Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>	
Title	**MS MAC Handover Procedure in an MR Network – Handover Execution**	
Date Submitted	2006-11-07	
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Re:	Submitted in response to Call for technical proposals issued by IEEE 802.16j on 2006-10-15	
Abstract	This document proposes a MS network entry/re-entry procedure to perform actual handover in IEEE 802.16j networks where both MR-BS and its subordinate RSs in an MR-cell transmit their own broadcast control message such as preamble, FCH, DCD, UCD, DL-MAP and UL-MAP.	
Purpose	This contribution is provided as input for the IEEE 802.16j amendment.	
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1. Introduction

The proposed MAC handover scheme will enable an 802.16e compliant MS to handover seamlessly in an MR network following the MAC handover procedure defined in subclause 6.3.22 of IEEE 802.16e-2005. This contribution proposes additions/modifications to the handover execution process defined in subclauses 6.3.22.2.7 and 6.3.22.2.8 of IEEE 802.16e-2005.

Figure 1 depicts the seven handover cases that are covered in this contribution.
Please refer to Sections 1.1 and 1.3 of [1] for terminologies and assumptions used in this contribution.

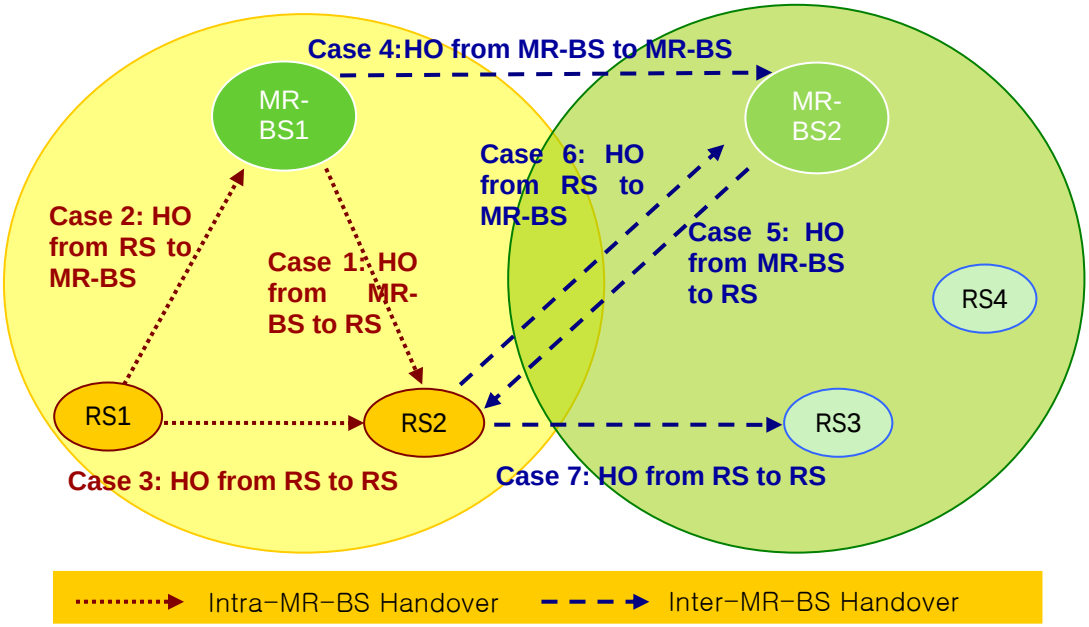


Figure 1. Seven Handover Cases in an MR network

2. MS Network entry/re-entry for handover

Unless indicated otherwise, MS network entry/re-entry due to handover in 802.16j systems is processed according to subclauses 6.3.9 and 6.3.22.2.7 of IEEE 802.16e-2005.

An MS and a target access station shall conduct ranging by exchanging RNG-REQ and RNG-RSP. An MS can indicates a handover attempt by sending a RNG-REQ message which

- includes a serving BSID TLV and
- sets bit number 0 of the ranging purpose indication TLV set to 1.

Upon receiving such a RNG-REQ message, the target access station will perform the following:

(1) The target access station may request the MS information if it has not received yet. Because the MS information may need to be obtained over the relay links as well as over the wired backbone, we propose two new MAC management messages *MS_INFO-REQ* and *MS_INFO-RSP*.

For intra MR-BS handover, if the target access station is the MR-BS, the MS information already exists at the MR-BS because it was the serving station of the MS. Hence, no signaling is required. However, if ARQ has been used hop by hop and the continuity of ARQ or SDU_SN enabled connections is to be maintained, then the ARQ status must be transmitted from the current access RS to the MR-BS over the relay links. The procedure to exchange *MS_INFO-REQ* and *MS_INFO-RSP* messages is summarized in Table 1(a).

For inter MR-BS handover, if the target and current access stations are MR-BSs, the MS information can be obtained over the backbone as defined in IEEE 802.16e-2005. If not, and if the target access station has not received the MS information yet, the target access station may request and receive the information using *MS_INFO-REQ* and *MS_INFO-RSP* over the relay links and/or over the wired backbone. The procedure to exchange these messages is summarized in Table 1 (b).

The target access station can determine whether a requested handover is inter or intra MR-BS by reading the *serving BSID TLV* in the received RNG-REQ.

(2) Upon receiving the MS information, if the target access station is an RS, existing connections needs to be re-established between the target serving MR-BS and the target access RS. Connection re-establishment process is processed according to the path management and routing procedure defined in TBD subclause of IEEE 802.16j amendment.

(3) To conclude the handover process, the target access station transmits a RNG-RSP message to the MS. Among many parameters in the RNG-RSP message, the following parameters are of particular interest when RSs are introduced into the network.

- Service Level Prediction: this value is assumed to be known at this stage because there has been connection re-establishment with the target serving station in (2).
- Basic and Primary CID Assignment:
  Assuming that CIDs are managed by the serving MR-BS for the entire MR-Cell, the MS can continue to use the same basic and primary CIDs before and after intra MR-BS handover. Hence, the target access station simply sends the same basic and primary CIDs to the MS. For inter MR-BS handover, basic and primary CID assignment is performed by the target serving MR-BS as defined in IEEE 802.16e-2005. If the target access station is an RS, the target serving MR-BS shall send the new CID assignment to the target access RS.
- HO process optimization
  - For intra MR-BS handover, bit numbers 0 – 7, 9, 10 of the RNG-RSP message can be set to 1.
  - For inter MR-BS handover, HO process optimization bitmap is determined according to Subclause 6.3.22 of IEEE 802.16e-2005.

After a successful ranging, if necessary, the target access station (i.e. new access station) sends a REG-RSP (unsolicited or as a response to REG-REQ) to the MS. It is possible to incorporate information in the REG_RSP into the RNG_RSP TLV message. The following parameters are of particular interest when RSs are introduced into the network:

- Secondary CID and CID update
  Assuming that CIDs are managed by the serving MR-BS for the entire MR-Cell, the MS can continuously use the same CIDs before and after an intra MR-BS handover. Therefore, target access station simply sends the same CIDs to the MS. For inter MR-BS handover, CID assignment and update is determined by the target serving MR-BS defined in IEEE

802.16e-2005. If the target access station is an RS, the target serving MR-BS makes the CIDs assignment for each new MS and sends them to the target access RS.

Other network entry process such as basic capability negotiation, authentication and key exchange, network address acquisition, and time of day acquisition messages, can be omitted for the intra MR-BS handovers. Network entry procedures can be found in subclause 6.3.9 network entry and initialization of IEEE 802.16e-2005.

During a handover, the target access station can set bit number 7 of *MS DL data pending element* of the HO process optimization TLV item in RNG-RSP to notify the MS of post-HO re-entry MS DL data pending. Upon the MS's successful re-entry at the target access station, the target access station (i.e., new access station) will forward the data to the MS. It is likely that there is no IP connectivity change after Intra MR-BS HO. For inter MR-BS handover, the MS may re-establish IP connectivity after receiving of all the forwarded data. Next, the new serving MR-BS will send a backbone message to the old serving MR-BS or other network entity to stop forwarding pre-HO pending MS DL data.

Figure 2 provides an example of signaling in relation to RNG_REQ/RSP and MS_INFO-REQ/RSP for six cases of Figure 1 (except Case 4). Case 4 is not included because it follows the 802.16e procedure exactly.

Table 1. **Signaling process for MS_INFO-REQ/RSP messages**
(a) when the target is for Intra MR-BS handover

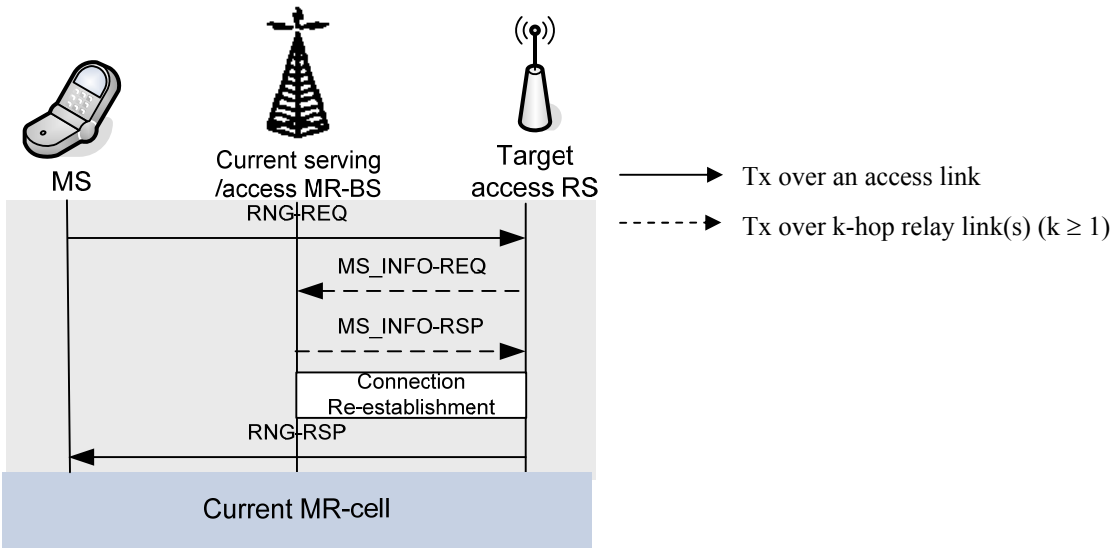
Current / Target	MR-BS in the same MR cell	RS in the same MR cell
MR-BS	N/A	The target access MR-BS and current access RSs can be k-hop (k≥1) away from each other. They know a relay path to reach each other because the RS is under the control of target access MR-BS. Since the MR-BS is the current serving MR-BS and thus already owns all the MS information, there is no need to exchange MS information. Only if the continuity of hop by hop ARQ or SDU_SN enabled connections is requested, (1) The target access MR-BS issues a *MS_INFO-REQ* destined to the current access RS. (2) The current access RS respond to the target access MR-BS with encoded ARQ state information in a *MS_INFO-RSP* message.

RS	The target access MR-BS and the current RS can be k-hop (k≥1) away from each other. They know a relay path to reach each other because the RS is under control of the target access MR-BS. (1) The target access RS issues a *MS_INFO-REQ* to the current access MR-BS which is its serving station. (2) Upon receiving the request, the current access MR-BS replies to the target access RS with a *MS_INFO-RSP*.	If the target and the current RSs can communicate with each other directly over the 1-hop relay link: (1) The target access RS issues a *MS_INFO-REQ* directly towards the current access RS. (2) Upon receiving the request message, the current access RS responds to the target access RS with a *MS_INFO-RSP*
		Both RSs have established a k-hop (k≥1) relay path to the serving MR-BS. If the target and current access RSs cannot communicate directly (i.e., no 1-hop relay link between them): (1) The target access RS issues a *MS_INFO-REQ* message destined to its serving MR-BS. (2) Only if the continuity of hop by hop ARQ or SDU_SN enabled connections is requested, the MR-BS forwards this request message to the current access RS. If not, the MR-BS can respond to the target access RS with a *MS_INFO-RSP* message (Skip (3) and (4)). (3) Upon receiving the request, the current access RS replies to the MR-BS with a *MS_INFO-RSP* message with ARQ status. (4) Then, the MR-BS passes the response message to the target access RS.

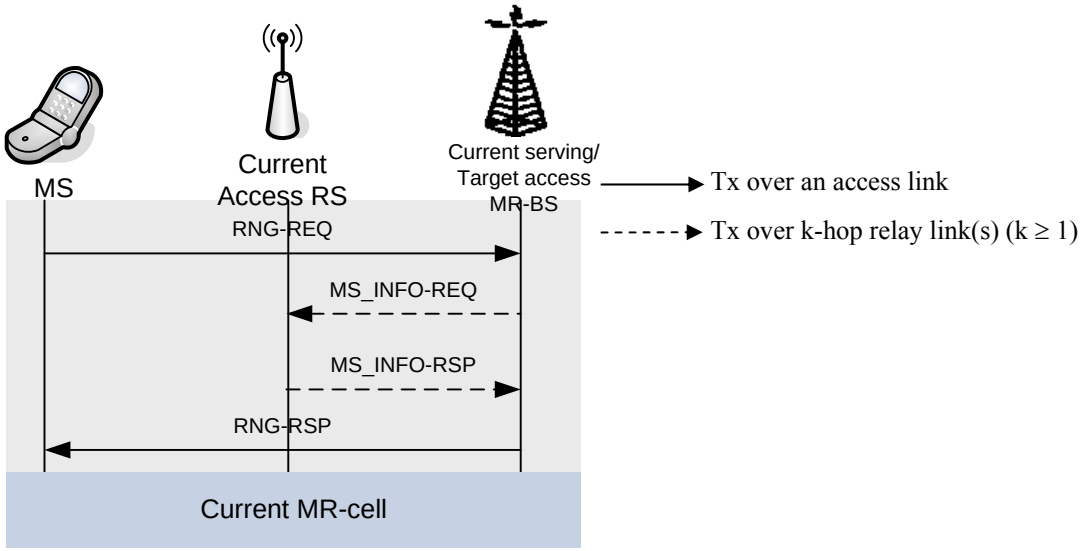
(b) when the target is for Inter MR-BS handover

Current / Target	MR-BS in a different MR cell	RS in a different MR cell
MR-BS	Follows the procedure as defined in IEEE 802.16e-2005	The target access MMS-BS and current access RS don't have knowledge of a relay path to reach each other because the RS is under the control of different MR-BSs. The procedure as defined in IEEE 802.16e-2005 is used to obtain MS information from the current serving MR-BS over the backbone. Only if the continuity of hop by hop ARQ or SDU_SN enabled connections is requested,

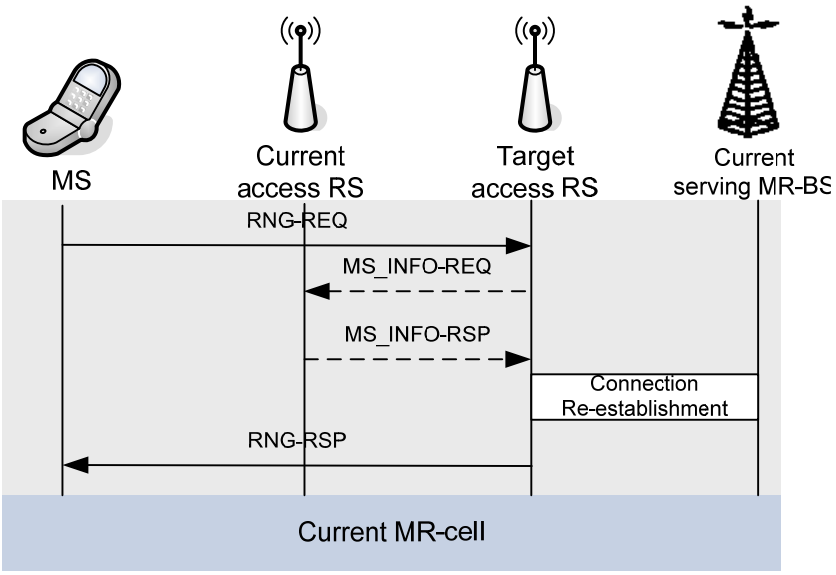
		(1) Upon receiving the MS information request from the target serving MR-BS over the backbone, the current serving MR-BS issues a *MS_INFO-REQ* destined to the current access RS. (2) The current access RS responds to the current serving MR-BS with encoded ARQ state information in a *MS_INFO-RSP* message. (3) The current serving MR-BS transmits all the MS information together with ARQ state to the target MR-BS over the backbone.
RS	The target access RS and the current access MR-BS don't have knowledge of a relay path to reach each other because the RS is under the control of different MR-BSs. (1) The target RS issues a *MS_INFO-REQ* message to the target serving MR-BS. (2) Upon receiving the request, the target serving MR-BS transmits a backbone message in order to obtain the MS information from the current access MR-BS. (3) Upon receiving the reply from the current access MR-BS, the target serving MR-BS transmits the *MS_INFO-RSP* message to the target access RS.	The target access RS always contacts the target serving MR-BS because the target serving MR-BS needs to perform a series of actions to allow the MS entry into its MR-Cell. (1) The target access RS issues a *MS_INFO-REQ* message destined to the target serving MR-BS. (2) Then, the target serving MR-BS transmits the request message to the current serving MR-BS over the backbone. (3) Only if the continuity of hop by hop ARQ or SDU_SN enabled connections is requested, the current serving MR-BS forwards this request message to the current access RS. If not, the current serving MR-BS responds over the backbone without querying the current access RS (Skip (4)). (4) If the current access RS receives the *MS_INFO-REQ* message, it responds with a *MS_INFO-RSP* message with ARQ state to the current serving MR-BS. (5) The current serving MR-BS transmits all the MS information together with ARQ state (if necessary) to the target MR-BS over the backbone. (6) The target serving MR-BS transmits the *MS_INFO-RSP* message to the target access RS.



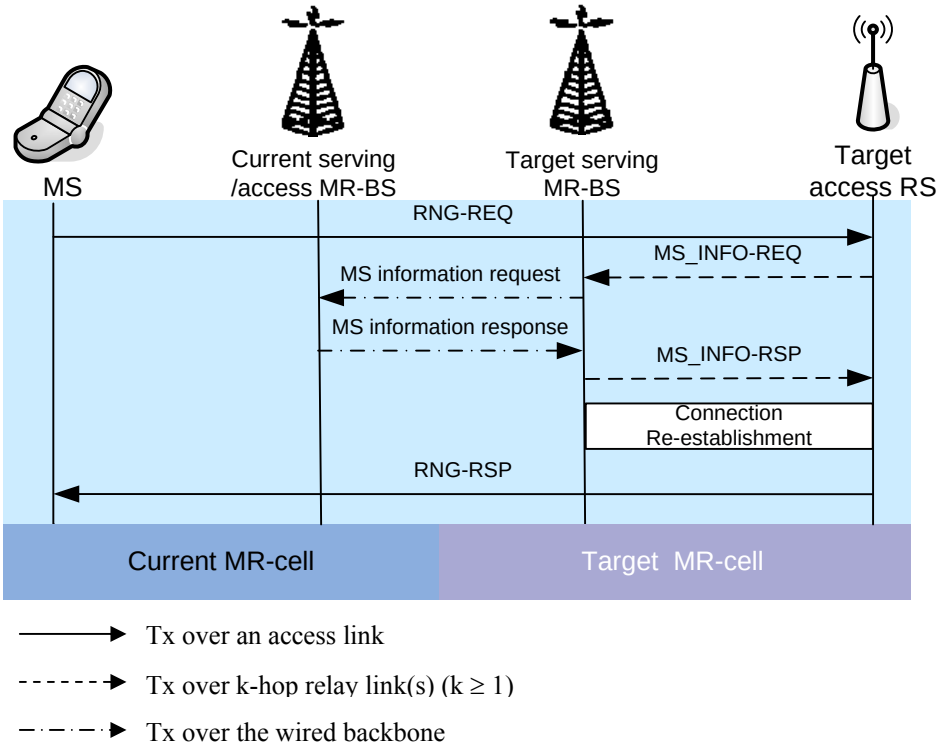
(a) Case1: Current access station is an MR-BS and target access station is an RS in the same MR cell



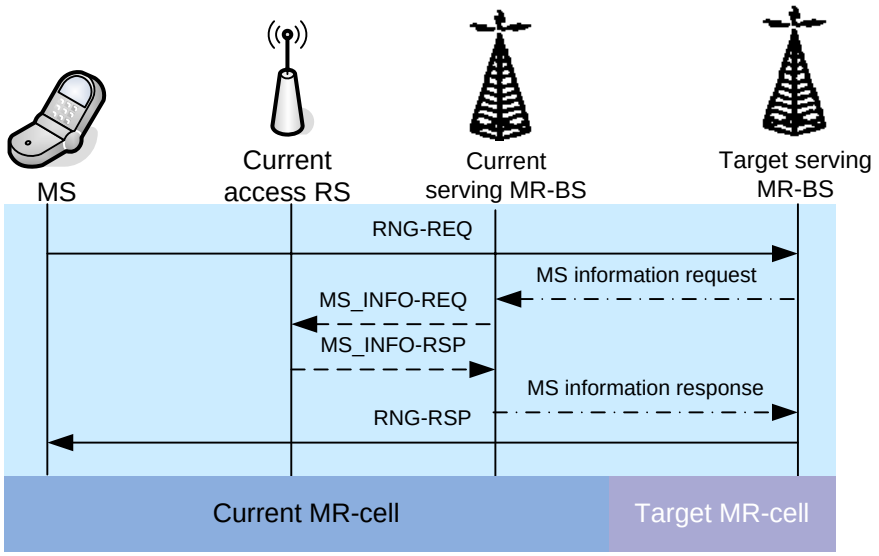
(b) Case 2: Current access station is an RS and target access station is a serving MR-BS. MS_INFO-REQ/RSP messages are exchanged only when hop by hop ARQ or SDU_SN is supported.



(c) Case 3: Current access station is an RS and target access station is another RS in the same MR cell. This flow is an example when a direct 1-hop relay link exists between the current and the target access RSs.



(d) Case 5: Current access station is an MR-BS and target access station is an RS in a different MR-cell

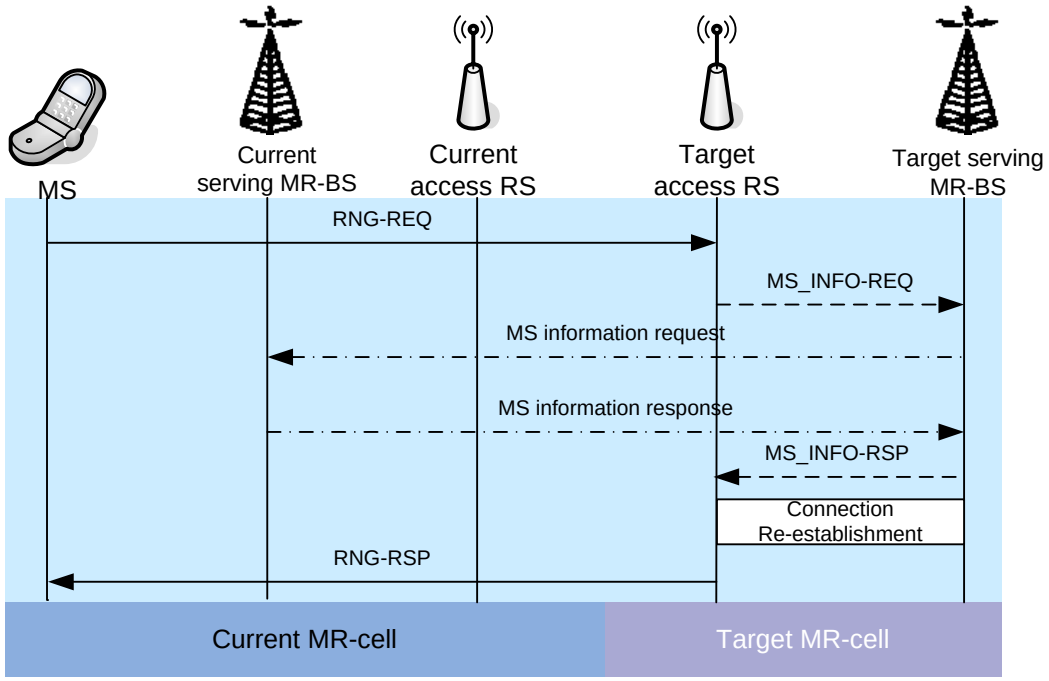


Tx over an access link

Tx over k-hop relay link(s) (k ≥ 1)

Tx over the wired backbone

(e) Case 6: Current access station is an RS and target access station is an MR-BS in a different MR-cell. MS_INFO-REQ/RSP message exchange between the access RS and the serving MR-BS is required only when hop by hop ARQ or SDU_SN is supported.



Tx over an access link

Tx over k-hop relay link(s) (k ≥ 1)

Tx over the wired backbone

(f) Case 7: Current access station is an RS and target access station is another RS in a different MR cell.

Figure 2. An example of signaling message exchanges for ranging. (Other flows are possible for each case)

3. Proposed text

[Editor's note: Figure and table numbers are subject to change when the text is inserted into the amendment. The figures and tables appeared in the above sections will not be repeated in this section]

[Insert the following at the end of subclause 6.3.22.2.7]

In MR networks, an MS and a target access station shall conduct ranging by exchanging RNG-REQ and RNG-RSP. When an RNG-REQ indicates an MS handover attempt by including a serving BSID TLV and ranging purpose indication TLV with bit number 0 set to 1, the target access station may request the MS information if it has not received yet. Because the MS information may need to be obtained over the relay links as well as over the backbone, two MAC management messages, i.e., *MS_INFO-REQ* and *MS_INFO-RSP* are used for the relay link transmission.

For intra MR-BS handover, if the handover is from an RS to its MR-BS, the MS information already exists at the MR-BS because it was the serving station of the MS. Therefore, no signaling is required. However, if ARQ has been used hop by hop and the continuity of ARQ or SDU_SN enabled connections is to be maintained, the ARQ status must be transmitted from the current access RS over the relay links to the MR-BS. The procedure to exchange these *MS_INFO-REQ* and *MS_INFO-RSP* messages is summarized in Table 1(a).

For inter MR-BS handover, if the target and current access stations are MR-BSs, the MS information can be obtained over the backbone. Otherwise if the target access station has not received the MS information, the target access station may exchange the information using *MS_INFO-REQ* and *MS_INFO-RSP* over the relay links and/or the wired backbone. The procedure to exchange these messages is summarized in Table 1 (b).

The target access station can determine whether a requested handover is inter or intra MR-BS by reading the *serving BSID TLV* in the received RNG-REQ.

Upon receiving the MS information, if the target access station is an RS, existing connections needs to be re-established between the target serving MR-BS and the target access RS. Re-establishment is processed according to the path management and routing procedure defined in TBD subclause.

The target access station transmits a RNG-RSP message to the MS. Among many parameters in the RNG-RSP message, the following parameters are of particular interest when RSs are introduced into the network.

- Service Level Prediction: This value is known at this stage because the connections have been re-established with the target serving station.
- Basic and Primary CID Assignment: Assuming that CIDs are managed by the serving MR-

BS for the entire MR-Cell, the MS can continuously use the same basic and primary CIDs before and after an intra MR-BS handover. Therefore, target access station simply sends the same basic and primary CIDs to the MS. For inter MR-BS handover, if the target access station is an RS, the target serving MR-BS determines the CID assignment and sends it to the target access RS.

- HO process optimization: For intra MR-BS handover, bit numbers 0 – 7, 9, 10 in the RNG-RSP message can be set to 1.

After a successful ranging, if necessary, the target access station (i.e. new access station) transmits a REG-RSP (unsolicited or as a response to REG-REQ). The REG_RSP information can be included as TLV items in the RNG_RSP message. The following parameters are of particular interest when RSs are introduced into the network:

- Secondary CID and CID update
  Assuming that CIDs are managed by the serving MR-BS for the entire MR-Cell, the MS can continuously use the same CIDs before and after an intra MR-BS handover. Target access station simply tells the MS to use the same CIDs. For inter MR-BS handover, if the target access station is an RS, the target serving MR-BS determines the CID assignment and send it to the target access RS.

Some network entry procedure can be omitted as indicated in the HO process optimization bitmap. All network entry procedures can be found in subclause 6.3.9 network entry and initialization.

During a handover, the target access station can set bit number 7 of MS DL data pending element of the HO process optimization TLV item in RNG-RSP to notify the MS of post-HO re-entry MS DL data pending. Upon the MS's successful re-entry at the target access station, the target access station (i.e., new access station) forwards data to the MS. It is likely that there will be no IP connectivity change after an Intra MR-BS HO.

[Insert new subclause 6.3.2.3.xx]

6.3.2.3.XX MS_INFO-REQ

Target access station issues this message to obtain the MS information.

Syntax	Size (bits)	Notes
MS_INFO-REQ_Message_format() {		
Management Message Type = TBD	TBD	
Current access station ID	48	
Target access station ID	48	
HO_ID_Indicator	1	
If (HO_ID = 1){		
HO_ID	8	
}		
If (HO_ID = 0) {		
MS ID	48	
}		
Information field Indicator	TBD	Each bit indicates if the corresponding field is required to appear in MS_INFO-RSP. − Bit #0: Basic CID

		− Bit #1: Primary Management CID − Bit #2: Secondary Management CID − Bit #3: CID_Update − Bit #4 – TBD Reserved.
Padding	TBD	Padding to reach byte boundary
}		

[Insert new subclause 6.3.2.3.xx]

6.3.2.3.XX MS_INFO-RSP

This is the reply message to MS_INFO-REQ.

Syntax	Size (bits)	Notes
MS_INFO-RSP_Message_format() {		
Management Message Type = TBD	TBD	
Target access station ID	48	
Current access station ID	48	
HO_ID_Indicator	1	
If (HO_ID_Indicator = 1) {		
HO_ID	8	
}		
If (HO_ID Indicator = 0){		
MS_ID	48	
}		
Information field Indicator	TBD	Each bit indicates if the corresponding field appear in MS_INFO-RSP. − Bit #0: Basic CID − Bit #1: Primary Management CID − Bit #2: Secondary Management CID − Bit #3: CID_Update − Bit #4 – TBD Reserved.
If Information Field Indicator Bit#0 == 1 {		
Basic CID	16	
}		
If Information Field Indicator Bit#1 == 1 {		
Primary Management CID	16	
}		
If Information Field Indicator Bit#2 == 1 {		
Secondary Management CID	16	
}		
If Information Field Indicator Bit#3 == 1 {		
N_CID	TBD	

For (i =0; i<N_CID, i++){		
SFID	32	
CID	16	
TLV encoded information	variable	ARQ related parameter (TBD) such as counter, timer, etc.
}		
Padding	variable	Padding to reach byte boundary
}		

References

[1] IEEE C802.16j-06/217, "Overview of the proposal for MS MAC handover procedure in an MR Network," Nov. 2006