Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>	
Title	**Overview of the proposal for MS MAC handover procedure in an MR Network**	
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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 provides an overview of the proposal on a MS MAC handover procedure for IEEE 802.16j network systems 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

In this proposal, we define the MAC handover procedure and corresponding MAC management messages over relay links so that an IEEE 802.16e compliant MS can handover seamlessly within an IEEE 802.16j network.

1.1 Terminologies and Definitions used in this contribution

access station: The station at the point of direct access into the network for a given MS or RS. An access station can be a BS, RS, or MR-BS.
serving station: For any MS, the serving station is the station with which the MS has most recently completed registration at initial entry or during a handover. A serving station can be a BS or MR-BS.
target access station: A station which is the primary candidate for MS network access following a handover. The target access station can be an RS, BS, or MR-BS.
target serving station: A station which is the primary candidate for MS registration following a handover. The target serving station can be a BS or MR-BS.
infrastructure station (IS): A station which is not a subscriber. The infrastructure station can be a BS, MR-BS, or RS.
neighbor station: For an MS, an access station whose downlink transmission over the access link can be received by the MS. (This definition follows the definition of the terminology *neighbor BS* in IEEE 802.16e-2005.) For an infrastructure station (IS), any other IS whose transmission over relay link can be received by the IS.

1.2 Problem statement

Due to the introduction of RSs into the network infrastructure, seven different handover cases illustrated in Figure 1 are possible to occur in an MR network. The seven cases belong to two main categories of handover: (1)Intra MR-BS handover if the handover is between two RSs controlled by the same MR-BS or between an MR-BS and one of its subordinate RSs; and (2) Inter MR-BS handover if the handover is between two MR-BSs, two RSs each controlled by different MR-BSs, or between an MR-BS and an RS controlled by a different MR-BS.

There can be two to four infrastructure stations directly involved with an MS handover by counting access and serving stations but not including intermediate RSs. Discussions on optional handover features such as MDHO and FBSS in IEEE 802.16e-2005 are not included in this proposal. The signaling between the involved infrastructure stations occurs over the wireless relay links as well as over the wired backbone in an MR-network.

There are only two infrastructure stations involved with an MS handover for Cases 1, 2, and 4. On the other hand, there are three infrastructure stations involved for Cases 3, 5, and 6: (1) Case 3: RS1 is the current access station, RS2 is the target access station, and MR-BS1 is the serving station. MR-BS1 remains as the serving station after the handover. (2)Case 5 - MR-BS2 is the current serving and access station, RS2 is the target access station, and MR-BS1 is the target serving station (3) Case 6- MR-BS1 is the current serving MR-BS, RS2 is the current access station, and MR-BS2 is the target serving and access station. Finally, there are four stations involved for Case 7: MR-BS1 is the current serving station, RS2 is the current access station, MR-BS2 is the target serving station and RS3 is the target access station.

The handover protocol defined in 802.16e can be used to support MS handover between two MR-BSs (case 4). However, all other six cases (i.e., Cases 1, 2, 3, 5, 6, and 7) require new MAC management messages over relay links and corresponding signaling procedure among involved infrastructure stations.

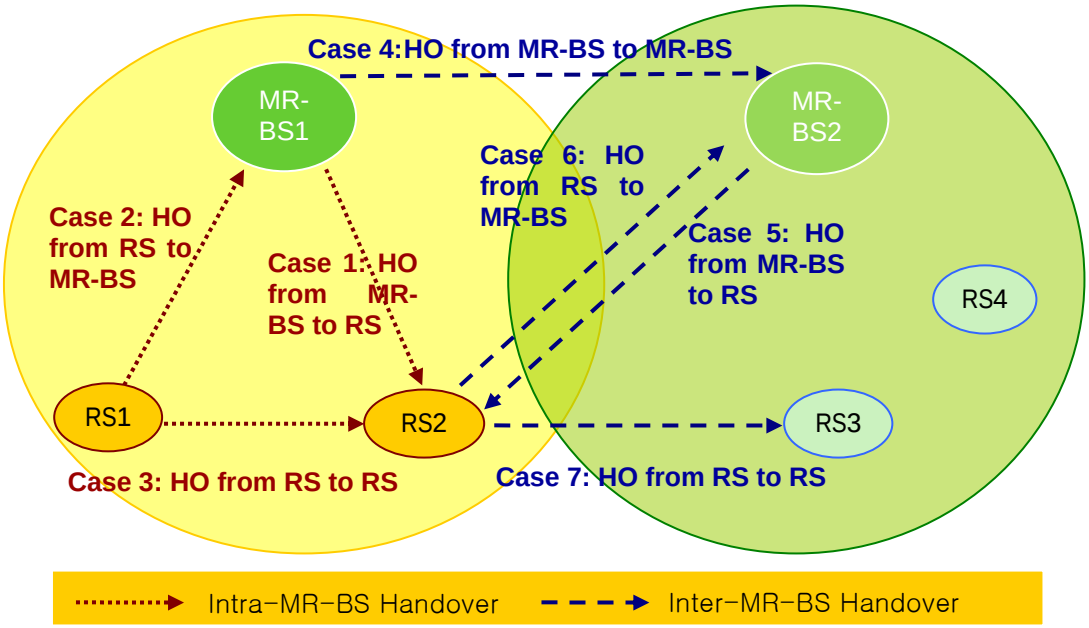


Figure 1 Seven Handover Cases in an MR network

Handover procedure can be different depending on the coordination between an MR-BS and its subordinate RSs with regards to broadcast control messages (i.e., Preamble, FCH, DCD, UCD, UL-MAP, DL-MAP). Accordingly, we further classify two different solutions based on this.

- Handover in a Synchronous Broadcast System: Only the MR-BS transmits all the broadcast control messages or RSs in the same MR-Cell transmit the same broadcast control messages with the ones from the MR-BS. Then, the MS considers these stations as the single BS. In this case, Intra MR-BS handover is transparent to the MS.
- Handover in an Asynchronous Broadcast System: RS can transmit its own Preamble, DCD, UCD, UL-MAP, and DL-MAP. In this case, the MS recognizes an RS as a BS and thus needs to be aware of Intra MR-BS Handover and treat it same as regular 802.16e handover.

This proposal provides an introduction to the subsidiary contributions [1]-[4] aiming at defining the MAC handover procedure for an asynchronous broadcast system.

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. The focus of this proposal will be on defining a MAC handover procedure with *fixed or nomadic* RS.

The proposed scheme addresses the following aspects of MAC handover procedure based on the structure of subclause 6.3.22 of IEEE 802.16e-2005:

- Network topology acquisition including network topology advertisement, MS scanning, and Cell reselection
- Handover decision and initiation
- Network entry/re-entry for handover execution with the new access and serving station(s)
- Termination with the current access and serving station(s)

1.3 Assumption

We assume that all the 802.16e procedures are followed in order to be backward compatible (no MS changes are required). Therefore, the contents in subclause 6.3.22 of IEEE 802.16e-2005

will not be repeated in this proposal unless it is necessary to understand the proposed schemes.

Throughout the proposal, we shall adhere to the following assumptions:

1. When a handover occurs, the current and target access stations may or may not connect with each other directly via a 1-hop relay link. The set of neighbor stations for an MS and the set of neighbor stations for current and target access stations can be different. An MS can handover from a current access station to a target access station if there is an overlap in coverage in terms of access link transmission. On the other hand, these two access stations can communicate directly if there exist a PMP link between them.
2. If a direct 1-hop relay link exists between a current access RS and a target access RS, they can exchange handover related MAC management messages directly with each other over the 1-hop relay link.
3. A current serving MR-BS always communicate with a target serving MR-BS in the case of inter MR-BS handover.
4. Access station maintains information for MSs that are directly attached to it. The information contains MS MAC address and the associated SFIDs and CIDs.
5. CIDs are managed and assigned by an MR-BS (i.e., CID is unique within an MR-Cell). Therefore, CIDs used by an MS remain same after intra MR-BS handover.
6. Unless indicated otherwise, network entry/re-entry and relay path management/routing for a handover are processed according to the corresponding subclauses of IEEE 802.6e-2005 and the IEEE 802.16j amendment that will result from the TGj project.

2. New MAC management messages over relay links

The following table lists the proposed new MAC management messages for infrastructure stations in an 802.16j network during each phase of the 802.16e MS MAC handover procedure.

Table 1. New MAC Management messages for infrastructure stations

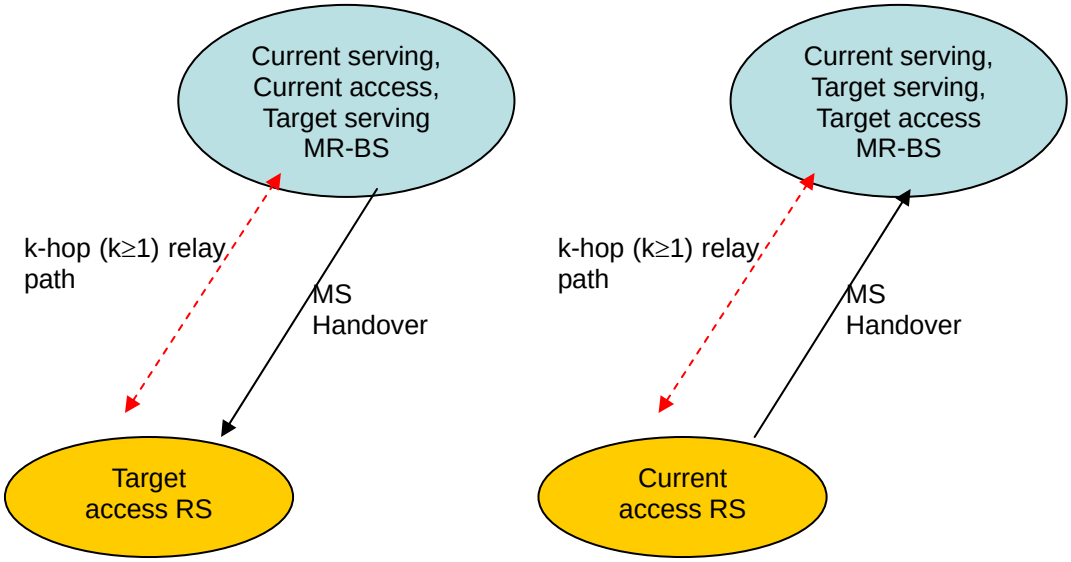
New MAC Management messages	Related MS handover Phase	Functionality
NBR_ADVINFO-REQ NBR_ADV-INFO	Network Topology Advertisement	A NBR_ADV-INFO message is used to inform ISs' access link channel information over relay links. A NBR_ADVINFO-REQ message is used by RSs to request access link channel information of other ISs of interest.
ST_SCN-REQ, ST_SCN-RSP	MS scanning	These messages are used to coordinate an association for an MS at target access station(s).
HO_INFO-REQ, HO_INFO-RSP	Handover decision and initiation	These messages are used to pass the handover related information of potential target access station(s) to the current access station over relay links.
MS_INFO-REQ/ MS_INFO-RSP	Handover execution	These messages are used to pass MS information to target (i.e., new) access and target serving station(s) when the actual handover is performed between the target access station and MS.
HO_CPL	Handover termination	This message is used to notify successful handover to the current access and serving station(s) and to the target serving station.

3. New MAC management message exchange flow

This section summarizes new MAC management message exchange flow and functions of ISs with regard to the related handover for the six cases (Cases 1, 2, 3, 5, 6, and 7) depicted in Figure 1. In Figures 2 – 4, the solid arrowed lines denote the MS handover direction and the dotted arrowed lines the path for MAC management message exchanges. Based on these flows, detail on each phase of the MS handover procedure can be found in the related contributions [1]-[4].

- **Case 1 and Case 2**

Figure 2 (a) and (b) depicts handover Cases 1 and 2 of Figure 1. There are only two ISs involved in the MS handover and there is a k-hop relay path between two involved ISs. All the new MAC management messages are exchanged over this k-hop relay path.



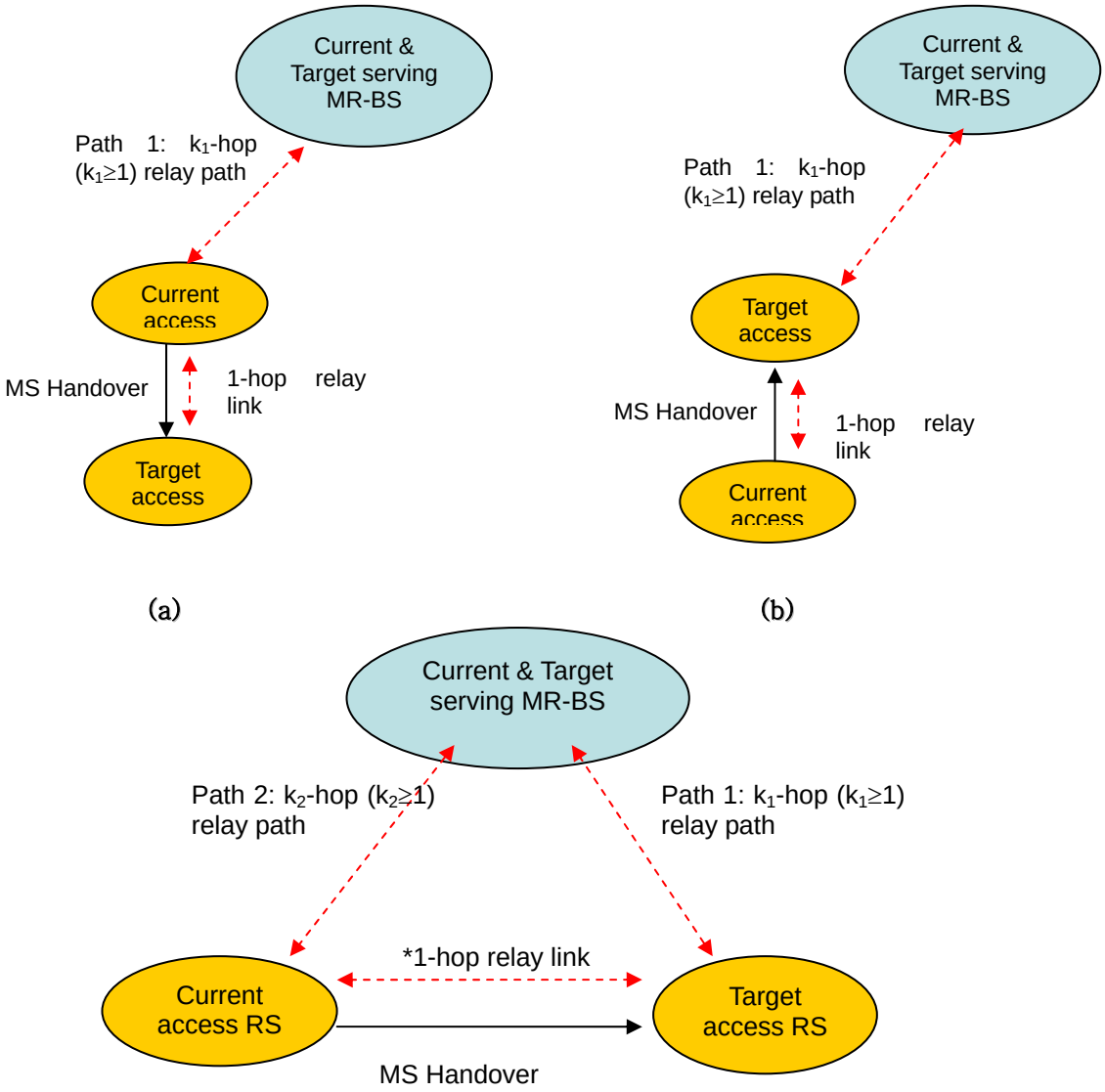
(a) Case 1 **(b) Case 2**

Figure 2. MAC management message exchange for handover Cases 1 and 2

- **Case 3**

As shown in Figure 3, one RS is the current access station and another RS is the target access station. The MR-BS is both the current and the target serving station because both RSs are its subordinates.

If a direct 1-hop relay link exists between the two RSs (i.e., two RSs are upstream and downstream station of each other in the topology), MAC management messages such as ST_SCN-REQ/ST_SCN-RSP, HO_INFO-REQ/ HO_INFO-RSP, and MS_INFO-REQ/ MS_INFO-RSP can be exchanged via the 1-hop relay link. HO_CPL is delivered to the serving MR-BS and current access RS using Path 1 and the 1-hop relay link, respectively. If the 1-hop relay link in Figure 3 (c) doesn't exist, current and target access RSs have to exchange all the MAC messages via Path 1 and Path 2 of Figure 3 (c).



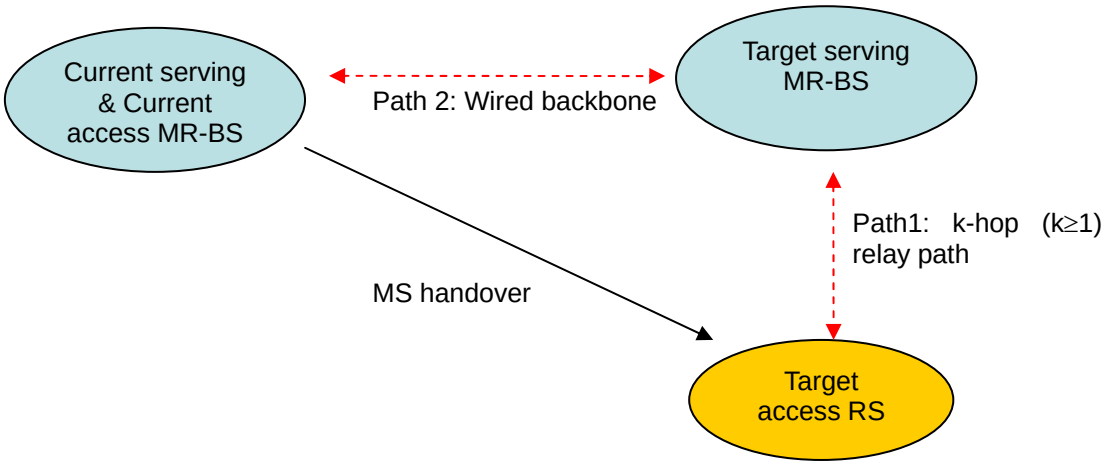
* The target access and the current access RSs are upstream and downstream station of each other when there are two relay paths between the MR-BS and the current access RS or between the MR-BS and the target access RS.

(c)

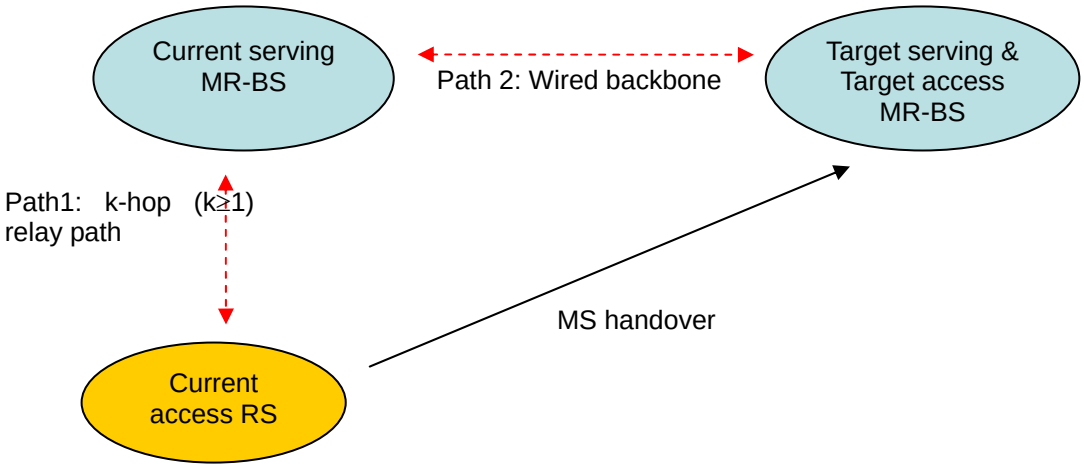
Figure 3. MAC management message exchange for handover Case 3

- **Case 5 and Case 6**

The MS handover from an MR-BS to an RS in a different MR-cell and from an RS to an MR-BS in a different MR-cell can be found in Figure 4 (a) and (b), respectively. In these cases, all MAC management messages are delivered using Path 1 (i.e., k-hop relay path) and Path 2 (i.e., wired backbone).



(a) Case 5



(b) Case 6

Figure 4. MAC management message exchange for handover Cases 5 and 6

- **Case 7**

As the most complicated case, an MS handovers from an RS to another RS in a different MR-cell. All MAC message exchanges use Path 1, Path 3, and Path 2.

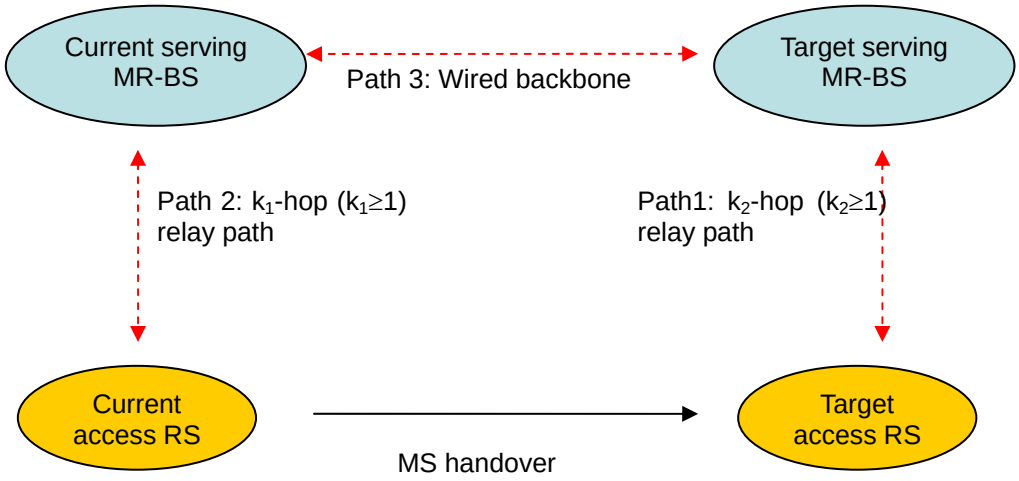


Figure 5. MAC management message exchange for handover Case 7

4. Proposed text change

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

[Insert the following in subclause 6.3.22 before subclause 6.3.22.1]

Due to the introduction of RSs into the network infrastructure, seven different handover cases illustrated in Figure 1 can occur in an MR network. The seven cases belong to two main categories of handover: (1)Intra MR-BS handover if the handover is between two RSs controlled by the same MR-BS or between an MR-BS and one of its subordinate RSs; and (2) Inter MR-BS handover if the handover is between two MR-BSs, two RSs each controlled by different MR-BSs, or between an MR-BS and an RS controlled by a different MR-BS.

All six cases (i.e., Cases 1, 2, 3, 5, 6, and 7) require signaling among involved RSs and MR-BSs to support handover. Therefore, this subclause also contains procedure for infrastructure stations to support MS handover if the MS is attached to an MR network.

[Editor's note: Include Figure 1 here]

In contrast with handover direction, MAC management message exchange flow among ISs and functions of each IS with regard to the related handover for the six cases (Cases 1, 2, 3, 5, 6, and 7) are depicted in Figures 2-5. The solid arrowed line denotes the MS handover direction and the dotted arrowed line the path for MAC management message exchanges.

[Editor's note: Include Figures 2-5 here]

References

[1] IEEE C802.16j-06/218, "MS MAC Handover Procedure in an MR Network – Network Topology Acquisition and MS Scanning," Nov. 2006
[2] IEEE C802.16j-06/219, "MS MAC Handover Procedure in an MR Network – Handover Decision and Initiation," Nov. 2006
[3] IEEE C802.16j-06/220, "MS MAC Handover Procedure in an MR Network – Handover

Execution," Nov. 2006
[4] IEEE C802.16j-06/221, "MS MAC Handover Procedure in an MR Network – Termination," Nov. 2006