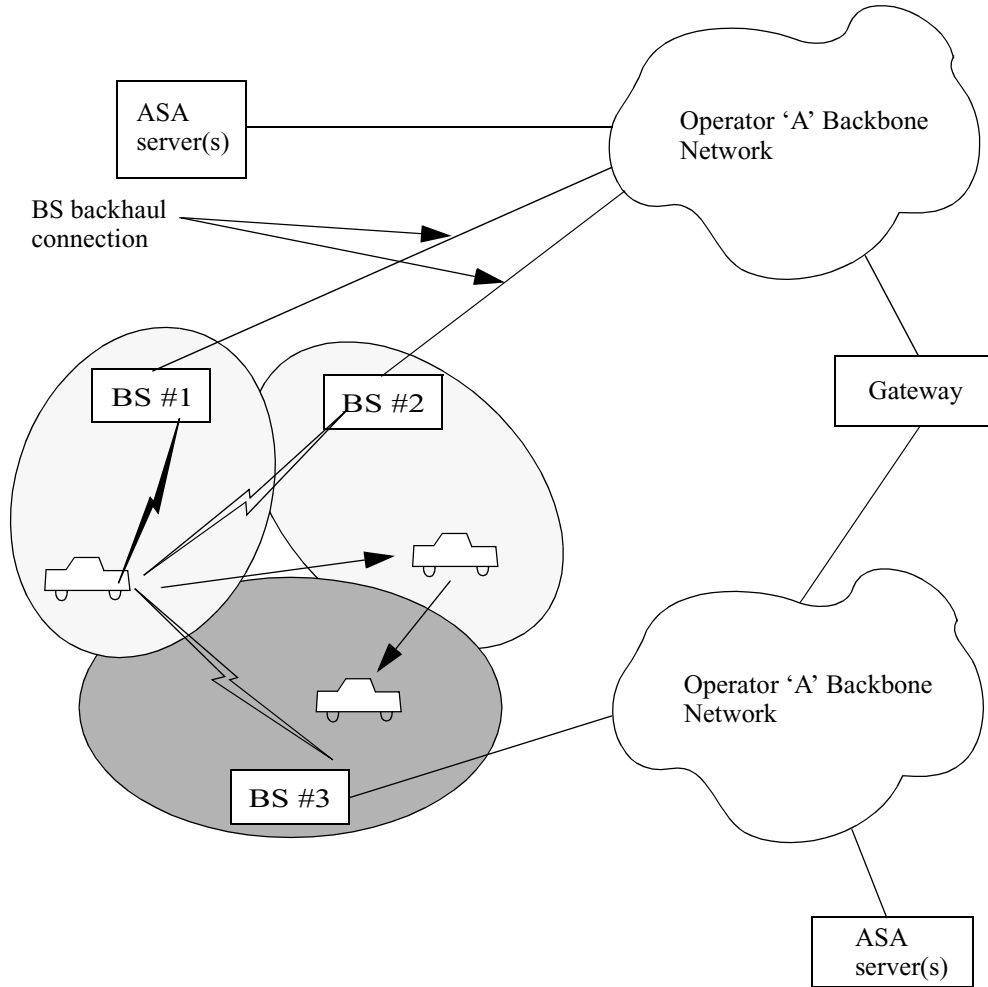
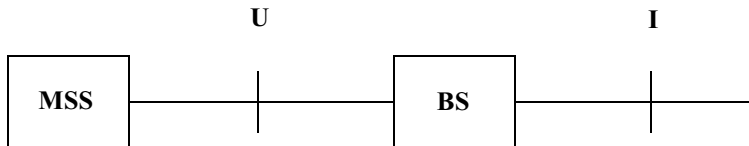


Figure 2: Network reference model, Data Plane shows the network reference model in the data plane.

**Figure 59b3—Network Reference Model - Data Plane**



The following reference points are present data plane network model,

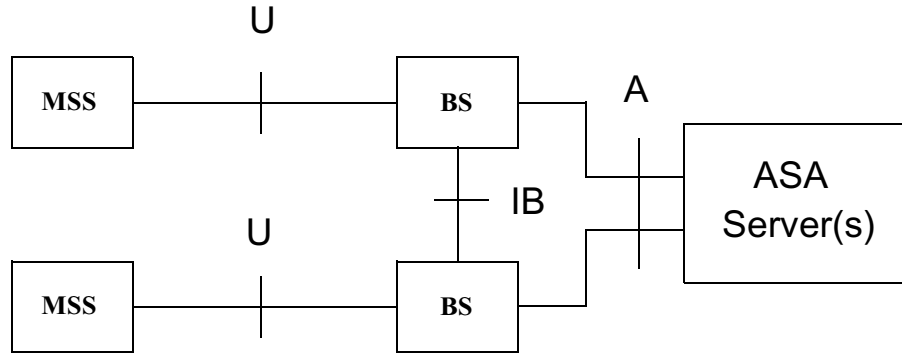
**Table 75b—Reference Points at Data Plane**

Reference Point	Elements to be Specified by 802.16E	Comments
U	PHY, MAC (including CS) operations	

I	None	This point corresponds to data backbone
---	------	---

Figure 3: Network reference model, Control Plane shows the network reference model in the control plane.

Figure 59b4—Network Reference Model, Control Plane



The following reference points are present at the control plane network model

Table 75c—Reference Points at Control Plane

Reference Point	Elements to be Specified by 802.16E	Comments
U	PHY, MAC (including CS) operations, Mobility Sub-layer messages exchange	
IB	BS-to-BS messages	Transport protocol is not specified
A	Messages serving MSS authentication and service authorization functions	Transport protocol is not specified

**Note:** In the case a BS is implemented as a set of BS controlled by a single central controller, IB reference point is located in the controller. This makes inter-cell and intra-cell HO indistinguishable.

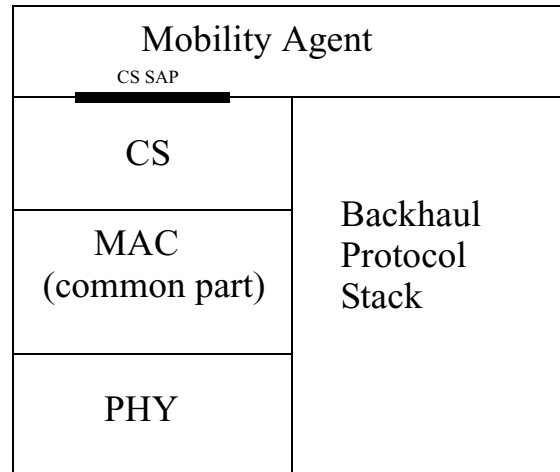
### 6.2.17.1.2 MSS Protocol Stack

No difference here compared to IEEE 802.16a standard.

### 6.2.17.1.3 BS Protocol Stack

The following picture displays BS protocol stack

**Figure 59b5—BS Protocol Stack**



#### 6.2.17.1.3.1 Mobility Agent (MA) Operations

In addition to regular 802.16 layers, the stack contains Mobility Agent (MA) layer. The functions of MA are similar to functions of Foreign Agent of Mobile IP working in "foreign agent care-of address" mode. Nevertheless, we avoid direct specification of Mobile IP as a protocol that implements mobility features from the backbone side.

MA provides the following functions,

- Termination of tunnel carrying data from MSS home network including de-capsulation of incoming data units

- Communication to CS about:

- After arrival of new MSS to the cell, creation of new connections. This includes

- Creation of new classifier(s) to forward data to the connections

- Specification of proper QoS per connection

- After MS departure, deletion of connections and classifiers

#### 6.2.17.1.4 MSS Service Context

*Network Service* is defined as a service provided to the MSS by the network through a single MAC connection with particular connectivity and MAC parameters (including QoS properties). Connectivity properties are defined by specification of MSS network address in its Home Network.

*MSS Service Context* specifies the set of network services authorized for a given MSS. It is composed of the following elements:

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**Table 75d—Mac Service Context**

Context Element	Meaning
MSS 48-bit MAC address unique identifier	48-bit unique identifier used by MSS on initial network. This ID does not change while MSS passes from one BS to another. During HO it is used to refer to specific connectivity (addressing) and properties of MAC connections (including QoS properties)
Number N of Network Service IEs	Number of Network Service Information Elements (NSIEs). Each SIE corresponds to a single data connection
N x NSIE	The structure of SIE is specified below
Number M of Security Association	Number M of Security Associations established for the MSS.
M x SAIE	TBD

**Table 75e—Service Information Element(SIE) Contents**

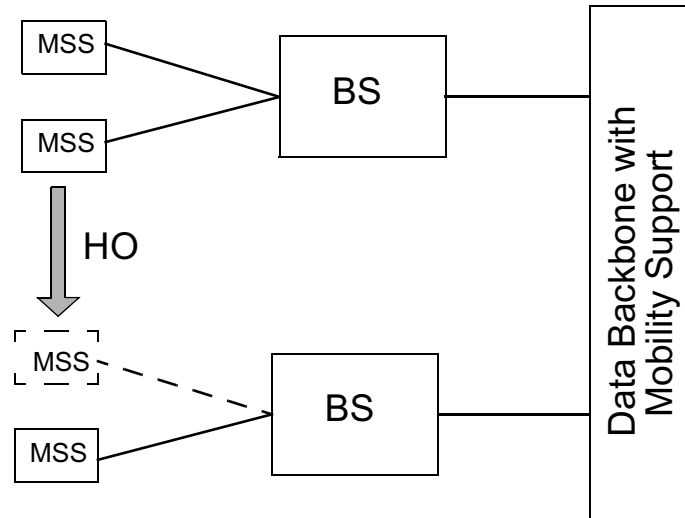
Field	Meaning
Address of MSS at Home Network	IP address of MSS at its Home Network. This address does not change while MSS travels from one BS to another. [?]

**Figure 59b6—Network Structure (control plane) and HO**



### 6.2.17.1.5 Transfer of Control Information During HO

Figure 59b7—Network Structure (data plane) and HO



### 6.2.17.2 MAC layer HO procedures

This section contains the procedures performed during HO on the air-interface.

#### 6.2.17.2.1 Network topology acquisition

##### 6.2.17.2.1.1 Network topology advertisement

A BS shall broadcast information about the network topology using the NBR-ADV MAC message. MSS may decode this message to find out information about the parameters of neighbor BS. Each MSS will thus be able to synchronize quickly with neighbor BS.

##### 6.2.17.2.1.2 MSS Scanning of neighbor BS

A BS may allocate time intervals to MSS for the purpose of seeking and monitoring neighbor BS suitability as targets for HO. Such a time interval will be referred to as a **scanning interval**.

A MSS may request an allocation of a scanning interval using the SCN-REQ MAC message. The MSS indicates in this message the duration of time it requires for the scan, based on its PHY capabilities.

Upon reception of this message, the BS shall respond with placement of a Scanning\_IE in the DL-MAP. The Scanning\_IE shall either grant the requesting MSS a scanning interval that is at least as long as requested by that MSS, or deny the request. The BS may also place unsolicited Scanning\_IE.

A MSS, upon detection of a Scanning\_IE addressed to it in the DL-MAP, shall use the allocated interval to seek for neighbor BS. When neighbor BS are identified, the MSS shall attempt to synchronize with their downlink transmissions, and estimate the quality of the PHY connection.

1 A MSS may use this interval for UL ranging as well to in a procedure is called **association**. When associat-  
2 ing with a neighbor BS, the MSS shall not only synchronize with neighbor BS downlink, but shall also per-  
3 form two additional stages called **association-initial-ranging** and **association-pre-registration**.  
4 Association-initial-ranging is performed by transmitting a RNG-REQ MAC message as specified in IEEE  
5 Std 802.16-2001 “Part 16: Air Interface for Fixed Broadband Wireless Access Systems” section 6.2.9.5 with  
6 the extensions specified in section Ranging Request/Response RNG-REQ/RSP. Upon reception of a RNG-  
7 RSP message with the **prediction of service level** parameter set to 2, the MSS marks the target BS as Asso-  
8 ciated. Information on Association is reported to the Serving BS. The target BS may store information on  
9 newly associated MSS. Association state of specific MSS at the BS shall be aged-out after ASC-AGING-  
10 TIMER timeout.  
11  
12

### 13 14 **6.2.17.2.2 HO process**

15  
16 The section defines the HO process in which a MSS migrates from the air-interface provided by one BS to  
17 the air-interface provided by another BS. The HO process belongs to the break-before-make type and con-  
18 sists of the following stages:  
19

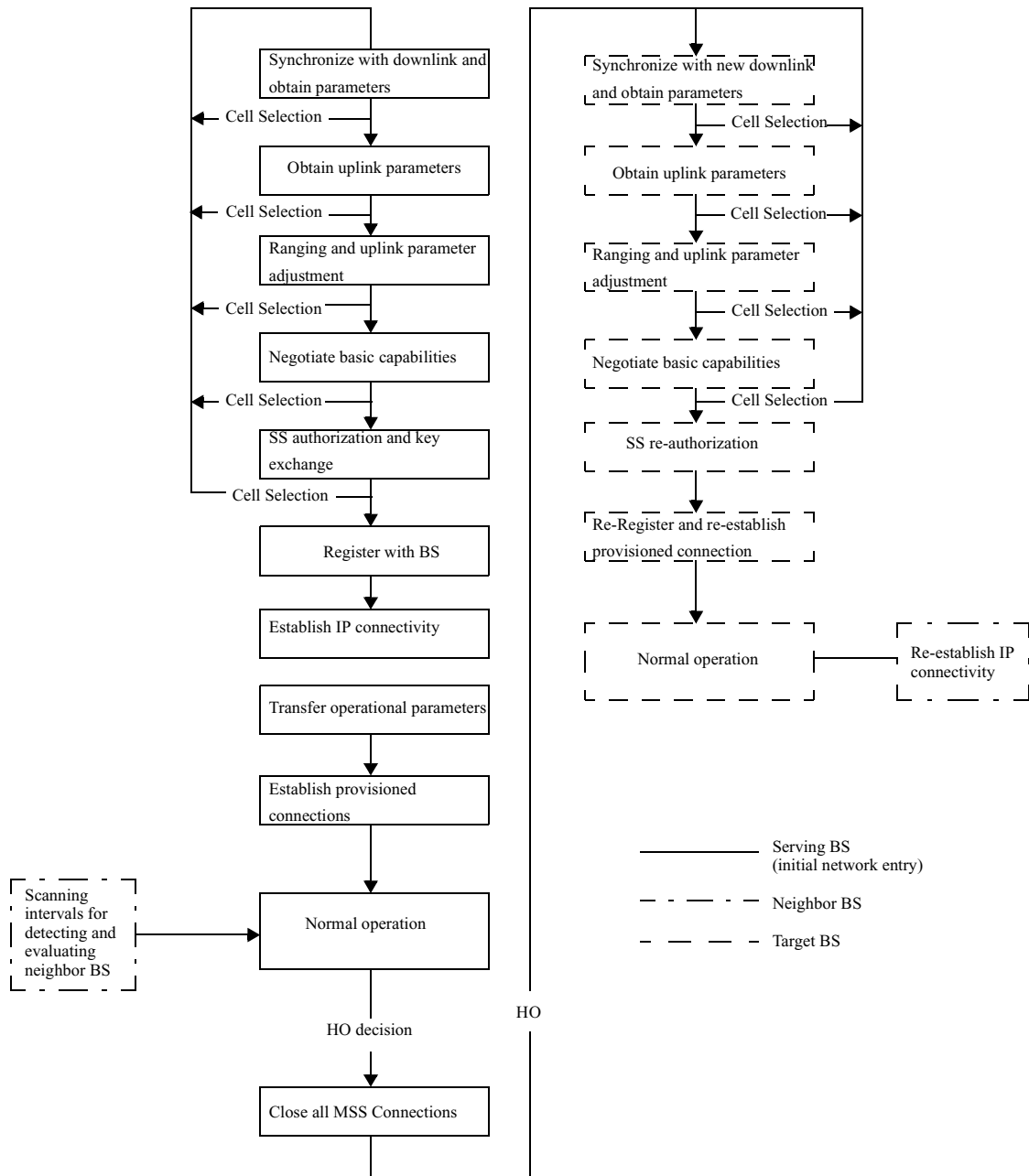
20  
21 HO initiation, the decision to start the process is taken  
22

23  
24 Termination of service with the serving BS, where all connections belonging to the MSS are terminated, and  
25 the context associated with them (i.e. information in queues, ARQ state-machine, counters, timers, etc.) is  
26 discarded  
27

28  
29 Network re-entry in target BS, where the MSS re-enters the network using a fast network entry procedure.  
30 After network re-entry, connection belonging to the MSS are re-established based on the availability of  
31 resources in the target BS.  
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33  
34 The HO process, and its similarity to the initial network entry process, is depicted in Figure 7: HO and initial  
35 network entry.  
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Figure 59b8—HO and Initial Network Entry

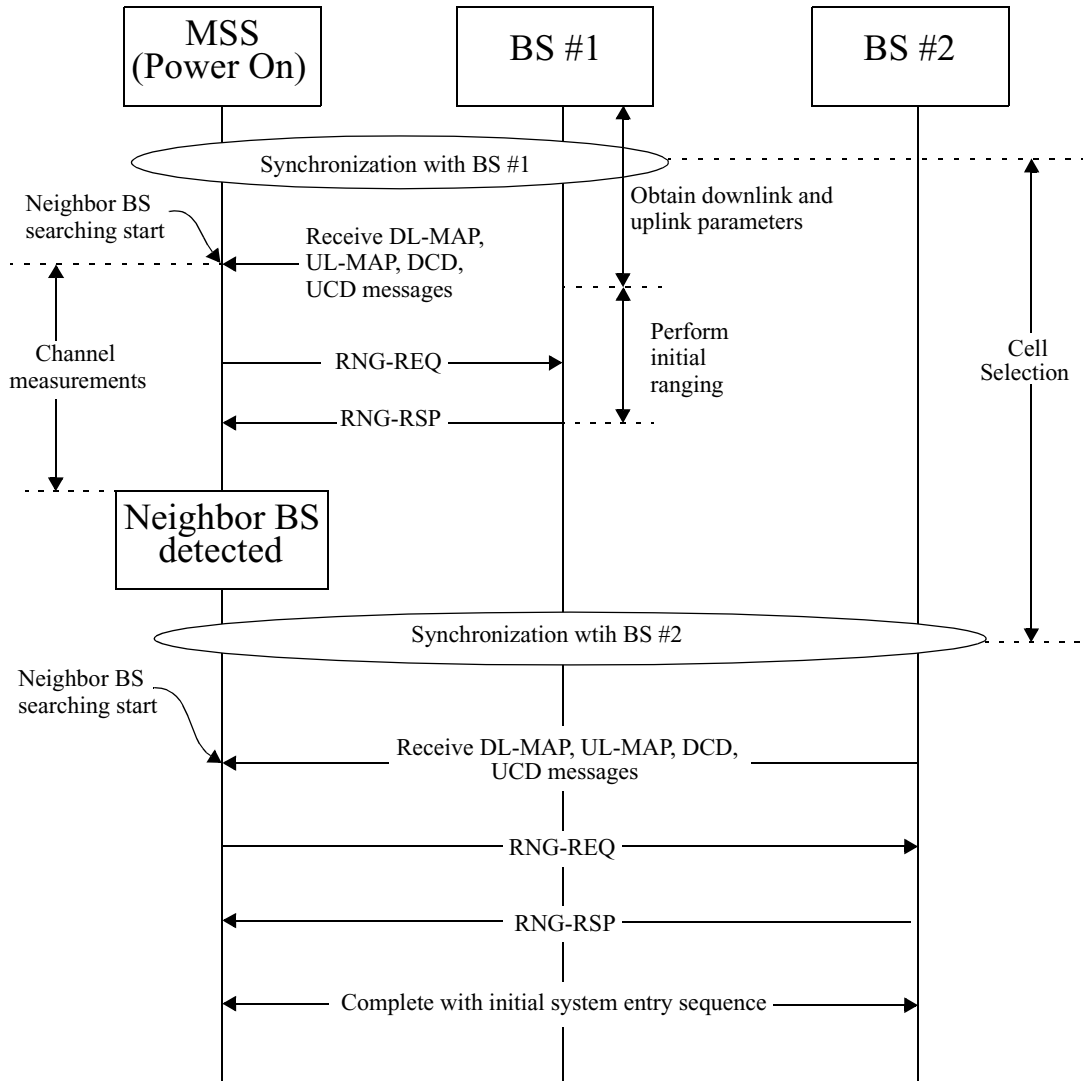


6.2.17.2.2.1 Cell Selection

Cell selection is a terminology use to refer to situations where a MSS leaves a BS before getting to the normal-operation state. Such procedure does not involve termination of existing connections and their re-opening in the target BS. A MSS may perform a cell selection if such an action is necessary with respect to its

PHY signal quality. In such a case the MSS shall restart the initial re-entry sequence or the HO sequence as applicable. No action is required from the BS during an cell selection.

Figure 59b9—Example of cell selection procedure



6.2.17.2.2.2 HO initiation

Either a MSS or a BS may initiate a HO by transmitting the MSSHO-REQ or BSHO-REQ MAC messages. It is anticipated that in most situations the MSS will be the initiator of the HO, but sometimes a BS may be the initiator of a HO to facilitate load sharing among BS.

When MSSHO-REQ is sent by a MSS, the MSS may indicate possible target BS (from signal quality point of view). When sent by a BS, the BS may indicate the recommended target BS (based on their capability to

1 meet the MSS QoS requirements). The MSSHO-REQ message may include an indication of the estimated  
2 time for performing the HO.  
3

4 At the BS side, before sending BSHO-REQ or after receiving a MSSHO-REQ message, the BS shall notify  
5 neighboring BS through the backbone of the HO request. The BS shall further acquire from the neighbor BS  
6 information regarding their capability of serving the requesting MSS. See section Ranging Request/  
7 Response RNG-REQ/RSP for specification of the communication through the backbone network, and the  
8 information exchanged between BS.  
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14 After receiving MSSHO-REQ or BSHO-REQ message, the receiving party shall respond with a HO-RSP  
15 MAC message. When sent by a BS, the HO-RSP message may indicate a recommended target BS. The  
16 MSS, at the risk that if it chooses an alternative target BS, it might receive a degraded level of service, may  
17 ignore this recommendation (this includes staying with its serving BS, i.e. skipping the HO). The HO-RSP  
18 message may also includes an estimation of the time when the HO would take.  
19

#### 20 21 **6.2.17.2.3 Termination with the serving BS** 22

23  
24 After the [MSS/BS]HO-REQ/HO-RSP handshake is completed, the MSS may begin the actual HO. This is  
25 done by sending a HO-IND MAC message.  
26

27 Upon reception of a HO-IND MAC message, the BS may close all connections and discard MAC state  
28 machines and MPDUs associated with the MSS.  
29

#### 30 31 **6.2.17.2.3 Drops and corrupted HO attempts** 32

33 A drop is defined as the situation where a MSS has stopped communication with its serving BS (either in the  
34 downlink, or in the uplink) before the normal HO sequence outlined in Cell Selection and Termination with  
35 the serving BS has been completed.  
36

37  
38 A MSS can detect a drop by its failure to demodulate the downlink, or by exceeding the RNG-REQ retries  
39 limit allowed for the periodic ranging mechanism. A BS can detect a drop by exceeding the RNG-REQ  
40 retries limit allowed for the periodic ranging mechanism.  
41

42  
43 When the MSS has detected a drop, it shall attempt network re-entry with its preferred target BS as outlined  
44 in section Re-entry with the target BS. When the BS has detected a drop, it shall react as if a HO-IND MAC  
45 message has been received from the dropped MSS.  
46

#### 47 48 **6.2.17.2.3.1 Re-entry with the target BS** 49

50 When re-entry with the target BS takes place, the target BS as well as all neighbor BS are aware of the HO in  
51 progress (except in a drop situation). At re-entry, the MSS performs the steps as shown in Figure 7: HO and  
52 initial network entry.  
53

#### 54 55 56 57 **6.2.17.2.3.1.1 Synchronize with downlink and obtain parameters** 58

59 For MSS that have used their scanning interval to synchronize with target BS and have decoded the NBR-  
60 ADV message, this stage should be immediate. In other situations this procedure defaults to the one speci-  
61 fied for initial network entry.  
62  
63  
64  
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#### 6.2.17.2.3.1.2 Obtain uplink parameters

For MSS that have decoded the NBR-ADV message, this stage should be immediate. In other situations this procedure defaults to the one specified for initial network entry.

#### 6.2.17.2.3.1.3 Ranging and uplink parameters adjustment

For MSS that have used their scanning interval to do UL ranging with target BS this stage should be immediate. Otherwise, this stage is similar to the one performed at initial network entry. During this stage the MSS is assigned a new basic and primary management CID in the target BS.

As opposed to initial network entry, where this stage is performed on contention basis, here the ranging opportunity may be allocated individually by the BS based on a MSS 48-bit MAC address identifier. This identifier is forwarded to the target BS via the backbone network (see section Backbone network HO procedures). This 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.

#### 6.2.17.2.3.1.4 Negotiate basic capabilities

This stage is identical to the one performed during initial network entry.

#### 6.2.17.2.3.1.5 MSS re-authorization

During this stage the MSS performs the re-authorization part of the PKM protocol used at initial network entry (see IEEE Std 802.16-2001 “Part 16: Air Interface for Fixed Broadband Wireless Access Systems” section 7.2). The BS authenticates the user and as the security context has not changed (it is transferred from the old BS via backbone, see section Backbone network HO procedures) the security sub-layer can continue in normal operation.

[More details should be provided here]

#### 6.2.17.2.3.1.6 Re-register and re-establish provisioned connections

This stage is equivalent to several stages performed during initial network entry. In this stage the MSS re-registers with the BS, and receives on the registration response a conversion table that maps the connections it had with its previous serving BS to a new set of connections on the current serving BS. In doing so, the MSS skips the **establish-IP-connectivity** stage, where it is assigned an IP address for management purposes. This stage is not really skipped during HO, instead it is postponed until the normal-operation stage is reached. The **transfer-operational-parameters** and the **time-of-day establishment** stage are skipped as none of the information contained in the configuration file, nor the time-of-day is expected to change. The MSS attempts the re-registration by sending the normal REG-REQ MAC message. At this stage the MSS has already provides its 48-bit MAC address identifier, and the BS can recognize that the MSS is per-

forming a HO. The BS REG-RSP shall therefore include TLV values for re-establishing the provisioned connections (see section REG-RSP TLVs for connection re-establishment).

**6.2.17.2.3.1.7 Commence Normal Operation**

At this stage, normal operation commences. The MSS shall re-establish its IP connectivity as specified at initial network entry. Figure <INSERT HERE> shows how a complete HO process might look like in the time domain.

**6.2.17.2.4 HO completion**

[This section should discuss the following:  
 Post HO operations (mostly applicable if make-before-break HO is supported)  
 ]

**6.2.17.3 Setup and negotiations**

[This section should discuss the following:  
 - Setup and negotiation procedures related to the HO  
 - PHY dependent parameters and associated handshake  
 - The model for coexistence of fixed and mobile-SS on the same air-interface instance

*[Insert the following text after section 8.3.1.4.5.2]*

**8.3.1.4.5.2.1 Scanning Information Element**

A Scanning\_IE shall be placed in the DL-MAP message by a BS in response to an SCN-REQ message sent by a MSS. The Scanning\_IE shall be placed in the extend DIUC (extension code = ?) within a DL-MAP IE. A value of zero in the Scan Duration field shall be interpreted as denial of the SCN-REQ. A BS may also send an unsolicited Scanning\_IE.

The format of the IE is PHY dependent as shown in <table>.

**Table 116w1—Scanning IE Format**

Syntax	Size	Notes
Scanning_IE {		
CID	16 bits	MSS basic CID
Scan Start	22 bits	Offset (in units of mini-slots) to the start of the scanning interval from the mini-slot boundary specified by the downlink Allocation_Start_Time
Scan Duration	22 bits	Duration (in units of mini-slots) where the MSS may scan for neighbor BS.
}		

[Insert the following after section 8.3.1.4.5.3]

### 8.3.1.4.5.3.1 Fast ranging (Paging) Information Element

A Fast\_UL\_ranging\_IE may be placed in the UL-MAP message by a BS to provide a non-contention based initial-ranging opportunity. The Fast\_UL\_ranging\_IE shall be placed in the extend UIUC (extension code = ?) within a UL-MAP IE.

The format of the IE is PHY dependent as shown in .

**Table 116z1—Fast UL Ranging Format IE: SCa PHY**

Syntax	Size	Notes
Fast_UL_ranging_IE {		
MAC address	48 bits	MSS MAC address as provided on the RNG_REQ message on initial system entry
UIUC	4 bits	UIUC $\neq$ 15. A four-bit code used to define the type of uplink access and the burst type associated with that access.
Offset	12 bits	Indicates the start time, in units of minislots, of the burst relative to the Allocation Start Time given in the UL-MAP message. The time instants indicated by offsets are the transmission times of the first symbol of the burst including preamble.
Reserved	4 bits	
}		

[Insert the following after section 8.4.4.3.5]

### 8.4.4.3.6 Fast ranging (Paging) Information Element

A Fast\_UL\_ranging\_IE may be placed in the UL-MAP message by a BS to provide a non-contention based initial-ranging opportunity. The Fast\_UL\_ranging\_IE shall be placed in the extend UIUC (extension code = ?) within a UL-MAP IE.

The format of the IE is PHY dependent as shown in .

**Table 116ao1—Fast UL Ranging Format IE: OFDM PHY**

Syntax	Size	Notes
Fast_UL_ranging_IE {		
MAC address	48 bits	MSS MAC address as provided on the RNG_REQ message on initial system entry



UIUC	4 bits	UIUC ≠ 15. UIUC ≠ 4. A four-bit code used to define the type of uplink access and the burst type associated with that access.
Duration	12 bits	The Duration indicates the length, in units of OFDM symbols, of the allocation. The start time of the first allocation shall be the Allocation Start Time given in the UL-MAP message.
Reserved	4 bits	
}		

[Insert the following text after 8.4.5.2.4]

**8.4.5.2.5 Scanning Information Element**

A Scanning\_IE shall be placed in the DL-MAP message by a BS in response to an SCN-REQ message sent by a MSS. The Scanning\_IE shall be placed in the extend DIUC (extension code = ?) within a DL-MAP IE. A value of zero in the Scan Duration field shall be interpreted as denial of the SCN-REQ. A BS may also send an unsolicited Scanning\_IE.

The format of the IE is PHY dependent as shown in <table>.

**Table 116aw1—Scanning IE Format**

Syntax	Size	Notes
Scanning_IE {		
CID	16 bits	MSS basic CID
Scan Start	18 bits	Indicates the scanning interval start time, in units of OFDM symbol duration, relative to the start of the first symbol of the PHY PDU (including preamble) where the DL-MAP message is transmitted.
Scan Duration	18 bits	Duration (in units of OFDM symbols) where the MSS may scan for neighbor BS.
}		

[Insert after section 8.5.1.1]

**8.5.1.2 System aspects**

There are several deployment scenarios for the OFDMA mode, the two major types are:

- Multi Cell Multi Frequency Network (MFN)
- Multi Cell Single Frequency Network (SFN)

The first option is the regular multi-cell with different frequencies allocated to each sector. Another possibility in OFDMA is to work with the SFN option, which means that each sector would use a logical entity of Sub-Channels (which will include several sub-channels). SFN allows the usage of a single channel to be

1 divided into logical entities, rather than splitting into smaller physical units, this way the frequency diver-  
2 sity of each logical entity still has the same properties as the basic channel.  
3

4 The key features of using the SFN architecture are:  
5

- 6 — ·Bandwidth sharing between sectors
- 7 — ·Flexible deployment, without the need to change RF components.
- 8 — ·Capacity increase in a multi sector configuration (by using the same principles as CDMA)
- 9 — ·Easy extension of existing deployments
- 10 — ·Faster handoffs
- 11 — ·Soft handoff possibility without the need to switch RF channels
- 12 — ·Frequency diversity
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19 The PHY layer supports this splitting seamlessly, but has to be aware that:  
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- 21 — ·Not all sub-channels might be used in the logical channel.  
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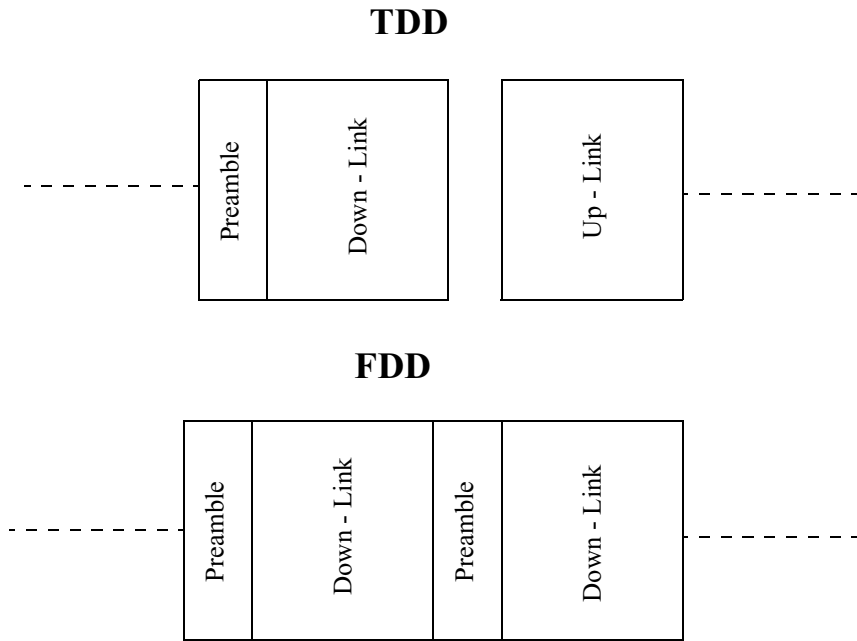
26 *[Insert after section 8.5.4.2]*  
27

### 28 **8.5.4.3 Preamble only signal** 29

30  
31 A preamble only symbol shall be added to the DL transmission; this preamble shall be located before the  
32 first the frame preamble (defined in section 8.5.9.4.3.1) as shown in Figure xxx: Preamble Location within  
33 the frame transmission in TDD/FDD. This preamble could be used in a multi-cell deployment for estima-  
34 tion, relative location calculation between base-stations and knowledge about the reception power and qual-  
35 ity of the surrounding base-stations.  
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**Figure 128av1—Preamble Location within the frame transmission in TDD/FDD**

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The preamble will be transmitted on the carrier indices that obey the following formula:

$$PN_{ID} = UsedCarriers_{mod(6)}$$

(65a)

where:

- $PN_{ID}$   
An integer 0-5, setting the carriers location and PN sequence used
- $UsedCarriers$   
The indices of the carrier to modulate

As can be noticed from the formula for which  $PN_{ID}$  differs in their modulo 6 calculation we have 6 different preambles, this will allow to work in a 6 sector deployment with each sector transmitting different preambles even for a single frequency deployment.

The modulation of the pilots shall be set accordingly to section 8.5.9.4.3, the initialization of the PRBS shall be set according to the following table:

**Table 116bi1—PRBS Initialization**

$PN_{ID}$	PRBS Initialization
0	[1111111111]
1	[00011101010]
2	[11001010111]
3	[10111000101]
4	[01010100011]
5	[01110001100]

The modulation of the pilots in the frame preamble specified in section 8.5.9.4.3.1 shall be set according to the following table:

**Table 116bi2—Pilot Modulation**

$PN_{ID}$	PRBS Initialization
0	[01010101010]
1	[00011101010]
2	[10011010011]
3	[01000101010]
4	[11100100011]
5	[00111001111]

*[Insert after section 8.5.4.6]*

#### **8.5.4.7 Logical channels (for 802.16e)**

When the SFN scheme is deployed, each sector may be allocated with a different set of sub-channels as the usable resource.

The set of sub-channels, which is allocated to each BS, shall be referred as *Logical Channel*.

Each BS shall be allocated with a specific logical channel through the management layer.

The allocation of logical channels to the BSs may be dynamic and can be dependent of the current load distribution within the cell, i.e. if BS<sub>1</sub> does not have many registered SSSs, while BS<sub>2</sub> approaching it's maximum capacity with current allocation, then the sub-channels can be moved from BS<sub>1</sub>'s logical channel to BS<sub>2</sub> logical channel.

*[In section 8.5.5.2 DL-MAP Information Element format:]*

Change number of bits of **OFDM Symbol offset** field from 10 to 9.

1 Change number of bits of **Boosting**<sup>1</sup> field from 2 to 3.

2  
3 Changed the possible values of the **Boosting** field as follows: 000: normal (not boosted); 001: +3dB; 010:  
4 +6dB; 011: +9dB; 100: -3dB; 101: -6dB; 110: -9dB; 111: -12dB;

5  
6  
7 *[Insert after section 8.5.5.2]*

8  
9 **8.5.5.2.1 DL-MAP information IE**

10  
11 The mini sub-channel Numbering shall be done as follows:

12  
13  
14 **Table 116bm1—OFDMA DL-MAP Information Element format**

15  
16

Syntax	Size	Notes
DL-Map_Information_Element() {		
DIUC	4 bits	
if (DIUC == 15) {		
Extended DIUC dependent IE	Variable	AAS_DL_IE()
} else {		
OFDM Symbol offset	8 bits	
Subchannel offset	5 bits	
Boosting	3 bits	000: normal (not boosted); 001: +6dB; 010: -6dB; 011: +9dB; 100: +3dB; 101: -3dB; 110: -9dB; 111: -12dB;
No. OFDM Symbols	8 bits	
No. Subchannels	5 bits	
Mini_Subchannel index	3 bits	000 – no mini subchannels used; 001 – mini subchannel 1 is allocated 010 – mini subchannel 2 is allocated 011 – mini subchannel 3 is allocated 100 – mini subchannel 4 is allocated 101 – mini subchannel 5 is allocated 110,111 – reserved
}		
}		

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54 *[Insert the following text after 8.5.5.2.3]*

55  
56 **8.5.5.2.4 Scanning Information Element**

57  
58 A Scanning\_IE shall be placed in the DL-MAP message by a BS in response to an SCN-REQ message sent  
59 by a MSS. The Scanning\_IE shall be placed in the extend DIUC (extension code = ?) within a DL-MAP IE.

60  
61  
62  
63  
64 <sup>1</sup>\* This field should be moved from UL-MAP IE to DL-MAP IE due to an editorial error, and should be fixed in the  
65 errata process.

A value of zero in the Scan Duration field shall be interpreted as denial of the SCN-REQ. A BS may also send an unsolicited Scanning\_IE.

The format of the IE is PHY dependent as shown in <table>.

**Table 116bo1—OFDMA PHY Parameters**

Syntax	Size	Notes
Scanning_IE {		
CID	16 bits	MSS basic CID
Scan Start	18 bits	The offset of the OFDM symbol in which the scanning interval starts. Measured in OFDM symbols from the time specified by the Allocation_Start_time field in the DL-MAP
Scan Duration	18 bits	Duration (in units of OFDM symbols) where the MSS may scan for neighbor BS.
}		

Table 8: Scanning\_IE format

*[Insert after section 8.5.5.3]*

**8.5.5.3.1 UL-MAP information IE**

The mini sub-channel Numbering shall be done as follows:

**Table 116bq1—OFDMA UL-MAP Information Element format**

Syntax	Size	Notes
UL-Map_Information_Element() {		
CID	16 bits	
UIUC	4 bits	
if (UIUC == 4) {		
CDMA_Allocation_IE()	52 bits	
} Else if (UIUC == 15) {		
Extended UIUC dependent IE	Variable	Power_Control_IE() or AAS_UL_IE()
} else {		
OFDM Symbol offset	10 bits	
Subchannel offset	6 bits	
No. OFDM Symbols	8 bits	

No. Subchannels	5 bits	
Mini_Subchannel index	3 bits	000 – no mini subchannels used; 001 – mini subchannel 1 is allocated 010 – mini subchannel 2 is allocated 011 – mini subchannel 3 is allocated 100 – mini subchannel 4 is allocated 101 – mini subchannel 5 is allocated 110,111 – reserved
}		
}		

*[Insert the following after section 8.5.5.3.4]*

**8.5.5.3.5 Fast ranging (Paging) Information Element**

A Fast\_UL\_ranging\_IE may be placed in the UL-MAP message by a BS to provide a non-contention based initial-ranging opportunity. The Fast\_UL\_ranging\_IE shall be placed in the extend UIUC (extension code = ?) within a UL-MAP IE.

The format of the IE is PHY dependent as shown in .

**Table 116bt1—Fast UL Ranging Format IE: OFDMA PHY**

Syntax	Size	Notes
Fast_UL_ranging_IE {		
MAC address	48 bits	MSS MAC address as provided on the RNG_REQ message on initial system entry
UIUC	4 bits	UIUC ≠ 15. A four-bit code used to define the type of uplink access and the burst type associated with that access.
OFDM Symbol offset	10 bits	The offset of the OFDM symbol in which the burst starts, the offset value is defined in units of OFDM symbols and is relevant to the Allocation Start Time field given in the UL-MAP message.
Subchannel offset	6 bits	The lowest index OFDMA subchannel used for carrying the burst, starting from subchannel 0.
No. OFDM Symbols	10 bits	The number of OFDM symbols that are used to carry the UL Burst
No. Subchannels	6 bits	The number OFDMA subchannels with subsequent indexes, used to carry the burst.
Reserved	4 bits	
CID	16 bits	MSS basic CID
}		

*[Insert after section 8.5.5.3.4]*

### 8.5.5.3.5 UL-MAP Fast tracking indication

The UL-MAP Fast Indication in an UL-MAP entry used to provide fast power, time and frequency indications\corrections to SS that have transmitted in the previous frame.

The extended UIUC=15 shall be used for this IE with sub-code 0x03

The CID used in the Information Element should be a broadcast CID.

**Table 116bt2—UL fast tracking Information Element**

Syntax	Size	Notes
UL_Fast_tracking_IE() {		
extended UIUC	4 bit s	Fast-Indication = 0x03
Number of Elements	8 bit s	Number of Fast Indication bytes
for ( $i = 1; i \leq n; i++$ ) {		For each Fast Indication bytes 1 to n ( $n$ =Number of Element field)
Power correction	2	Power correction indication, 00: no change; 01: +2dB; 10: -1dB; 11: -2dB
Frequency correction	4	Frequency correction. Units are PHY-specific  For OFDM/OFDMA: The correction is 0.1% of the carrier spacing multiplied by the 4-bit number interpreted as a signed integer (i.e. 1000: -8; ... 0000: 0; ... 0111: 7)
Time correction	2	Time offset correction. Units are PHY-specific  For OFDM/OFDMA: The correction is $\text{floor}(2 / F_s)$ multiplied by, 00: 0; 01: 1; 10: -1; 11: Not used
}		





The UL Fast tracking IE is an optional field in the UL\_MAP. When this IE is sent it provides an indication about corrections that should be applied by SS that have transmitted in the pervious UL frame. Each Indication byte shall correspond to one unicast allocation-IE that has indicated an allocation of an uplink transmission slot in the previous UL\_MAP. The order of the indication bytes shall be the same as the order of the unicast allocation-IE in the UL-MAP.

*[Insert after section 8.5.6.1.2]*

#### 8.5.6.4 Mini Sub-Channels (for 802.16e)

The OFDMA Sub-Channel shall be further divided into smaller granularity mini Sub-Channels in order to gain more power concentration and better granularity.

##### 8.5.6.4.1 DL Mini Sub-Channels

The regular Sub-Channel in the DL shall be further divided into 6 mini sub-channels. The regular sub-channel includes 48 data carriers, and a burst consists 3 time symbols, in order to keep backward compatibility and not change the frame structure the mini sub-channel will consists 8 carriers and a mini burst will consist 3 time symbol, this will give us a total of 24 data carriers per burst (1/6 the granularity of a regular burst).

The formula that defines what are the carrier indices allocated to a mini sub-channel out from the regular sub-channel:

$$mCarrier[j, k, i] = Carrier[6j + k, i]$$

where:

$mCarrier[j, k, i]$  defines carrier  $j$  of mini sub-channel  $k$  within subchannel  $i$ ,  
 $carrier[x, y]$  defines carrier  $x$  of sub-channel  $y$ , as defined in 8.5.6.1.2.

This structure enables each mini sub-channel to have the best frequency diversity, but still maintain a simple derivation from the regular sub-channel.

The usage of regular sub-channels and mini sub-channels is allowed in the system and therefore coexistence with 802.16a user is possible (a sub-channel that is divided into mini sub-channels will be used only in this structure).

##### 8.5.6.4.2 UL Mini Sub-Channels

The regular Sub-Channel in the UL shall be further divided into 5 mini sub-channels. The 53 carriers of the regular sub-channel will be divided into 3 mini sub-channels each including 11 carriers and another 2 mini sub-channels each including 10 carriers.

The carriers which obey the following formula, are allocated to one mini sub-channel:

$$Carrier[j, i]_{mod(5)} = k$$

where:

*Carrier[j, i]* defines carrier *j* of subchannel *i* as defined in 8.5.6.1.2

*k* defines mini sub-channel *k*.

The structure of the mini sub-channel includes 8 data carriers and 2/3 pilot carriers.

Figure 2: Mini Sub-Channel organization and structure depicts the mini sub-channel organization and structure.

**Figure 128bb1—Mini Sub-Channel Organization and Structure**



The structure proposed will enable a module 5 frame structure, with maximum frequency diversity.

**8.5.6.4.3 Randomization**

The randomization procedure will be performed as specified in section 8.5.9.1, with the same randomization procedure. The Sub-Channel offset, which sets the 6 LSB bits of the randomizer, shall be the 6 LSB bits of the mini Sub-Channel numbering.

**8.5.6.4.4 FEC**

The FEC option proposed shall include CTC and performed per mini burst, with the following options (and performed as described in section 8.5.9.2.3):

**Table 116by1—FEC Options**

Modulation	Data Block Size (Bytes)	Coded Block Size (Bytes)	Code Rate	N	P0		
QPSK	3	6	–				
QPSK	4.5	6	–				

...

16QAM	6	12	–					
16QAM	9	12	–					
64QAM	9	18	2/3					
64QAM	13.5	18	–					

#### 8.5.6.4.5 Interleaving

The interleaving shall be performed per mini burst, as described in section 8.5.9.3.

The parameters for the interleaver are:

**Table 116by2—Interleaving**

Modulation	Coded Bits Per Block (Ncbps)	Modulo used (d)
QPSK	48	16
16QAM	96	18
64QAM	144	16

#### 8.5.6.4.6 Modulation

As described in section 8.5.9.4.

#### 8.5.6.4.7 Pilots Modulation

The modulation of the pilots shall be set accordingly to section 8.5.9.4.3, the initialization of the PRBS shall be set according to the following table:

**Table 116by3—PRBS Initialization**

$PN_{ID}$	PRBS Initialization
0	[1111111111]
1	[00011101010]
2	[11001010111]
3	[10111000101]
4	[01010100011]
5	[01110001100]

The modulation of the pilots in the frame preamble specified in section 8.5.9.4.3.1 shall be set according to the following table:

**Table 116by4—Frame Preamble Pilot Modulation**

<i>PN<sub>ID</sub></i>	PRBS Initialization
0	[01010101010]
1	[00011101010]
2	[10011010011]
3	[01000101010]
4	[11100100011]
5	[00111001111]

**10.1 Global Values**

Add the following values to table 118:

**Table 118a1—Parameters and Constants**

System	Name	Time Reference	Minimum Value	Default Value	Maximum Value
SS	Min_Sleep_Interval	Minimum sleeping time allowed to SS	2ms		
SS	Max_Sleep_Interval	Maximum sleeping time allowed to SS			5s
SS	Listening_Interval	The time duration during which the SS, after waking up and synchronizing with the DL transmissions, can demodulate downlink transmissions and decides whether to stay awake or go back to sleep			

*[Add the following values to table 118a]*

**Table 118a2—Parameters and Constants**

System	Name	Time reference	Min. value	Default value	Max value
BS	NBR-ADV interval	Nominal time between transmission of NBR-ADV messages			1s
BS	ASC-AGING-TIMER	Nominal time for aging of MSS associations	0.1s		

1  
2  
3 **10.1.0.1 Ranging Request/Response RNG-REQ/RSP**  
4

5  
6 **11.1.4 REG-RSP TLVs for connection re-establishment**  
7

8 *[Add the following rows to table 127a]*  
9

10  
11  
12 **Table 127b—REG-RSP Encodings**

Name	Type (1 byte)	Length (1 byte)	Value (Variable-length)
CID_update	?	16-bits	CID in the previous serving BS
		16-bits	Replacement CID in the current serving BS
Connection_Info	?	Variable	The Connection_Info is a compound TLV value that encapsulates the <b>Service Flow Parameters</b> and the <b>CS Parameter Encodings</b> TLVs allowed on the DSA-RSP message. All the rules and settings that apply to the TLVs when used in the DSA-RSP message apply to the contents encapsulated in this TLV.

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31 *[Insert the following section after 11.1.6]*  
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33 **11.1.7 NBR-ADV Message Encodings**  
34

35  
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37  
38 **Table 127c—NBR-ADV Encodings**

Name	Type (1 byte)	Length (1 byte)	Value (Variable-length)
DCD_settings	?	Variable	The DCD_settings is a compound TLV that encapsulates an entire DCD message (excluding the generic MAC header). All the rules and settings that apply to the DCD message apply to the contents encapsulated in this TLV.
UCD_settings	?	Variable	The UCD_settings is a compound TLV value that encapsulates an entire UCD message (excluding the generic MAC header). All the rules and settings that apply to the UCD message apply to the contents encapsulated in this TLV.

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53 *[Insert a new Annex]*  
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# Annex C Backbone network HO procedures

[This section should contain the procedures performed on backbone to support HO such that BS from different manufacturers are interoperable. The section should address issues such as,

- Centralized HO controller and/or distributed decision
- The information that should be exchanged (Post-HO, Pre-HO and during HO)
- Information exchange model (publishing, on request, combined)
- The transport protocol to use
- Formal definition of the messages

]

## C.1 Backbone network services

The backbone network provides a backhaul transmission path to the BS, and may provide other services at the control plane level. shows a list of services provided to the BS through backbone network. Some of these services may be provided by other means (highlighted).

**Table C1—Backbone Network Services**

Service	Possible methods for providing service	Comments
Backhaul for traffic	-	Transport protocol is not specified
Provide a BS with the identity of its neighbors	Get info from ASA server Configuration (network management)	Options (1) and (2) are really the same, the only difference is where the configuration is done
Provide a BS with the identity of the ASA server	ASA server publishes its presence Configuration (network management)	Message format and transport protocol need to be specified for interoperability
Advertise the fact that a certain MSS has registered with a certain BS	BS notifies ASA server BS notifies neighbor BS	Message format and transport protocol need to be specified for interoperability
Provide a BS information about a certain MSS	ASA server provides information Serving BS provides information (or network management if serving BS cannot be found)	Message format and transport protocol need to be specified for interoperability
Information exchange during HO	ASA server is in the middle BS to BS direct exchange	Message format and transport protocol need to be specified for interoperability

As evident from , it is possible to exchange information between BS directly or through the ASA server. In that respect the protocol used for information exchange on the backbone can regard the ASA server as another BS, and therefore no special message will be required with regards to the ASA server.

## C.2 Backbone network communication primitives

The primitives described in this section may be used for communication with peer BS or with an ASA server through the backbone.

### C.2.1 I-am-host-of message

This message is sent by a BS to notify other BS (or the ASA server) that a certain MSS is registered with it. The message shall be sent upon MSS registration, and periodically (TBD period). The message might trigger a neighbor BS to request more information on the MSS (either directly from the sender BS, or from the ASA server). The message contains the following information,

**Table C2—I-am-host-of Message**

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
		ity records
		er used by MSS on initial network
		ate this message

erver) to request information about a  
an *I-am-host-of* message, or in cases  
e contains the following information,

#### Message

##### Notes

entifier (Same number as that broad-  
P message)

entifier (Same number as that broad-  
P message)

ds since midnight GMT (set to

y records

For (j=0; j<Num Records; j++) {

MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the <i>I-am-host-of</i> message)
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

### C.2.3 MSS-info-response message

This message may be sent from one BS to another (or from the ASA server) to provide information about a MSS. Typically the message will be sent in response to a *MSS-info-request* message. The message contains the following information,

**Table C4—MSS-info-response Message**

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)
Num Records	16-bit	Number of SS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the <i>I-am-host-of</i> message)
N_NSIE		Number of Network Service Information Elements
For (k=0; k<N_NSIE; k++) {		
Field Size	16-bit	Size of TLV encoded information field below
TLV encoded information	Variable	TLV information as allowed on a DSA-REQ MAC message
}		
N_SAIE		Number of Security Association Information Elements
For (k=0; k<N_SAIE; k++) {		
Field Size	16-bit	Size of TLV encoded information field below
TLV encoded information	Variable	TLV information as allowed on a PKM-xxx MAC messages
}		
Field Size	16-bit	Size of TLV encoded information field below
TLV encoded information	Variable	TLV information as allowed on a SBC-REQ MAC message



}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

## C.2.4 HO-notification message

This message is sent by a BS to advertise a MSS intention to perform HO. The message is typically sent to all neighbor BS. The message serves to alert the neighbor BS that a HO event is going to happen. The message contains the following information,

**Table C5—HO-notification Message**

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)
Num Records	16-bit	Number of MSS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the <i>I-am-host-of</i> message)
Estimated Time to HO	16-bit	In milliseconds, relative to the time stamp, value 0 of this parameter indicates that no actual HO is pending
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

## C.2.5 HO-notification-response message

This message is sent from one BS to another BS, typically in response to a *HO-notification* message. The message serves to provide the BS that sent the *HO-notification* message with information about the level of service the MSS could expect if it transitions to this BS. The message contains the following information,

**Table C6—HO-notification-response Message**

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)
Num Records	16-bit	Number of MSS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the <i>I-am-host-of</i> message)
QoS Estimate	8-bit	TBD
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

### C.2.6 Association-notification message

This message is sent from one BS to another BS, to report an association of a MSS. The message contains the following information,

**Table C7—Association-notification Message**

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)
Num Records	16-bit	Number of MSS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit universal MAC address of the MSS (as provided to the BS on the RNG-REQ message)
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

## **C.3 Backbone network communication protocol**

**TBD**

## **C.4 Convergence sub-layer HO procedures**

### **C.4.1 Supported convergence sub-layers**

[This section should discuss the types of convergence sub-layer that are supported (i.e. IPv4, IPv6, Ethernet, or others)]

### **C.4.2 SAP for higher layer protocols**

This section defines the services between the MAC and higher layers for supporting the HO process. In some scenarios the higher layers may use information provided by the MAC layer HO process to optimize their HO process and reduce the overall HO duration.

The information is defined as set of messages sent by the MAC layer to the higher layers, providing indication of particular events before and after MAC layer HO.

#### **C.4.2.1 MSS Movement**

Occurs at the MSS, indication that the MSS has registered to a new Target BS.

#### **C.4.2.2 Serving BS Pre-HO**

Occurs at the Serving BS, indication that a MAC layer HO of a certain MSS is about to take place.

#### **C.4.2.3 Target BS Pre-Ho**

Occurs at the Target BS, indication that a MAC layer HO of a certain MSS is about to take place.

#### **C.4.2.4 BS Post-HO**

Occurs at the Target BS or MSS, indication that a MAC layer HO between the MSS and the Target BS has been completed.

#### **C.4.2.5 Serving BS-Link Loss**

Occurs at the Serving BS, indication that MAC layer link between the Serving BS and a certain MSS has been lost.