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Re:	Response to the call for technical proposal regarding IEEE Project 802.16j (i.e., IEEE 802.16j-06/034, "Call for Technical Proposals regarding IEEE Project P802.16j", December 12, 2006).
Abstract	This contribution describes MDHO and FASS for MMR network
Purpose	The contribution is provided as input for the IEEE 802.16j amendment
Notice	
Release	
Patent Policy and Procedures	

Macro Diversity Handover and Fast Access Station Switching for MMR Network

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1. Introduction

In this proposal, we discuss the MAC MDHO and FASS 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.

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In HO mode the MS communicates with just one access station, which allows only low speed mobility (portability or simple mobility). For higher speed mobility (full mobility) FASS and MDHO are implemented. In MDHO mode MS can communicate simultaneously with all active stations in diversity active set. In uplink (downlink), active stations (MS) are capable of diversity combining of received signals. In contrast to MDHO, in FASS the data are sent to all active stations in diversity active set but without diversity combining. Further the data are processed in anchor station only. An advantage of this handover type is not using of explicit handover signaling messages when anchor station is changed.

2. Definitions and terminologies used in this contribution

Anchor Station : A station where a MS or MRS is synchronized, performs ranging and monitors the downlink for control information. The anchor station can be a RS, BS, or MR-BS.

Fast Access Station Switching (FASS) : Method by which an MS can change its access station from frame to frame depending on the station selection mechanism. The access station can be an RS, BS, or MMR-BS. The MS is transmitting/receiving data to/from one of the active stations (the anchor station) during any given frame.

Macro Diversity Handover (MDHO) : The process in which an mobile station (MS) migrates from the air-interface provided by one or more access stations to the air-interface provided by one or more other access stations. This process is accomplished in the downlink (DL) by having two or more access stations transmitting the same

MAC/PHY protocol data unit (PDU) to the MS such that diversity combining can be performed by the MS. In the uplink (UL) it is accomplished by having two or more access stations receiving (demodulating, decoding) the same PDU from the MS, such that diversity combining of the received PDU can be performed among the access stations.

Active Station : A station that is informed of the necessary MS or MRS MAC/PHY information to enable it to provide access to the MS or MRS in the context of macro diversity.

MMR Diversity Set : The list of active stations of a given MS. This set is applicable to macro diversity handover, cooperative relay, and fast access station switching.

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 MMR-BS.

Neighbor Station : For any MS or RS, a neighbor station is a station (other than the anchor station) whose downlink transmission can be received by the MS or RS. A neighbor station can be a RS, BS, or MMR-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 MMR-BS.

Target Anchor Station : For any MS or MRS, the station which is the primary candidate to be the anchor station following a handover. A target anchor station can be a 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 MMR-BS.

3. Problem Statement

Due to the introduction of RSs in to the network infrastructure, there are two main categories of MDHO or FASS handover: (1) Intra MR-BS handover the diversity set is updated among a group of RSs or the MR-BS controlled by the same serving MR-BS which consists of four cases:
Case 1: the current anchor station and target anchor station is MR-BS ;
Case 2: the current anchor station is RS and target anchor station is MR-BS ;
Case 3: the current anchor station is MR-BS and target anchor station is RS ;
Case 4: the current anchor station and target anchor station is the same RS ;
Case 5: the current anchor station and target anchor station is the different RSs ;

(2) Inter MR-BS handover if the diversity set is updated among a group of RSs controlled by the multiple MR-BSs which consists of four cases:
Case 6: the current anchor station and target anchor station is the different MR-BSs ;
Case 7: the current anchor station is MR-BS and target anchor station is RS controlled by the different MR-BS ;
Case 8: the current anchor station is RS and target anchor station is MR-BS in a different MR-cell ;
Case 9: the current anchor station and target anchor station are the different RSs and also they are located in different MR-cells.

The signaling between the involved stations occurs over the wireless relay links as well as over the wired backbone. Handover procedure can be different depending on the coordination between an MR-BS and its subordinate RSs with regards to broadcast control messages such as preamble, FCH, DL-MAP, UL-MAP, DCD and UCD. In synchronous broadcast system only the MR-BS transmits all the broadcast control messages or RSs in the same MR-cell forward the same broadcast control messages. In asynchronous broadcast system a RS can transmit its own preamble, FCH, DL-MAP, UL-MAP, DCD, and UCD. The contribution discusses the MDHO handover and FASS handover in MR-cell network and defines the MAC handover procedure for an asynchronous broadcast system. The proposed MAC handover procedure and MAC messages will enable 802.16e compliant MS to handover seamlessly following the handover procedure defined in subclause 6.3.22 of 802.16e-2005. The proposed schemes will address network topology advertisement, MS scanning, cell selection, handover decision and initiation, network entry/re-entry for the diversity set update and anchor station update with the new access and serving stations(s), and termination with the current access and serving station(s).

3.1 Macro diversity handover and fast access station switching

The MDHO or FASS capability can be enabled or disabled in the REG-REQ/RSP message exchange. With MDHO or FASS enabled, the MS shall perform the following stages:

--- MDHO Decision: A MDHO begins with a decision for an MS to transmit to and receive from multiple MR-BS and/or RSs at the same time. A MDHO can start with either MOB_MSHO-REQ message by the MS or MOB_BSHO-REQ message by the anchor station.

--- FASS Decision: A FBSS handover begins with a decision for an MS to receive/transmit data from/to the anchor station that may change within the Diversity Set. A FASS handover can be triggered by either MOB_MSHO-REQ by the MS or MOB_BSHO-REQ message by the anchor station.

--- Diversity Set Selection/Update: An MS may scan the neighbor stations and to select those stations that are suitable to be included in the diversity set. The MS shall report the selected stations. The diversity set update procedure shall be performed by the anchor station and the MS.

--- Anchor Station Selection/Update: an MS is required to continuously monitor the signal strength of the stations that are included in the diversity set. The MS shall select one station from its current Diversity Set to be the Anchor station and reports the selected anchor station on CQICH or MOB_MSHO-REQ messages.

3.2 MDHO/FASS decision and initiation

The MR-BS or RS supporting MDHO or FASS shall broadcast the DCD message that includes the H_Add Threshold and H_Delete Threshold. These thresholds are used by the FASS/MDHO capable MS to determine if MOB_MSHO-REQ should be sent. When long term CINR of a anchor station is less than H_Delete Threshold, the MS shall send MOB_MSHO-REQ to require dropping this anchor station from the diversity set; when long-term CINR of a neighbor MR-BS or RS is higher than H_Add Threshold, the MS shall send MOB_MSHO-REQ to require adding this neighbor MR-BS or RS to the diversity set.

As defined in IEEE 802.16e-2005, MOB_BSHO-REQ and MOB_BSHO-RSP messages include the following information about possible target access stations for a particular MS:

--- Service level prediction
--- Preamble index/subchannel index
--- HO process optimization
--- Network assisted HO supported

--- HO_authorization policy support

This information was obtained over the backbone in 802.16e network,however it may need to be obtained over the relay links as well as the backbone. Therefore we may define two new MAC management messages MR_HOINFO-REQ and MR_HOINFO-RSP in order to exchange the information about the potential stations in diversity set.

3.3 Diversity Set update for MDHO/FBSS

When MOB_MSHO-REQ is sent by an MS, the MS may provide a possible list of MR-BSs and/or RSs to be included in the MS' Diversity Set. The MS may evaluate the possible list of MR-BSs and/or RSs through the received MOB_NBR-ADV message, and previously performed signal strength measurement, propagation delay measurement, scanning, ranging, and association activity. When MOB_BSHO-RSP is sent by the Anchor station in the MS' current Diversity Set, the MR-BSs may provide a list of MR-BSs or RSs recommended for incorporation into the MS' Diversity Set.

An MS and the potential stations in the diversity set shall conduct ranging by exchanging RNG-REQ and RNG-RSP. An MS can indicates a handover attempt by sending RNG-REQ message which includes a station ID TLV and sets bit number of the ranging purpose indication TLV set to 1.

Upon receiving such a RNG-REQ message, the potential stations 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, we define two new MAC management messages MR_MSINFO-REQ and MR_MSINFO-RSP for informing the MS information.

3.4 MDHO/FBSS handover termination

In IEEE 802.16e-2005, the successful MS network attachment at the diversity set is informed to the old anchor BS over backbone. However in 802.16j, this attachment may be informed over the relay links as well as the backbone, so we propose a new MAC management message MR_HO-IND. This information is used to inform the old anchor station of the successful MS network attachment at a new anchor MR-BS and/or RS.
change flows

4. Topology of MDHO and FASS handover

This section summarizes new MAC management message exchange flows and topology with regard to the related MDHO and FASS handover for the nine cases which is depicted in Figure1 1-9. In these figures, the solid arrowed lines denote the MS handover direction and the dotted arrowed lines the anchor update direction.

Figure 1depicts handover case 1 Intra MR-BS handover, the current anchor station and target anchor station is the same MR-BS and only diversity set updates in the same MR cell. Figure 2 depicts handover case 2 Intra MR-BS handover, the current anchor station is RS 1 and target anchor station is its serving MR-BS. Figure 3 depicts the handover for case 3 Intra MR-BS handover, the current anchor station is MR-BS and target anchor station is its RS 4 in the same MR-BS. Figure 4 depicts the handover case 4 Intra MR-BS handover, the current anchor station

and target anchor station is the same RS. Figure 5 depicts the handover case 5 Intra MR-BS handover, the current anchor station and target anchor station are the different RSs, but still in the same MR cell. Figure 6 depicts the handover case 6 Inter MR-BS handover, the current anchor station and target anchor station is the different MR-BSs. Figure 7 depicts the handover for case 7 Inter MR-BS handover, the current anchor station is MR-BS and target anchor station is RS controlled by the different MR-BS. Figure 8 depicts the handover for case 8 Inter MR-BS handover, the current anchor station is RS and target anchor station is MR-BS in a different MR-cell. Figure 9 depicts the handover for case 9 Inter MR-BS handover, the current anchor station and target anchor station are the different RSs and also they are located in different MR-cells.

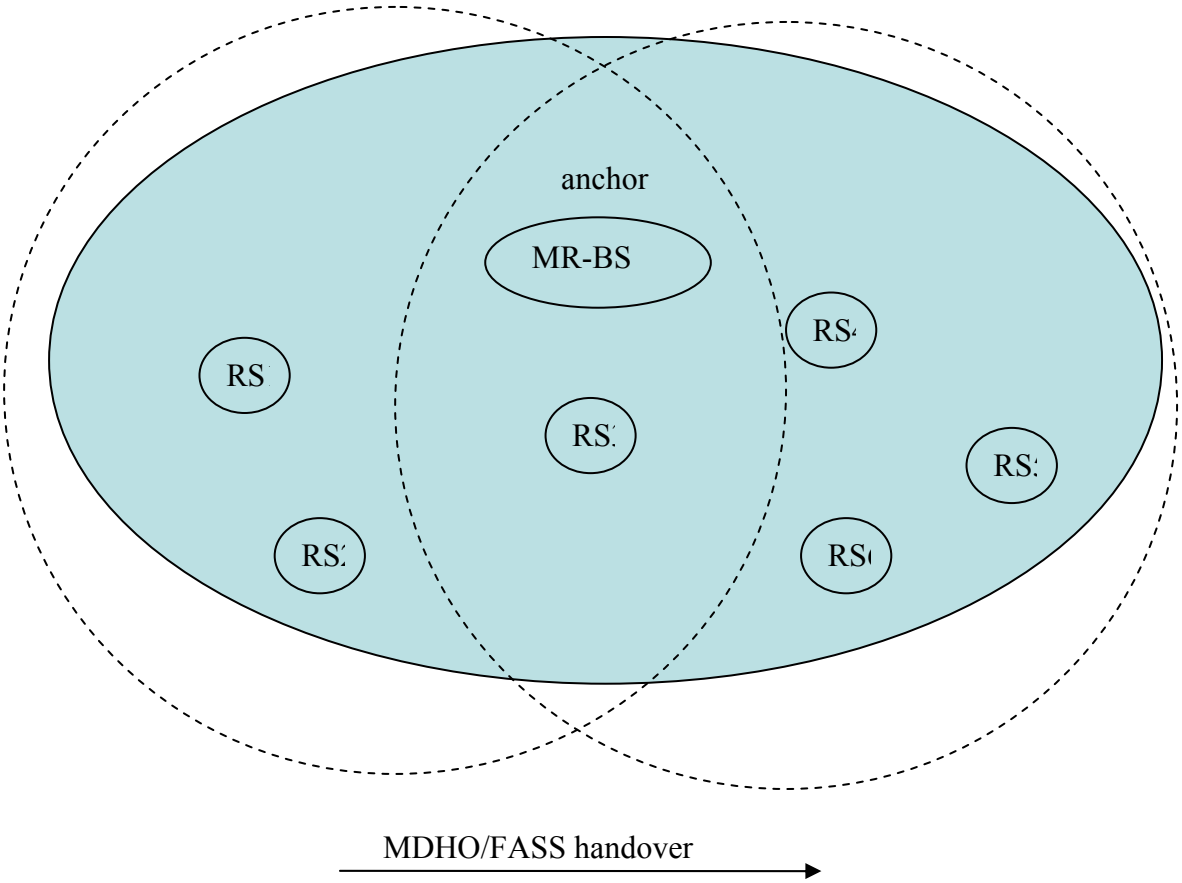

Figure 1 : Intra MR-BS handover, the current anchor station and target anchor station is the same MR-BS

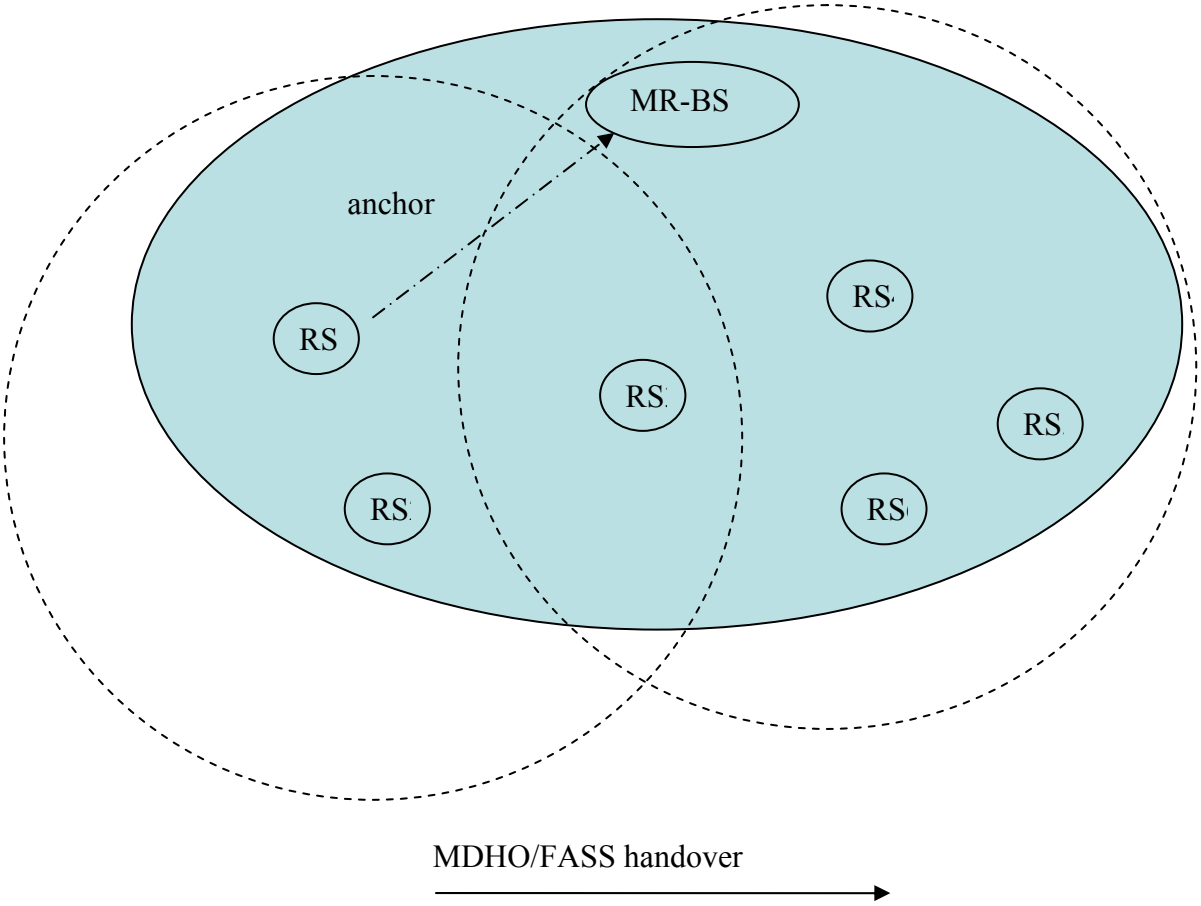

Figure 2 : Intra MR-BS handover, the current anchor station is RS 1 and target anchor station is its MR-BS

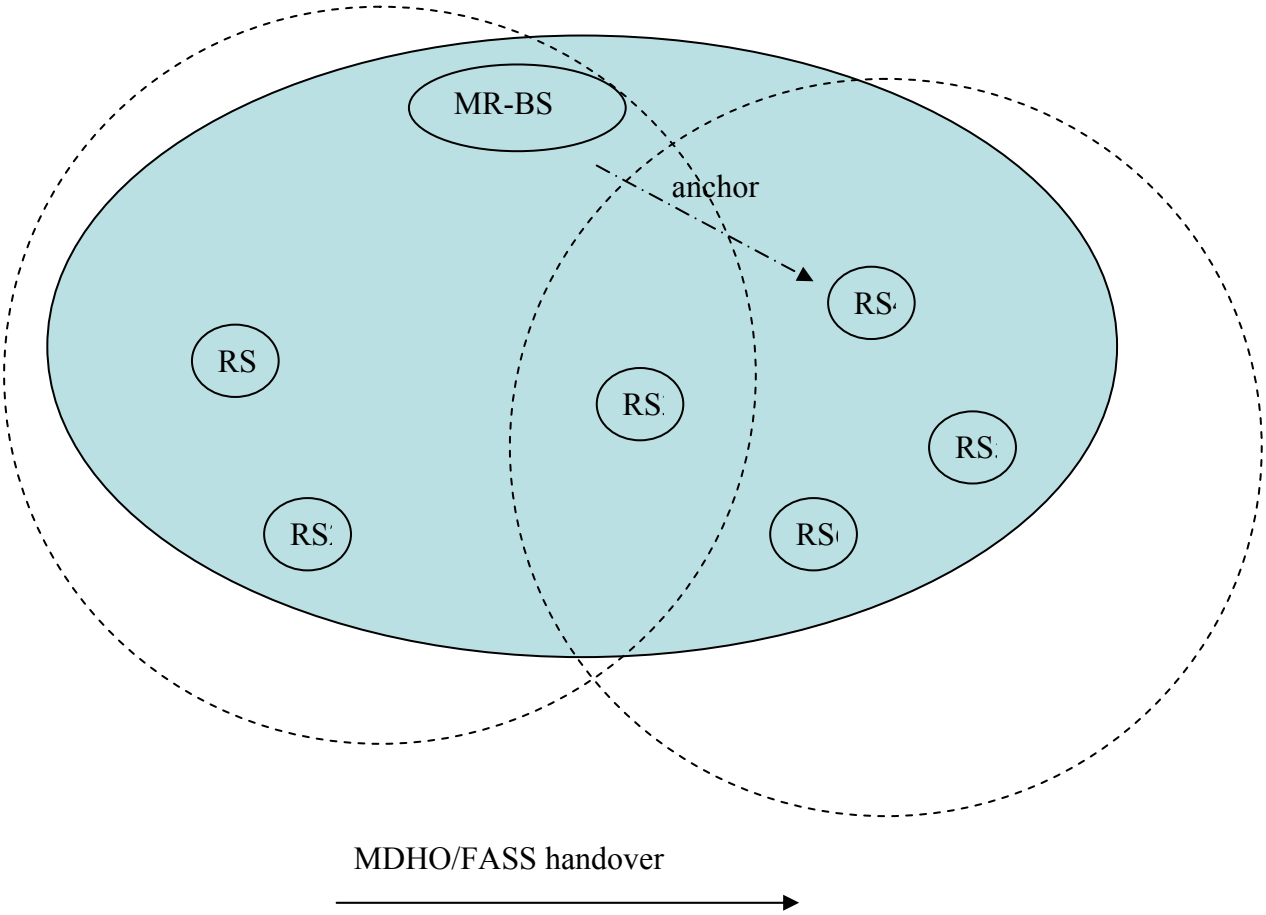

Figure 3 : Intra MR-BS handover, the current anchor station is MR-BS and target anchor station is its RS 4 in the same MR cell

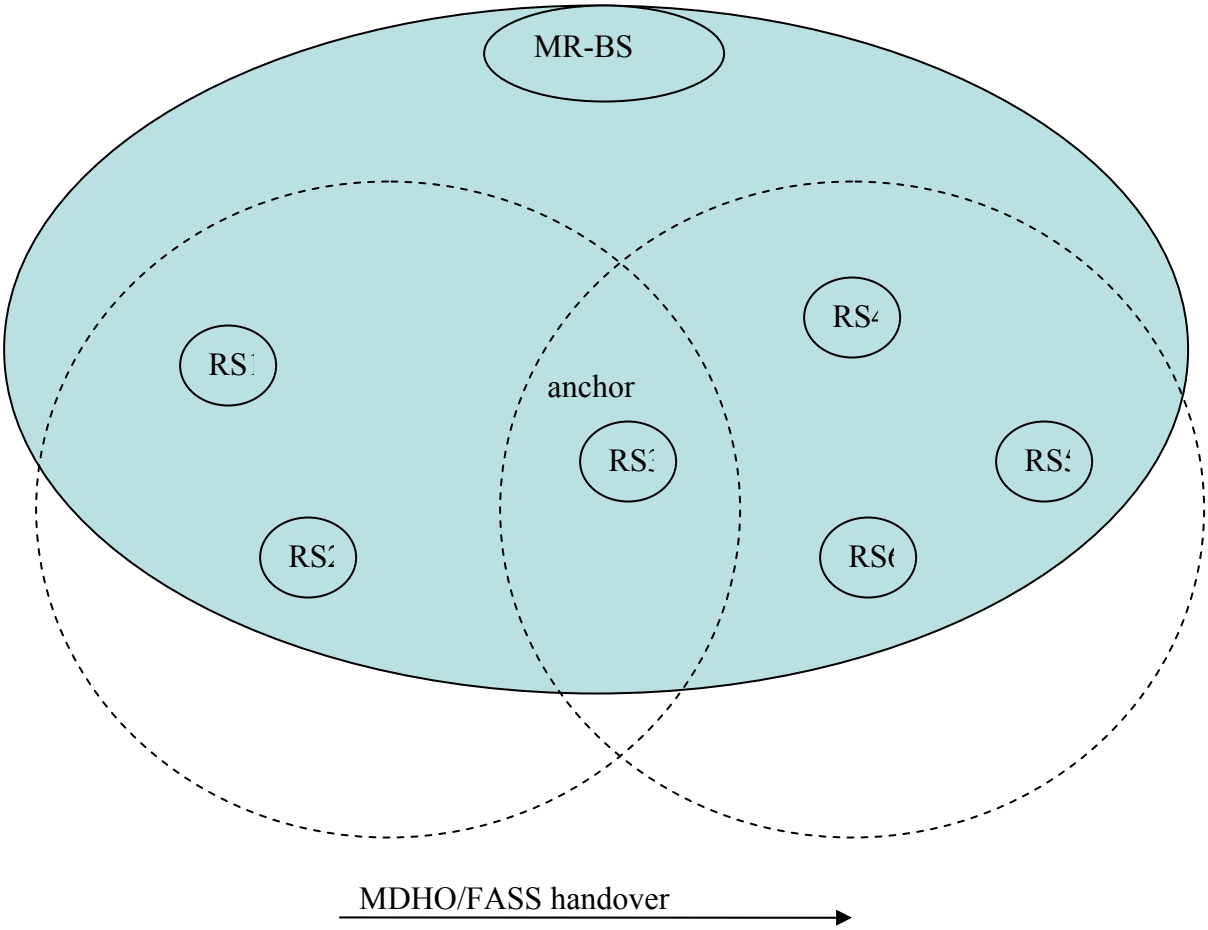

Figure 4 : Intra MR-BS handover, the current anchor station and target anchor station is the same RS

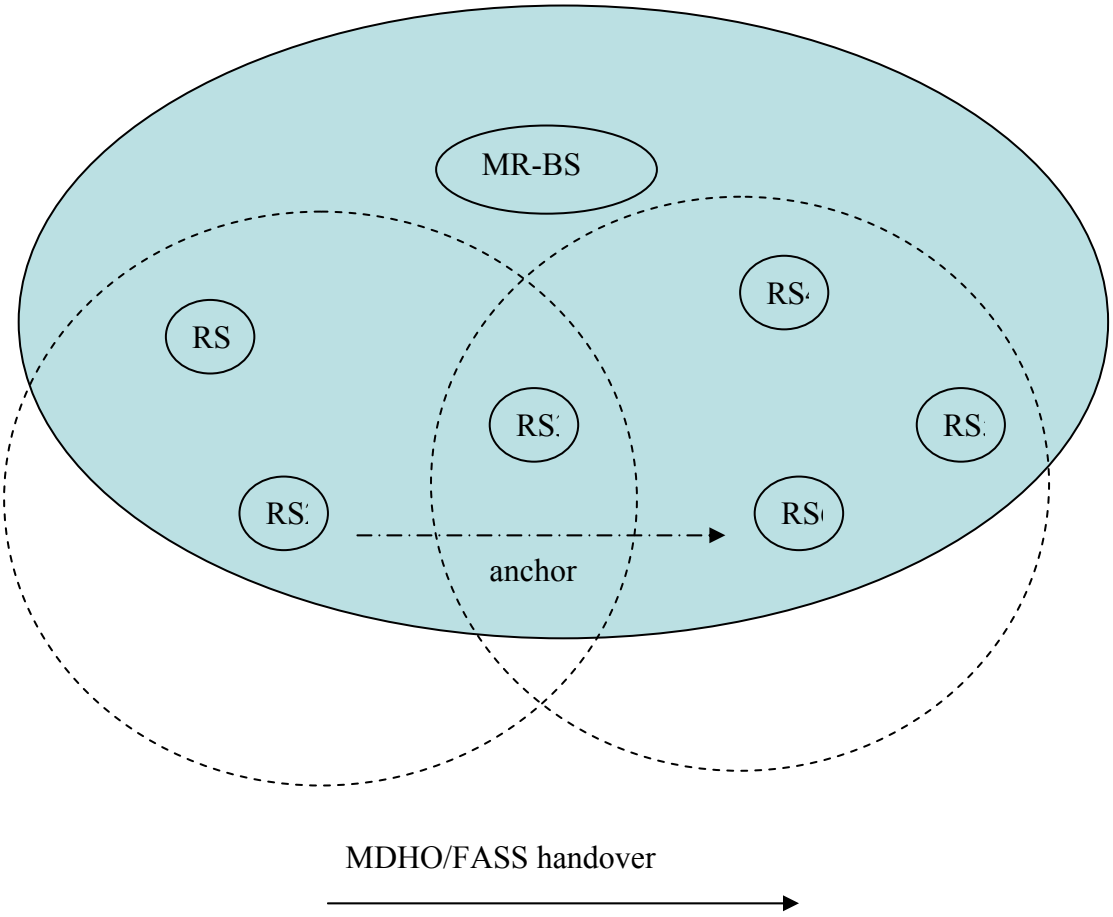

Figure 5 : Intra MR-BS handover, the current anchor station and target anchor station is the different RSs in the same MR cell

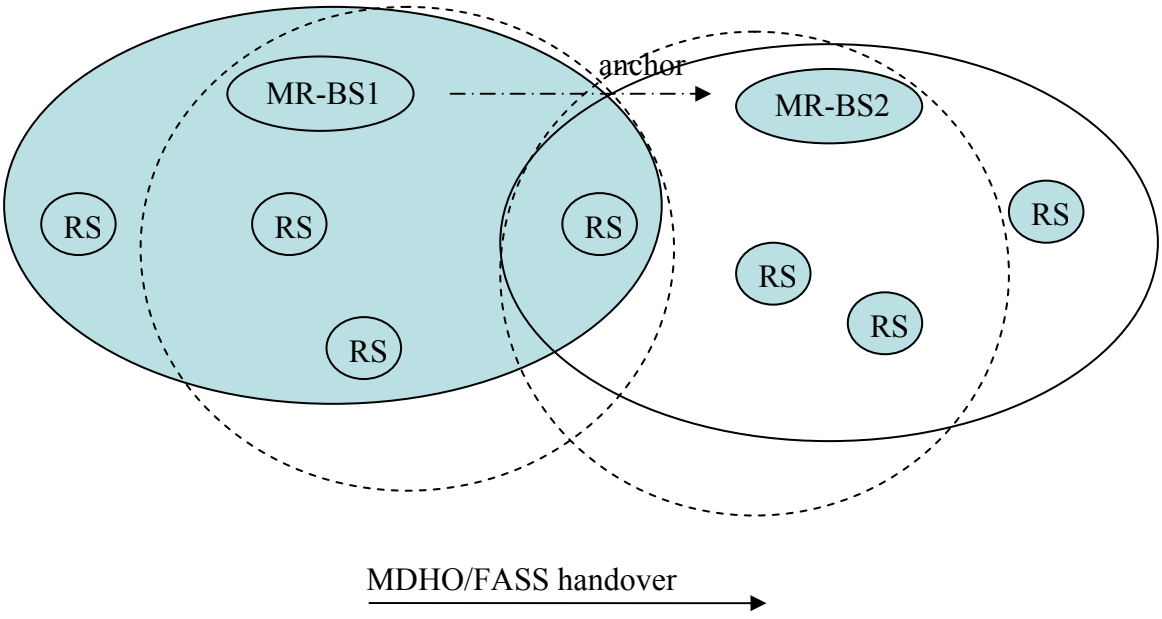

Figure 6 : Inter MR-BS handover, the current anchor station and target anchor station is the different MR-BSs

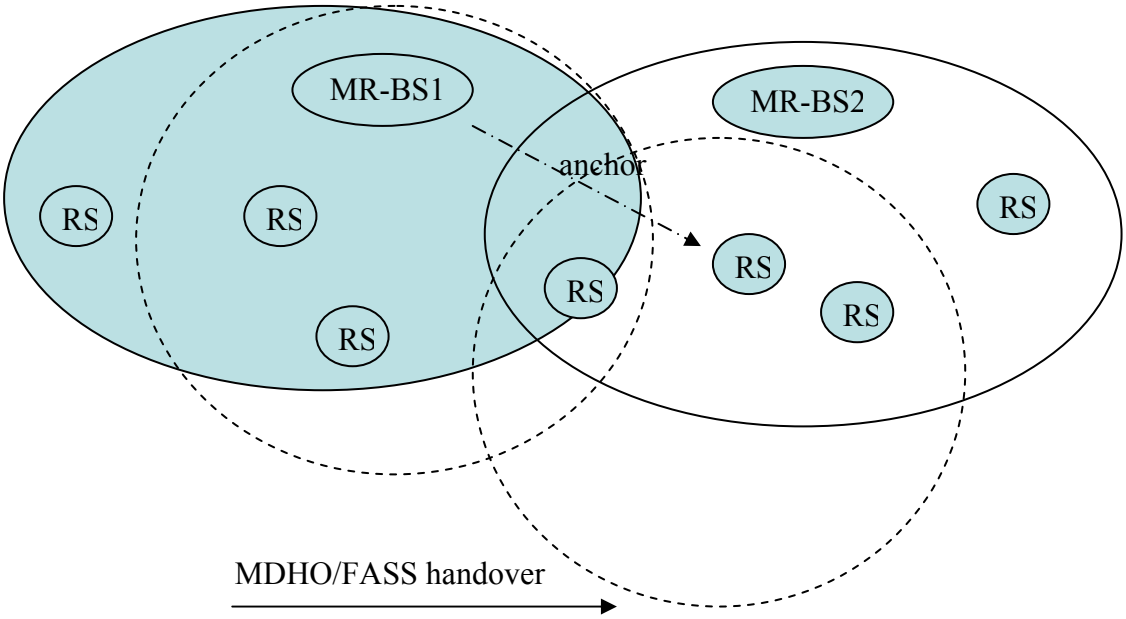

Figure 7 : Inter MR-BS handover, the current anchor station is MR-BS and target anchor station is RS controlled by the different MR-BS

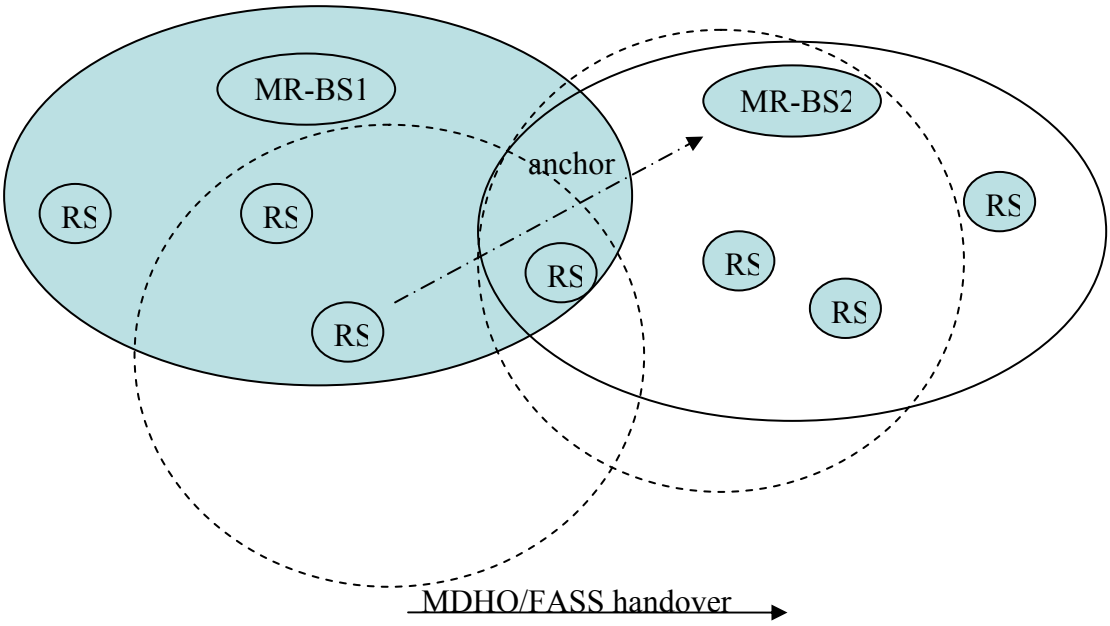

Figure 8 : Inter MR-BS handover, the current anchor station is RS and target anchor station is MR-BS in a different MR-cell

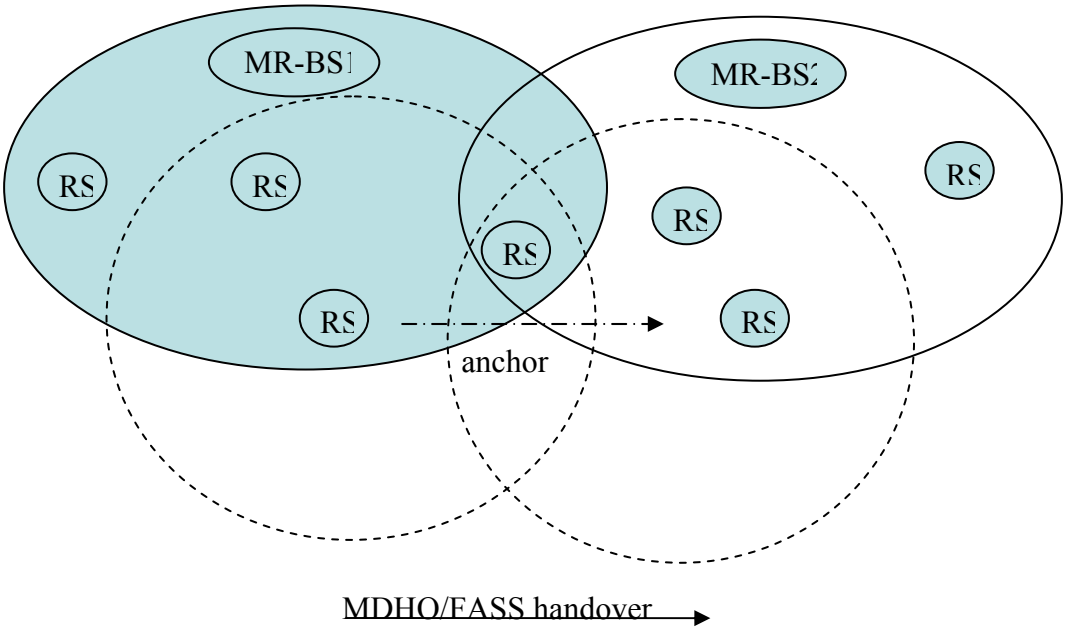

Figure 9 : Inter MR-BS handover, the current anchor station and
target anchor station are the different RSs and also they are located in different MR-cells

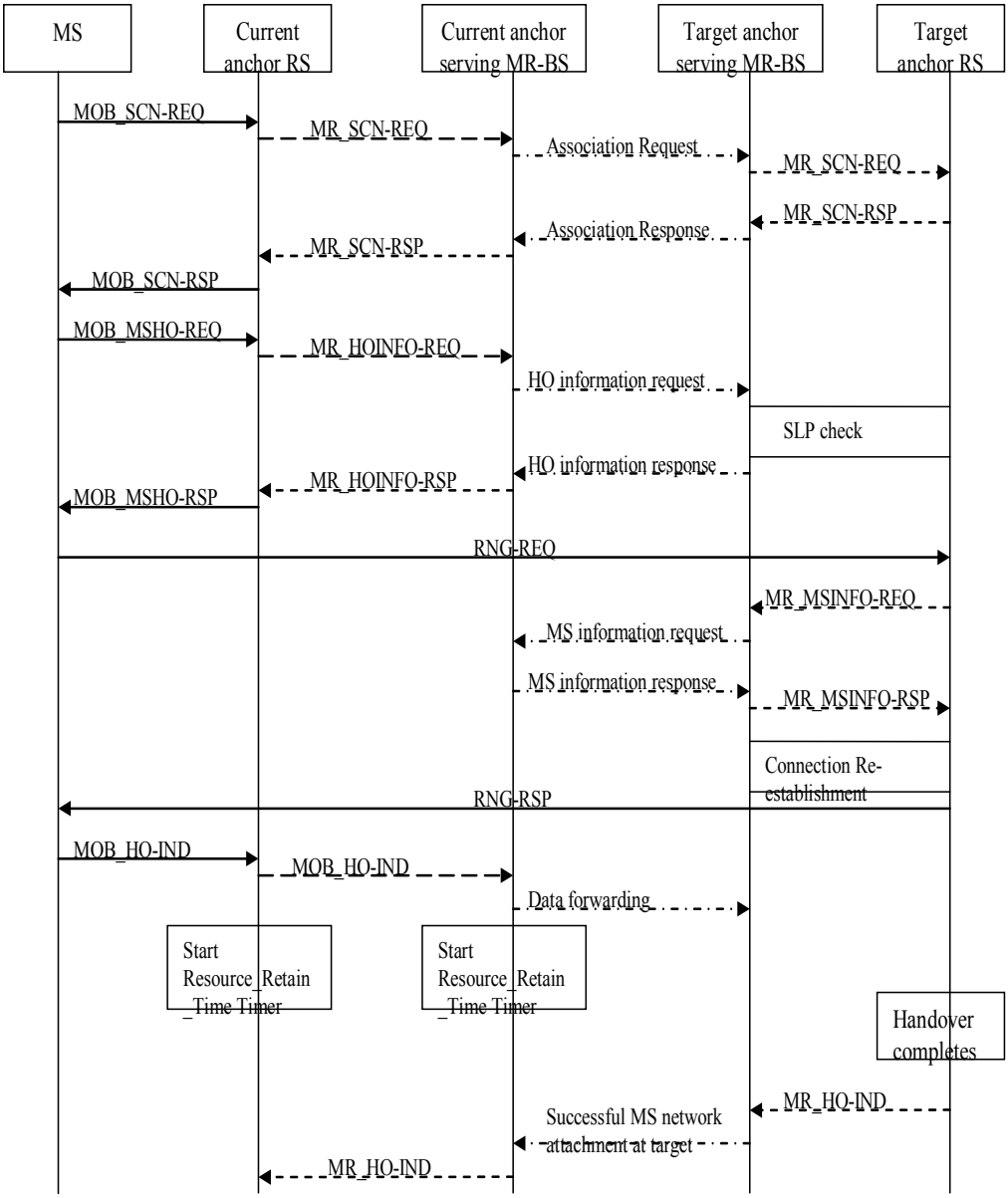

Figure 10: an example of MDHO/FASS handover flow diagram for case 9

5. Summary of New MAC management messages

The following table lists the proposed new MAC management messages for stations in an 802.16j network during each phase of the 802.16e MS MAC handover procedure. Figure 11 gives an example about MDHO/FASS handover procedure MDHO/FASS handover for case 9.

Table 1: new MAC management messages over relay links

New MAC messages	MS handover phase	Descriptions
MR_SCN-REQ MR_SCN-RSP	MS scanning	These two messages are used to coordinate an association for an MS at target anchor station
MR_HOINFO-REQ MR_HOINFO-RSP	MDHO/FASS decisi and initiation	These two messages are used to pass the handover related information of potential target anchor station to the current anchor station over relay links
MR_MSINFO-REQ MR_MSINFO-RSP	Handover execution	These messages are used to pass MS information to new anchor and target anchor station when actual handover is performed.
MR_HO-IND	Handover terminatio	This message is used to notify successful handover to the current anchor station and to the target anchor station.

6. Network topology advertisement

This section describes additions/modifications to network topology advertisement and MS scanning procedure.

An MR-BS or RS shall periodically broadcast a MOB_NBR-ADV message to all MSs that belong to its coverage. The MOB_NBR-ADV message includes access link channel information of other stations. The information may be obtained over wireless relay links as well as the backbone in an MR network. Therefore we define a new MAC management message MR_NBR-REQ for the information exchange over wireless relay links between MR-BS and RS, or between RS and RS. The new MR_NBR-RSP may be defined for the response of the MR_NBR-REQ messages.

The access station prepares a MOB_NBR-ADV message based on the information collected form the received MR_NBR-REQ messages. Then the access station transmits the MOB_NBR-ADV messages to its associated MSs.

MR_NBR-REQ message is used by an RS or MR-BS to make a request of access channel information of other stations to the serving MR-BS or upstream RS. The CID encoded in the general MAC header is the primary CID between an RS and an MR-BS or between the requesting RS and its upstream RS.

7. MS scanning

An access station may allocate scanning intervals to an MS seeking and monitoring suitability of a potential target access station for a handover. As defined in IEEE 802.16e-2005, an MS may request an allocation of scanning intervals and a certain type of association with each potential target access station using a MOB_SCN-REQ message. In IEEE 802.16e-2005, three association levels: Association Level 0, Association Level 1, and Association Level 2, are defined. The requested association level is encoded in the scanning type field of the MOB_SCN-REQ message. Upon receiving a MOB_SCN-REQ message, the access station responds with a MOB_SCN-RSP message. In IEEE 802.16e-2005, coordination between BSs can be achieved over backbone. However the coordination needs to occur over the relay links as well as the backbone in 802.16j networks. We define two new MAC management messages MR_SCN-REQ and MR_SCN-RSP for the coordination over relay links.

A current access station send messages MR_SCN-REQ message to negotiate the association level with a upstream relay station, or even MR-BS to provide MSs with the appropriate scanning opportunity.

8. Proposed text change

[Insert the following at the end of 6.3.22]

6.3.22.1.1 Topology of MDHO and FASS handover

Due to the introduction of RSs in to the network infrastructure, there are two main categories of MDHO or FASS handover: (1) Intra MR-BS handover the diversity set is updated among a group of RSs or the MR-BS controlled by the same serving MR-BS which consists of four cases:
Case 1: the current anchor station and target anchor station is MR-BS ;
Case 2: the current anchor station is RS and target anchor station is MR-BS ;
Case 3: the current anchor station is MR-BS and target anchor station is RS ;
Case 4: the current anchor station and target anchor station is the same RS ;
Case 5: the current anchor station and target anchor station is the different RSs .

(2) Inter MR-BS handover if the diversity set is updated among a group of RSs controlled by the multiple MR-BSs which consists of four cases:
Case 6: the current anchor station and target anchor station is the different MR-BSs ;
Case 7: the current anchor station is MR-BS and target anchor station is RS controlled by the different MR-BS ;
Case 8: the current anchor station is RS and target anchor station is MR-BS in a different MR-cell ;
Case 9: the current anchor station and target anchor station are the different RSs and also they are located in different MR-cells .

[Include Figures 1-10 here]

[Insert a new subclause following subclause 6.3.2.3.47.1]

6.3.2.3.47.1 Mutiple relay neighbor station request (MR_NBR-REQ)message

The access station prepares a MOB_NBR-ADV message based on the information collected form the received MR_NBR-REQ messages. Then the access station transmits the MOB_NBR-ADV messages to its associated MSs.

MR_NBR-REQ message is used by an RS or MR-BS to make a request of access channel information of other stations to the serving MR-BS or upstream RS. The CID encoded in the general MAC header is the primary CID between an RS and an MR-BS or between the requesting RS and its upstream RS.

Syntax	Size (bits)	Notes
MR_NBR-REQ_Message_format() {	-	-
Management message type = TBD	TBD	
N_Stations		Number of stations for requesting the channel information
For (i=0;i<N_Stations; i++) {		
Station ID	48	
Padding	TBD	
}		
}		

[Insert a new subclause following subclause 6.3.2.3.48.1]

6.3.2.3.48.1 Mutiple relay scanning interval allocation request (MR_SCN-REQ)message

An access station may allocate scanning intervals to an MS seeking and monitoring suitability of a potential target access station for a handover. As defined in IEEE 802.16e-2005, an MS may request an allocation of scanning intervals and a certain type of association with each potential target access station using a MOB_SCN-REQ message. In IEEE 802.16e-2005, three association levels: Association Level 0, Association Level 1, and Association Level 2, are defined. The requested association level is encoded in the scanning type field of the MOB_SCN-REQ message. Upon receiving a MOB_SCN-REQ message, the access station responds with a MOB_SCN-RSP message. In IEEE 802.16e-2005, coordination between BSs can be achieved over backbone. However the coordination needs to occur over the relay links as well as the backbone in 802.16j networks. We define two new MAC management messages MR_SCN-REQ and MR_SCN-RSP for the coordination over relay links.

A current access station send messages MR_SCN-REQ message to negotiate the association level with a upstream relay station, or even MR-BS to provide MSs with the appropriate scanning opportunity.

Syntax	Size (bits)	Notes
MR_SCN-REQ_Message_format() {	-	-
Management Message Type =	TBD	

TBD		
N_recommended_station	TBD	
For(i=0; i<N_recommended_station;i++)		
Recommended Station ID	48	
Recommended Type	3	
}		
Current access station ID	48	
Current MS ID	48	
Padding	TBD	Padding to reach byte boundary
}		

[Insert a new subclause following subclause 6.3.2.3.49.1]

6.3.2.3.49.1 Mutiple relay scanning interval allocation respo.1nse (MR_SCN-RSP) message

MR_SCN-RSP message is a response to MR_SCN-RSP

Syntax	Size(bits)	Notes
MR_SCN-REQ_Message_format () {		
Management Message Type = TBD	TBD	
N_recommended_station	TBD	
For(i<0; i<N_recommended_station;i++		
Recommended station ID	48	
Scanning Type	3	
If(scanning type.0) {		
Rendezvous time	8	
CDMA code	8	
Transmission opportunity offse	8	
}		
}		
Current access station ID	48	
Associated MS ID	48	
Padding	TBD	Padding to reach byte boundary
}		

9. Reference

"IEEE 802.16j Mobile Multihop Relay Project Authorization Request (PAR)," Official IEEE 802.16j Website: http://standards.ieee.org/board/nes/projects/802-16j.pdf, March 2006.

"IEEE Standard for Local and Metropolitan Area Networks − Part 16: Air Interface for Fixed Broadband Wireless Access Systems," IEEE Computer Society and the IEEE Microwave Theory and Techniques Society, October 2004.

"IEEE Standard for Local and Metropolitan Area Networks − Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands," IEEE Computer Society and the IEEE Microwave Theory and Techniques Society, February 2006.

"Harmonized definitions and terminology for 802.16j Mobile Multihop Relay," IEEE 802.16j-06/014r1 http://www.ieee802.org/16/relay/index.html, October 2006.