

2003-04-14

IEEE 802.16e-03/07r1

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

3
 4
 5 **Part 16: Air Interface for Broadband**
 6 **Wireless Access Systems -**
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 10
 11 **Amendment 4: Mobility Enhancements**
 12
 13
 14
 15

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.

3
4
5
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.

59
60
61
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64
65 **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 0 = No service possible for this MSS
- 31 1 = Service requested (as determined by the 48-bit MSS MAC address) is available
- 32 2 = Service request at requested QoS level is available
- 33
- 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_updtac** – 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 **Connection_Info** – The Connection_Info is a compound TLV value that encapsulates the **Service Flow**
 48 **Parameters** and the **CS Parameter Encodings** TLVs allowed on the DSA-RSP. This TLV enables the new
 49 serving BS to renew a connection used in the previous serving BS, but with different QoS settings.
 50
 51

52 *[add the following new MAC messages after section 6.2.2.3.42]*
 53
 54

55 **6.2.2.3.43 Neighbor Advertisement (NBR-ADV) message**

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.

6.2.2.3.44 Scanning Interval Allocation Request (SCN-REQ) message

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

Table 56ae—SCN-REQ Message Format

| 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 |
| } | | |

A MSS shall generate SCN-REQ messages in the format shown in . The following parameters shall be included in the SCN-REQ message,

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

6.2.2.3.45 BS HO Request (BSHO-REQ) message

The BS may transmit a BSHO-REQ message when it wants to initiate an HO. The message shall be transmitted on the basic CID.

Table 56af—BSHO-REQ Message Format

| 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 | |
| } | | |
| } | | |

A BS shall generate BSHO-REQ messages in the format shown in . The following parameters shall be included in the BSHO-REQ 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 parameter shall be included,

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

6.2.2.3.46 MSS HO Request (MSSHO-REQ) message

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

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 | |
| } | | |
| } | | |

A MSS shall generate MSSHO-REQ messages in the format shown in . The following parameters shall be included in the MSSHO-REQ 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 S/(N + I) –This parameter indicates the signal to noise and interference ratio measured by the MSS from the particular BS. The value shall be interpreted as an unsigned byte with units of 0.25dB.

6.2.2.3.47 HO Response (HO-RSP) message

Either a MSS or a BS shall transmit an HO-RSP message upon reception of HO-REQ message. The message shall be transmitted on the basic CID.

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 A MSS shall generate HO-IND messages in the format shown in . If Privacy is enabled, the HO-IND mes-
4 s-
5 s-
6 s-
7 s-
8 s-
9 s-
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...
This is an IEEE 802.16 TGe working document.

7 **HMAC Tuple** (see 11.4.10 in IEEE 802.16-2001) – The HMAC Tuple Attribute contains a keyed Message
8 digest (to authenticate the sender).
9

13 **6.2.16 Sleep-mode for mobility-supporting SS**

15 **6.2.16.1 Introduction**

17 Sleep-mode is a mode in which SS supporting mobility may power down. Sleep-mode is intended to enable
18 mobility-supporting SS to minimize their energy usage while staying connected to the network. Implemen-
19 tation of power-save mode is optional.
20

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

- 25 Awake
- 26 Sleep

28 When SS is in awake-mode, it is receiving and transmitting PDUs in a normal fashion. When SS is in a
29 sleep-mode, it does not send or receive PDUs. In sleep-mode the SS may power down.
30

32 Two intervals are defined:

35 **Sleep-interval**

36 A time duration, measured in whole frames, where the SS is in sleep-mode. During consecutive
37 sleep periods the sleep-interval shall be updated using an exponentially increasing algorithm
38 with adjustable minimum and maximum limits.

39 **Listening-interval**

40 A time duration, measured in whole frames, during which the SS, shall be able to demodulate
41 downlink transmissions. During this interval the SS shall decide whether to stay awake or go
42 back to sleep based on an indication from the BS. The Listening-interval is agreed between the
43 BS and the SS and is adjustable.
44
45

46 Before entering sleep-mode the SS shall inform the BS and obtain its approval. The BS may buffer (or it
47 may drop) incoming PDUs addressed to the sleeping SS, and shall send notification to the SS in its awak-
48 ening periods about whether data has been addressed for it.
49

51 A SS shall awake according to the sleep-interval and check whether there were PDUs addressed for it. If
52 such PDUs exist, it shall remain awake. A SS may terminate sleep-mode and return to awake-mode anytime
53 (i.e. there is no need to wait until the sleep-interval is over). If the BS receives data from a SS that is sup-
54 posed to be in sleep-mode, the BS shall assume that the SS is no longer in sleep-mode.
55
56

57 **6.2.16.2 Sleep-interval update algorithm**

59 A SS shall enter sleep-mode after receiving an SLP-RSP message from the BS. In the first time it enters
60 sleep-mode, it shall use the min-window value for the sleep interval. If during the following listening inter-
61 val the BS has not signaled that traffic has been addressed for the SS, the SS shall re-enter sleep-mode an
62 double the duration of the sleep-interval. This procedure shall be repeated as long as the resulting sleep-
63 interval does not exceed the max-window value.
64
65

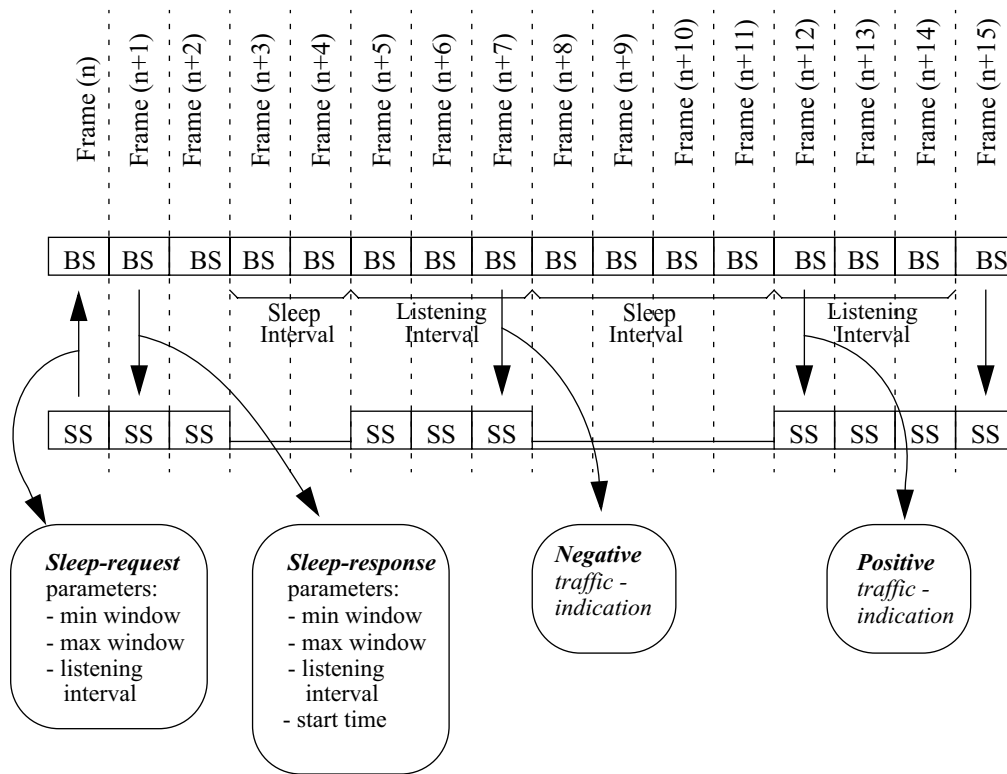
1 **6.2.16.3 Traffic indication signaling**

2
3 The BS shall indicate for each SS in sleep-mode, during its listening-interval, whether traffic has been
4 addressed to it. The indication is sent on the TRF-IND broadcast message. The SS shall examine the frame
5 number from the PHY Synchronization Field and shall verify it synchronization with the BS. If such syn-
6 chronization is lost, i.e. expected frame number is different than found frame number, the SS shall return
7 into awake mode.
8
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10 If the SS did not find any TRF-IND message, or did not find any positive indication with it's CID in the
11 TRF-IND, it shall consider this as a negative indication and shall return into sleep mode.
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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 **6.2.17.1 Network reference model**

55 **6.2.17.1.1 Entities**

56 The network reference model consists of BS units covering a certain area, and connected by a backbone net-
57 work. Several such networks, owned by different operators may coexist in the same service area. Each back-
58 bone network may contain centralized AAA (Authorization, Authentication and Accounting), management,
59 provisioning or other specialized servers. Specifically, those servers responsible for authentication and ser-
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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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 24
 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

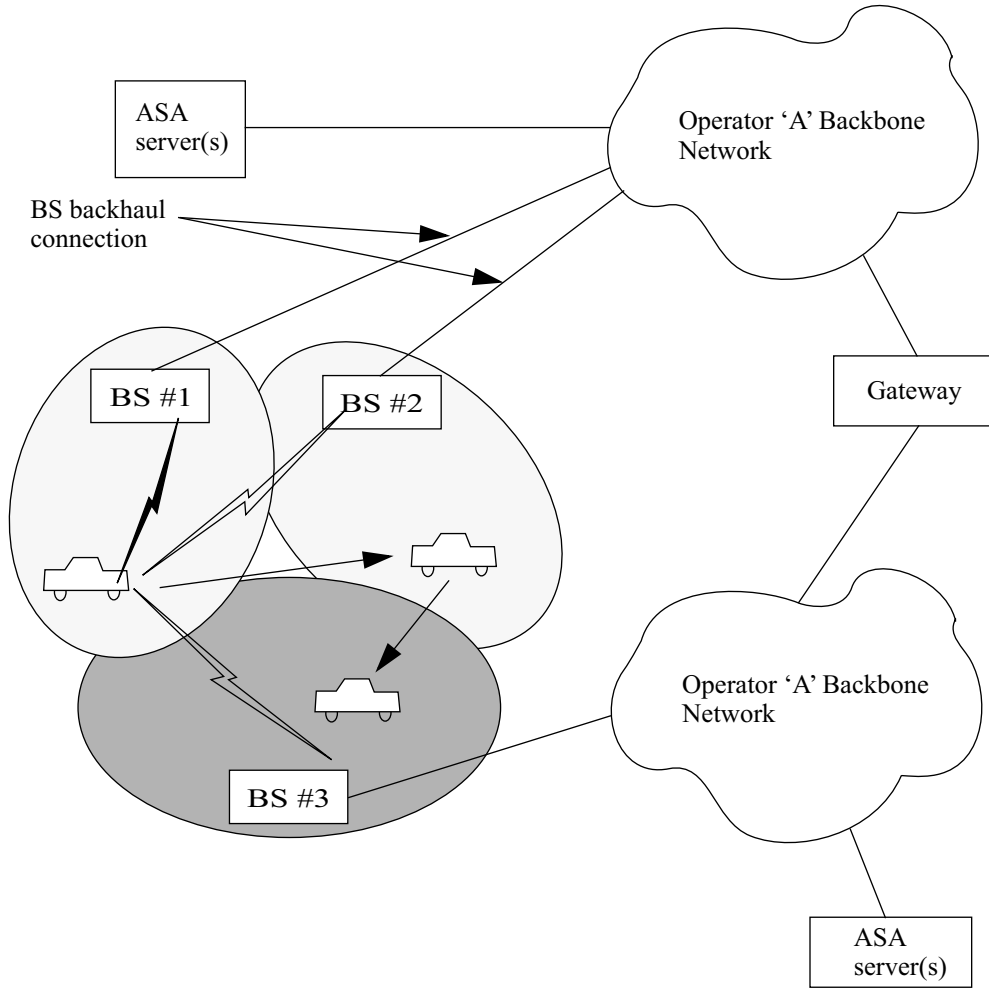
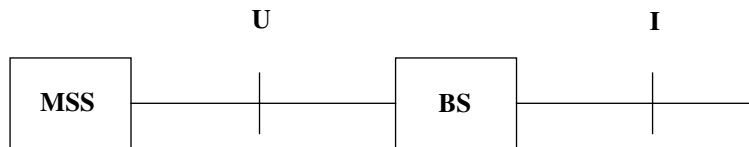


Figure 2: Network reference model, Data Plane shows the network reference model in the data plane.

Figure 59b3—Network Reference Model - Data Plane



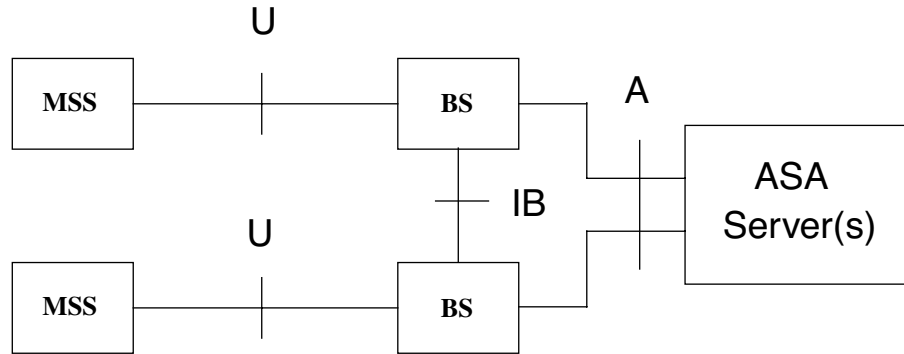
The following reference points are present data plane network model,

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.

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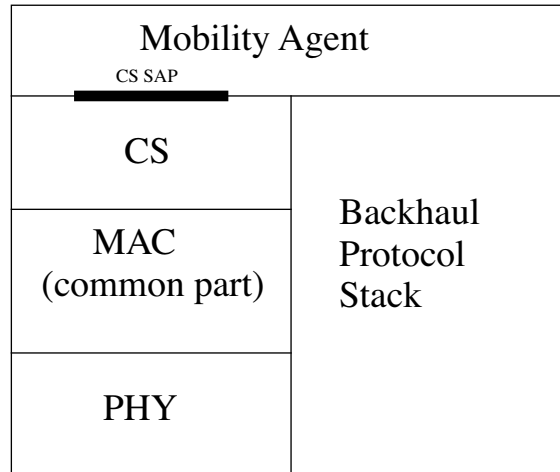
6.2.17.1.2 MSS Protocol Stack

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:

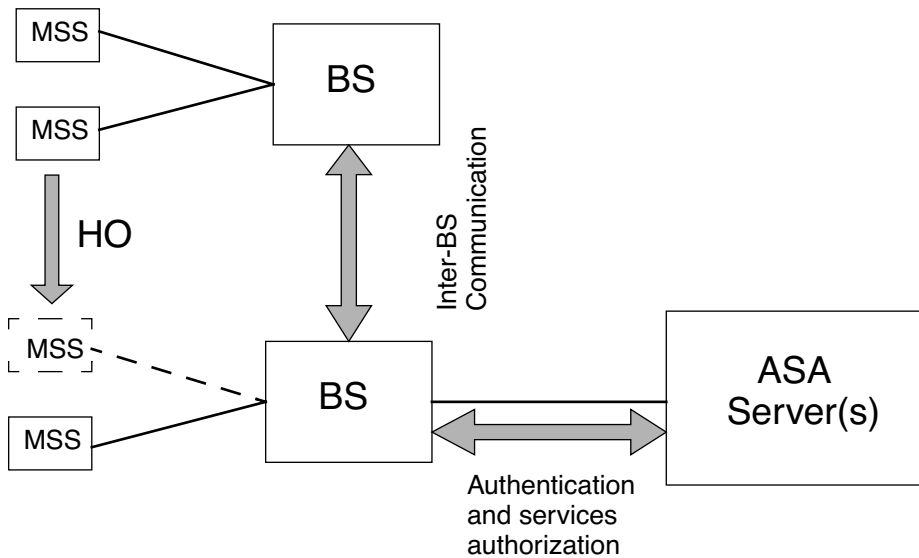
Table 75d—Mac Service Context

| 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. [?] |
| MAC Connection Parameters | Connection parameters as specified in , section 6.1.1.1.2 |

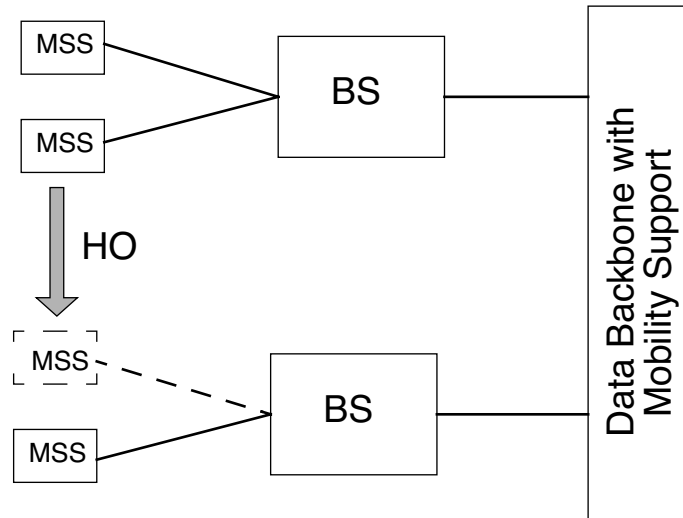
Figure 59b6—Network Structure (control plane) and HO



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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

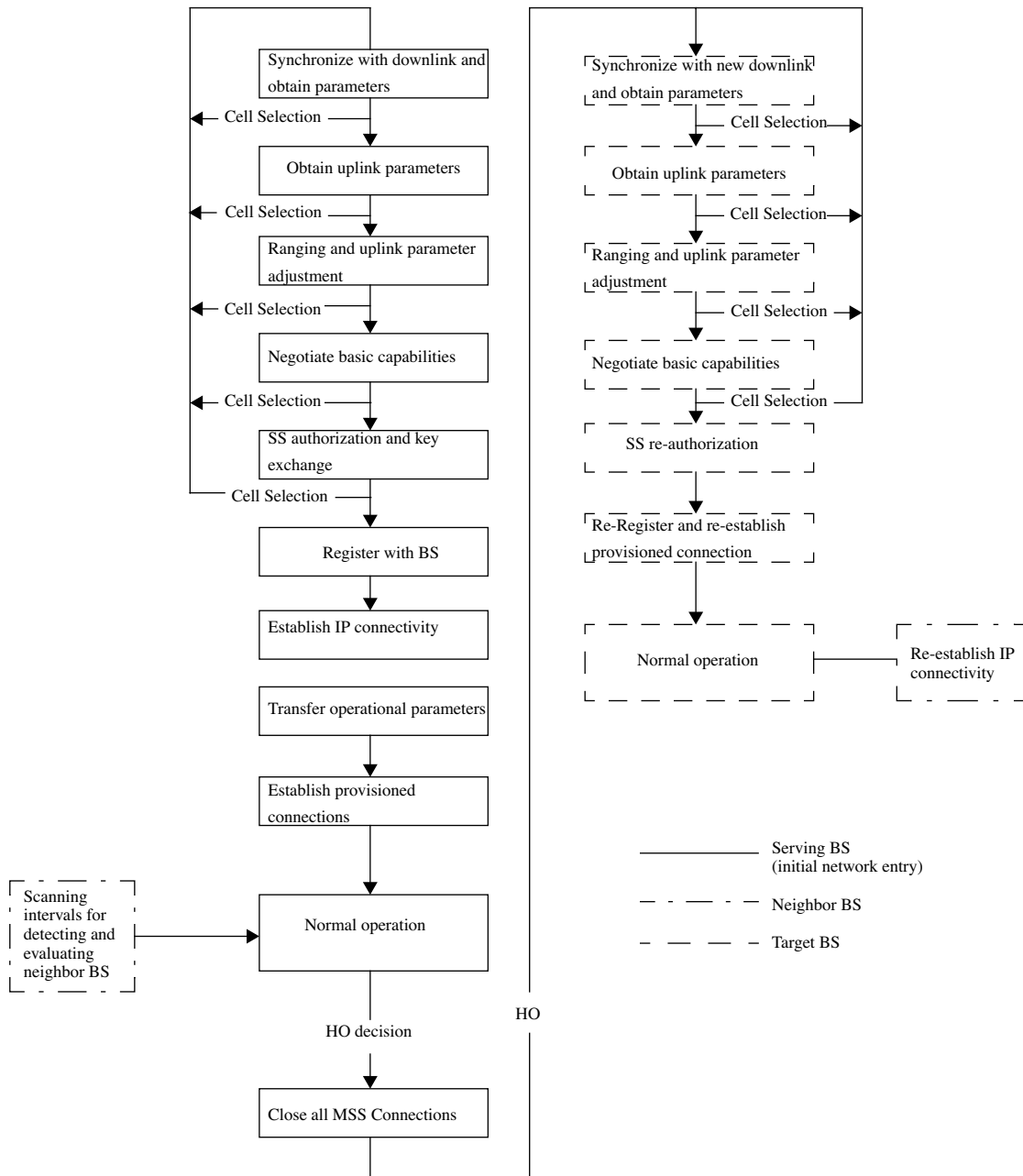
20
21 HO initiation, the decision to start the process is taken
22

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.
32

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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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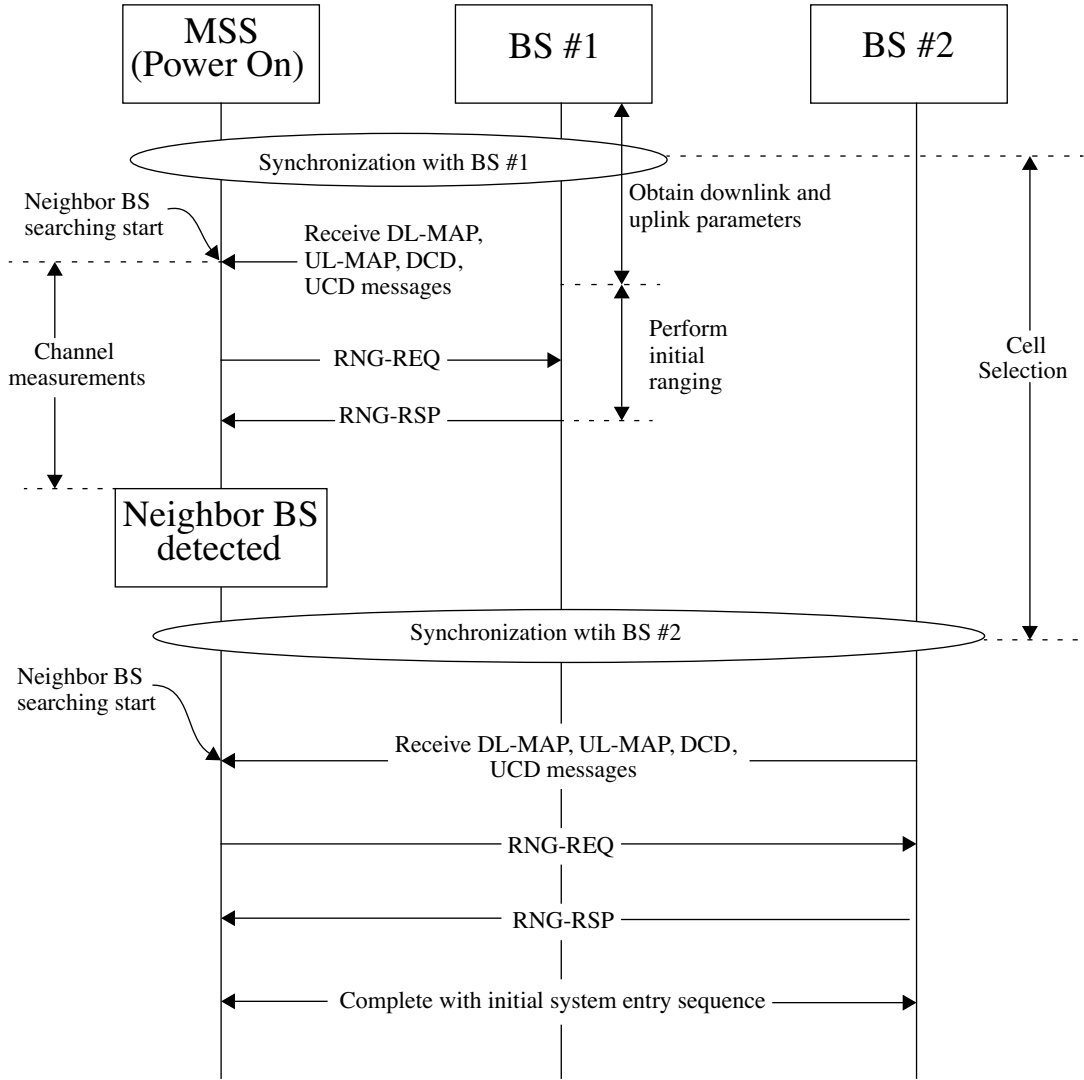
Figure 59b8—HO and Initial Network Entry



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

1 At the BS side, before sending BSHO-REQ or after receiving a MSSHO-REQ message, the BS shall notify
2 neighboring BS through the backbone of the HO request. The BS shall further acquire from the neighbor BS
3 information regarding their capability of serving the requesting MSS. See section Ranging Request/
4 Response RNG-REQ/RSP for specification of the communication through the backbone network, and the
5 information exchanged between BS.
6

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10 After receiving MSSHO-REQ or BSHO-REQ message, the receiving party shall respond with a HO-RSP
11 MAC message. When sent by a BS, the HO-RSP message may indicate a recommended target BS. The
12 MSS, at the risk that if it chooses an alternative target BS, it might receive a degraded level of service, may
13 ignore this recommendation (this includes staying with its serving BS, i.e. skipping the HO). The HO-RSP
14 message may also includes an estimation of the time when the HO would take.
15
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17 **6.2.17.2.3 Termination with the serving BS**

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19
20 After the [MSS/BS]HO-REQ/HO-RSP handshake is completed, the MSS may begin the actual HO. This is
21 done by sending a HO-IND MAC message.
22

23
24 Upon reception of a HO-IND MAC message, the BS may close all connections and discard MAC state
25 machines and MPDUs associated with the MSS.
26

27 **6.2.17.2.3 Drops and corrupted HO attempts**

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29
30 A drop is defined as the situation where a MSS has stopped communication with its serving BS (either in the
31 downlink, or in the uplink) before the normal HO sequence outlined in Cell Selection and Termination with
32 the serving BS has been completed.
33

34
35 A MSS can detect a drop by its failure to demodulate the downlink, or by exceeding the RNG-REQ retries
36 limit allowed for the periodic ranging mechanism. A BS can detect a drop by exceeding the RNG-REQ
37 retries limit allowed for the periodic ranging mechanism.
38

39
40 When the MSS has detected a drop, it shall attempt network re-entry with its preferred target BS as outlined
41 in section Re-entry with the target BS. When the BS has detected a drop, it shall react as if a HO-IND MAC
42 message has been received from the dropped MSS.
43

44 **6.2.17.2.3.1 Re-entry with the target BS**

45
46
47 When re-entry with the target BS takes place, the target BS as well as all neighbor BS are aware of the HO in
48 progress (except in a drop situation). At re-entry, the MSS performs the steps as shown in Figure 7: HO and
49 initial network entry.
50

51 **6.2.17.2.3.1.1 Synchronize with downlink and obtain parameters**

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53
54 For MSS that have used their scanning interval to synchronize with target BS and have decoded the NBR-
55 ADV message, this stage should be immediate. In other situations this procedure defaults to the one speci-
56 fied for initial network entry.
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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 performing 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).

1 **6.2.17.2.3.1.7 Commence Normal Operation**

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

7
8 **6.2.17.2.4 HO completion**

9
10 [This section should discuss the following:
11 Post HO operations (mostly applicable if make-before-break HO is supported)
12]

13
14 **6.2.17.3 Setup and negotiations**

15
16
17 [This section should discuss the following:
18 - Setup and negotiation procedures related to the HO
19 - PHY dependent parameters and associated handshake
20 - The model for coexistence of fixed and mobile-SS on the same air-interface instance
21

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24
25 *[Insert the following text after section 8.3.1.4.5.2]*

26
27 **8.3.1.4.5.2.1 Scanning Information Element**

28
29
30 A Scanning_IE shall be placed in the DL-MAP message by a BS in response to an SCN-REQ message sent
31 by a MSS. The Scanning_IE shall be placed in the extend DIUC (extension code = ?) within a DL-MAP IE.
32 A value of zero in the Scan Duration field shall be interpreted as denial of the SCN-REQ. A BS may also
33 send an unsolicited Scanning_IE.
34

35
36 The format of the IE is PHY dependent as shown in <table>.

37
38 **Table 116w1—Scanning IE Format**

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| 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. |
| } | | |

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62 *[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 \neq 15. UIUC \neq 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 divided into logical entities, rather than splitting in into smaller physical units, this way the frequency diversity of each logical entity still has the same properties as the basic channel.

The key features of using the SFN architecture are:

- Bandwidth sharing between sectors
- Flexible deployment, without the need to change RF components.
- Capacity increase in a multi sector configuration (by using the same principles as CDMA)
- Easy extension of existing deployments
- Faster handoffs
- Soft handoff possibility without the need to switch RF channels
- Frequency diversity

The PHY layer supports this splitting seamlessly, but has to be aware that:

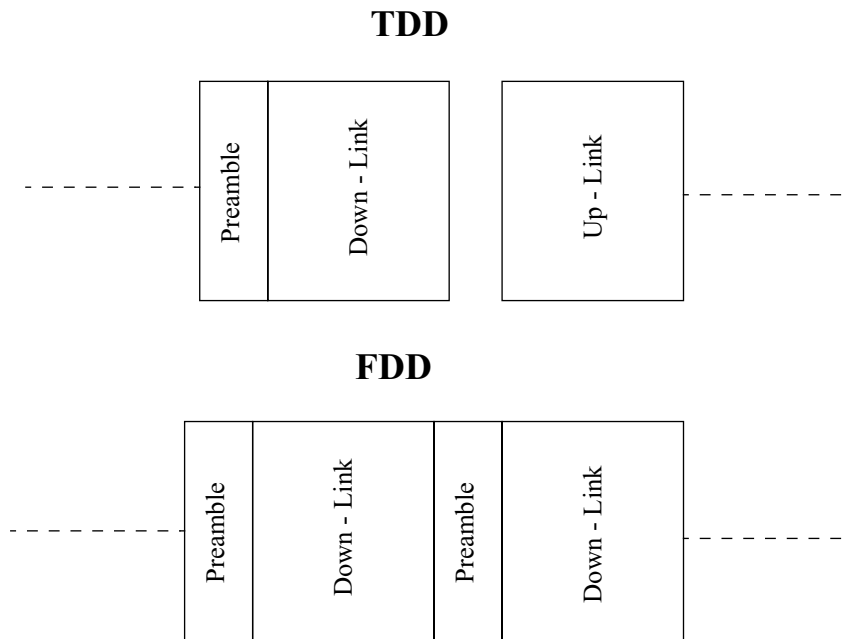
- Not all sub-channels might be used in the logical channel.

[Insert after section 8.5.4.2]

8.5.4.3 Preamble only signal

A preamble only symbol shall be added to the DL transmission; this preamble shall be located before the first the frame preamble (defined in section 8.5.9.4.3.1) as shown in Figure xxx: Preamble Location within the frame transmission in TDD/FDD. This preamble could be used in a multi-cell deployment for estimation, relative location calculation between base-stations and knowledge about the reception power and quality of the surrounding base-stations.

Figure 128av1—Preamble Location within the frame transmission in TDD/FDD



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

$$PN_{ID} = UsedCarriers_{mod(6)} \tag{65a}$$

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 BS₁ does not have many registered SSs, while BS₂ approaching it's maximum capacity with current allocation, then the sub-channels can be moved from BS₁'s logical channel to BS₂ 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.

Change number of bits of **Boosting**¹ field from 2 to 3.

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

[Insert after section 8.5.5.2]

8.5.5.2.1 DL-MAP information IE

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

Table 116bm1—OFDMA DL-MAP Information Element format

| Syntax | Size | Notes |
|--------------------------------|----------|-------------|
| DL-Map_Information_Element() { | | |
| DIUC | 4 bits | |
| if (DIUC == 15) { | | |
| Extended DIUC dependent IE | Variable | AAS_DL_IE() |
| } else { | | |

¹* This field should be moved from UL-MAP IE to DL-MAP IE due to an editorial error, and should be fixed in the errata process.

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| | | |
|-----------------------|--------|---|
| 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 |
| } | | |
| } | | |

[Insert the following text after 8.5.5.2.3]

8.5.5.2.4 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 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 |
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| | | |
|----------------------|---------|---|
| 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:

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

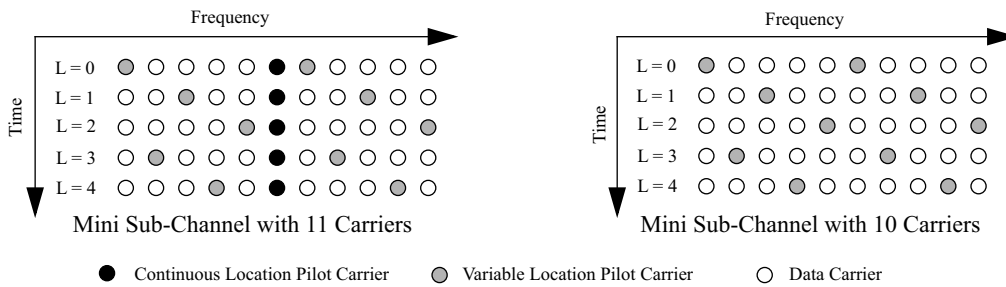
where:

$Carrier[j, i]$ 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:

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 initialization procedure. The Sub-Channel offset, which sets the 6 LSB bits of the randomizer, shall be taken from the 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 parameters (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 | P1 | P2 | P3 |
|------------|-------------------------|--------------------------|-----------|---|----|----|----|----|
| 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) |
|------------|------------------------------|-----------------|
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| | | |
|-------|-----|----|
| 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

| <i>PN_{ID}</i> | 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_{ID}</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 | | |
| | | | | | |
| | | | | | |

10.1.0.1 Ranging Request/Response RNG-REQ/RSP

11.1.4 REG-RSP TLVs for connection re-establishment

[Add the following rows to table 127a]

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 Service Flow Parameters and the CS Parameter Encodings 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. |
|-----------------|---|----------|--|

[Insert the following section after 11.1.6]

11.1.7 NBR-ADV Message Encodings

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. |

[Insert a new Annex]

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 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 on initial network entry |
| } | | |
| Security field | TBD | A means to authenticate this message |
| CRC field | 32-bit | IEEE CRC-32 |

C.2.2 MSS-info-request message

This message may be sent from one BS to another (or to the ASA server) to request information about a MSS. Typically the message will be sent as a reaction to reception of an *I-am-host-of* message, or in cases where a MSS is trying to re-enter the network after a HO. The message contains the following information,

Table C3—MSS-info-request 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) |
| } | | |
| 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

1 This section defines the services between the MAC and higher layers for supporting the HO process. In
2 some scenarios the higher layers may use information provided by the MAC layer HO process to optimize
3 their HO process and reduce the overall HO duration.
4

5
6 The information is defined as set of messages sent by the MAC layer to the higher layers, providing indica-
7 tion of particular events before and after MAC layer HO.
8

9 **C.4.2.1 MSS Movement**

10 Occurs at the MSS, indication that the MSS has registered to a new Target BS.
11
12

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

14 Occurs at the Serving BS, indication that a MAC layer HO of a certain MSS is about to take place.
15
16

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

18 Occurs at the Target BS, indication that a MAC layer HO of a certain MSS is about to take place.
19
20

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

22 Occurs at the Target BS or MSS, indication that a MAC layer HO between the MSS and the Target BS has
23 been completed.
24
25

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

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