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Re:	IEEE 802.16j-07/019: "Call for Technical Comments Regarding IEEE Project 802.16j"	
Abstract	Text changes for FBSS/MDHO operation in multihop relay networks are proposed.	
Purpose	To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r4)	
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FBSS and MDHO operation in Multihop Relay Networks

Israfil Bahceci, Senarath Gamini, Peiying Zhu, Wen Tong, Mo Han Fong, Derek Yu, David Steer, Mark Naden

1. Introduction

Macro diversity handover (MDHO) and fast base station switching (FBSS) are two optional modes of handover operation in 802.16e. These two modes provide diversity gain, and reduce the disturbance due to frequent hard handovers. For a multihop relay network, we can also benefit from MDHO/FBSS operation by also including the RS into the diversity set.

First, the macro diversity gain from multiple RSs can improve the performance significantly. Second, when relays are in operation, since relay coverage areas is much smaller than the BS coverage, there may be many handovers among them compared to a 802.16e system. There may be a large number of ping pong situations where mobiles moving from one relay area to the other can return very often. In order to minimize such disturbances, to reduce the impact of these handovers, and to increase the signal quality in the relay boundaries, we propose that FBSS and MDHO be supported between relay stations and between relay stations and MR-BS(s).

The FBSS/MDHO procedures defined in the 16e need to be extended for this purpose and the objective of this contribution is to identify those changes necessary and to define the operation procedures for MDHO and FBSS. In the case of MR network with decentralized schedulers, some changes and new messaging between the MRBS and the RS are required. In the centralized scheduler case, we do not need any changes in 16e.

There can be several types of handover situations depending on whether RS, MRBS or 16e BS station is involved and in case of RS involvement, whether they belong to the same MRBS(s) (intra-MRBS) or different MRBS(s) (inter-MRBS) or whether they are transparent, non-transparent or whether RS(s) belong to different RS groups. In this contribution, we focus on inter-MRBS handovers since the standard changes required for other cases could be a subset of the changes indicated for this case.

There is another situation where a RS connects to its parent in FBSS or MDHO mode. This is helpful for MS FBSS/MDHO in order to save resources in the uplink when a MS is in MDHO/FBSS. This comes under a separate category of “RS Handover”, although its usage for MS handover is discussed in this contribution. Since the MDHO/FBSS for an RS follows in a similar way to that for the MS, we do not need further amendments for this case.

2. IEEE 802.16e procedures for FBSS/MDHO and Amendments for MR operation

In this section, we provide some background information for MDHO/FBSS operation in 16e and propose the required changes to enable it for MR operation.

2.1. Handover Scenarios for MR Networks with Non-transparent Relays

In FBSS/MDHO, the standard support is required to enable

(1) updating the diversity set and establishment/disconnection of the parallel data communication paths,

(2) establishment of the data communication after the change of the anchor station (FBSS),

(3) change of the anchor station (FBSS).

- **Diversity set update:**

  BS and MS keep a diversity set list and an anchor base station for each MS. For this a Temp BSID may be used (diversity member ID). For FBSS, only one BS of the diversity set is active (or anchor BS) and communicate with the MS at a given time. For MDHO, in the downlink, all the members in the diversity set synchronously transmit same data to the MS so that MS does soft combining. For MDHO uplink operation, all the members in the diversity set receives signal and forward to the central node for soft/selection combining. MOB_BSHO_REQ/RSP (from BS to MS), MOB_MSHO_REQ (from MS to BS) messages are used for establishing/updating the diversity sets in both MDHO and FBSS operation.

  There are two messages for neighbourhood and topology advertisement:

  MR_NBR_INFO: MR-BS sends to RS this message to update RS with information regarding neighbourhood stations.

  MOB_NBR_ADV: MR-BS transmits neighbourhood info for MSs. There are DCD/UCD, preamble index, etc. and some other information in this message (DCD_setting and UCD_setting).

  In a MR-BS system, the diversity set may also include RSs in addition to the BSs. In the messages above, it is not mentioned that the neighbourhood stations can include non-transparent RS(s). It is required to update these messages such that they may include parameters for the non-transparent RSs and MRBSs in addition to the BSs. Furthermore, MOB_BSHO_REQ/RSP and MOB_MSHO_REQ messages need to be updated to reflect this.

  MRBS and MS keep track of the diversity set for the MSs. There is no special advantage by keeping the diversity set at the RSs. However, each RS in the diversity set should know its own presence in a diversity set when an MS adds that RS to the diversity set. In addition, the anchor station needs to know that it is the anchor station. Therefore, the anchor RS should inform the MRBS explicitly or forward to the MRBS the MS's request for addition of another RS and again forward back the MRBS's response. The MRBS can inform the new diversity member (RS) about its addition, by sending a new message.

  A removal of an RS from the diversity also can be done in a similar manner. Using 16e procedures the anchor station relays the MS messages to MRBS and MRBS's messages to the anchor station. The MRBS can then inform the diversity member about its deletion.

- **Anchor BS/RS update:**

  There are two methods defined for this purpose.

  (a) HO MAC Management message method (for both FBSS and MDHO): MS inform BS of preferred anchor BS using MOB_MSHO_REQ. BS sends its recommendation using MOB_BSHO_REQ or MOB_BSHO_RSP. MS can accept/reject it by MOB_HO_IND. When they clash, MS ignores BS's message or even reject it using MOB_HO_IND message. Final confirmation of the list is sent by MOB_HO_IND (which includes the list) as well. MS can later cancel the set by

MOB_HO_IND message.

The RS has to forward these messages to the MR-BS in the centralized operation or responds to them in the decentralized operation. When RS receives MOB_MSHO_REQ or MOB_BSHO_REQ, it can relay the message to the destination node. The MOB_HO_IND message can also be relayed from MS to MRBS by the anchor RS. In case of any update on the diversity set status of the anchor RS, the MRBS sends the RS_Diversity_Set_Update_REQ() message to this RS.

(b) Fast Anchor/BS Selection feedback Mechanism (Only for FBSS): Fast feedback channel is used for informing the anchor BS on a MS's anchor Station Selection. BS informs all the MSs L (frame number for minimum wait time) and M (frame number) parameters as a configuration message. After detecting a potential target BS, MS requests an anchor switch indicator to the current anchor BS using the CQICH channel assigned by the current anchor BS. Anchor BS may accept it using the Anchor_BS_switch_IE message which includes the BS (it may also select a different one from the one requested by MS), "time to switch" and the "CQICH channel" information or request cancel indicator. After waiting minimum time of L frames (timer in the MS), the MS could transfer to the new BS. A CQICH is already assigned in the new BS (as indicated above) or MS may request a new channel and continue switching.

If this method is used for updating the anchor station, the RS may send a MOB_MSHO_REQ message to the serving MRBS, which can inform the new anchor station (if it is a nontransparent RS) via RS_Diversity_Set_Update_REQ() message.

Allocation of CQICH channel: In decentralized MR network, a RS may allocate the CQICH channel to its subordinate nodes when it is selected as an anchor station. If the RS is included in the diversity set of an MS, the RS may need to inform MRBS about this allocation. The RS_Diversity_Set_Update_RSP() message is introduced to transmit the CQICH information to MRBS and, also to acknowledge the reception of a RS_Diversity_Set_Update_REQ() message.

- **Share/transfer MAC context between two BSs:**

Such MAC context includes all information MS and BS normally exchange during Network Entry, particularly authentication state, so that an MS authenticated/registered with one of BSs from diversity set BSs is automatically authenticated/registered with other BSs from the same diversity set. The context also includes a set of Service Flows and corresponding mapping to connections associated with MS, current authentication, and encryption keys associated with the connections.

Since MRBSs already have all MAC context of MSs that they serve, they can transfer the required portion of the MAC context to the RSs if the that RS is included into the diversity set of the MS. These parameters are included as the MACSetting_TLV into the RS_Diversity_Set_Update_REQ() message. Alternatively, the DSx-REQ/RSP/ACK messages can also be used to populate this information at the anchor RS.

- **MS-Assisted coordination of DL Transmission at new Anchor BS for FBSS**

Once the MS has successfully switched to the new anchor BS, to maintain continuity of transmission to the MS between the old and new anchor BSs, the last successfully received information unit needs to be identified to the new anchor BS. Depending on whether the connection is ARQ enabled or ARQ

disabled, the identity of the next information unit can be given by the ARQ block sequence number or the MAC SDU sequence number respectively.

If SN feedback is enabled, the MS can feedback the ARQ block sequence number or virtual MAC SDU sequence number after switching to new anchor station. If anchor station is an RS, the MRBS or RS may allocate UL resource to the MS via UL MAP IE for MS to transmit the LSB of the sequence numbers of ARQ blocks or virtual MAC SDU on the SN Report MAC header. Note that the RSs can intercept the headers and they can extract the SN from the message as well as required. Once the handover to the new anchor station has been completed, acknowledgement and/or retransmission of any outstanding ARQ blocks is handled per the ARQ mechanism defined in 6.3.4.

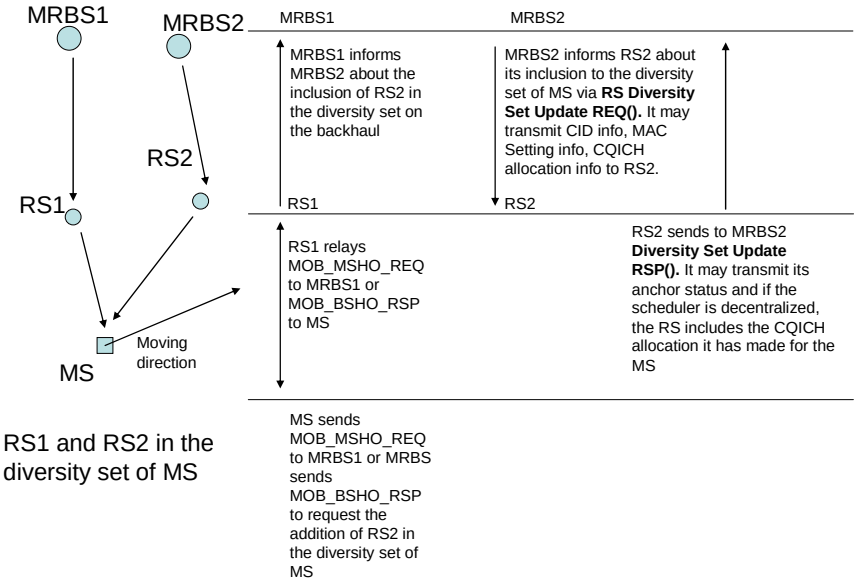

Figure 1 Example message flow for diversity set update

2.2. FBSS/MDHO Handover Scenarios for MR Networks with Transparent Relays and Virtual Relay Groups

Since no changes are required for the standards and current base line document C6802.16-06/26r4, we omit this case.

2.3. FBSS/MDHO for RS Handover

No further changes in the standard are required for this case. The same procedures for MS can be employed for the RS(s).

3. Proposed Text Changes

[Modification in 6.3.2.3.47, 6.3.2.3.52, 6.3.2.3.53, 6.3.2.3.54 and 6.3.2.3.55. These messages currently refer to only BSs for diversity sets for MDHO and FBSS scenarios. They shall be modified to include non-transparent RSs as potential members of a diversity set. At the end of first paragraph of each section, include the following text]

[Insert the following text at the end of the first paragraph in 6.3.2.3.47]

Non-transparent RSs and MRBS(s) may also be included as the neighbor stations in addition to BS(s). Furthermore, this message may also be targeted for a RS.

[Insert the following text at the end of the first paragraphs in 6.3.2.3.52, 6.3.2.3.53, 6.3.2.3.54 and 6.3.2.3.55]

Non-transparent RSs and MRBS(s) may also be included as the diversity set members in addition to BS(s). Furthermore, this message may also be targeted for an RS to enable FBSS/MHDO for a RS.

[Insert new subclause 6.3.2.3.91]

6.3.2.3.91 RS_Diversity_Set_Update_REQ message

The MRBS may transmit a RS_Diversity_Set_Update_REQ message to a RS when the RS is included into a diversity set of MS or if the status of the RS in a diversity set needs update.

RS_Diversity_Set_Update_REQ is transmitted on RS Basic CID.

RS_DiversitySet_Update_REQ_Message_format() {	**Size**	**Notes**
Management Message Type=XX	8 bits	
Mode	3 bits	0b000: Include RS to the diversity set 0b001: Update RS status in the diversity set without CID update 0b010: Diversity set update with CQICH allocation info included. For decentralized RS, CQICH allocation may not be included 0b011: MAC Context parameters included 0b100-0b111 reserved
If (Mode = 0b000) {		
Temp BSID		0..7: Diversity set member ID
Anchor_IND	1 bit	0b1: RS is the anchor access station 0b0: RS is a diversity set member
N_CIDs	8 bits	Number of CIDs associated with the MS who has this RS as a member of its diversity set
for (j=0 ; j<N_CIDs ; j++) {		
New CID	16 bits	New CID to be used after Diversity Set is updated. CIDs for the MS whose data to be forwarded in MDHO/FBSS mode. The New CIDs shall be set according to the followings: the first CID in the list shall be basic CID; the second CID in the list shall be primary management CID, the third CID in the list shall

		be Secondary Management CID if secondary management connection is established for the MS at the current serving BS. The remaining CIDs shall be transport CIDs, multicast CIDs are enumerated by the ascending order of corresponding current SFIDs. The MS shall store the CIDs associated with the newly added RS and using the CIDs when the newly added RS becomes the anchor station
}		
Action time	8 bits	Action time when the anchor station will be updated
}		
If (Mode == 0b001) {		
Temp BSID	3 bits	Diversity set member ID
Anchor IND	1 bit	0b1: RS is the anchor access station 0b0: RS is a diversity set member
Action time	8 bits	Action time when the anchor station will be updated
}		
If (Mode == 0b010) {		CQICH allocation for the MS included
Temp BSID		
Anchor_IND	1 bit	0b1: RS is the anchor access station 0b0: RS is a diversity set member
N_CIDs	8 bits	Number of CIDs associated with the MS who has this RS as a member of its diversity set
for (j=0 ; j<N_CIDs ; j++) {		
New CID	16 bits	New CID to be used after Diversity Set is updated. CIDs for the MS whose data to be forwarded in MDHO/FBSS mode. The New CIDs shall be set according to the followings: the first CID in the list shall be basic CID; the second CID in the list shall be primary management CID, the third CID in the list shall be Secondary Management CID if secondary management connection is established for the MS at the current serving BS. The remaining CIDs shall be transport CIDs, multicast CIDs are enumerated by the ascending order of corresponding current SFIDs. The MS stores the CIDs associated with the newly added RS and using the CIDs when the newly added RS becomes the anchor station
}		
If (Anchor IND == 1[IB1]) {		If RS is set as anchor station
CQICH_ID	Variable	Index to uniquely identify the CQICH resource assigned to the MS after the MS switched to the new anchor station.
Feedback channel offset	6 bits	Index to the fast-feedback channel region of the new Anchor BS marked by UIUC.
Period(p)	2 bits	A CQI feedback is transmitted on the CQICH every 2^p frames.
Frame offset	3 bits	The MS starts reporting at the frame of which the number has the same 3 LSB as the specified frame offset. If the current frame is specified, the MS should start reporting in eight frames.
Duration	3 bits	A CQI feedback is transmitted on the CQI

		channels indexed by the CQICH_ID for 10×2^d frames. If d == 0b000, the CQI-CH is de-allocated. If d == 0b111, the MS should report until the BS command for the MS to stop.
MIMO permutation feedback cycle	2 bits	0b00 = No MIMO and permutation mode feedback 0b01 = the MIMO and permutation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every four CQICH transmission opportunities allocated to the MS in this message. The first indication is sent on the 4th CQICH transmission opportunity allocated to the MS in this message. 0b10 = the MIMO mode and permutation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every eight CQICH transmission opportunities allocated to the MS in this message. The first indication is sent on the 8th CQICH transmission opportunity allocated to the MS in this message. 0b11 = the MIMO mode and permutation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every 16 CQICH transmission opportunities allocated to the MS in this message. The first indication is sent on the 16th CQICH transmission opportunity allocated to the MS in this message.
}		
Action time	8 bits	Action time when the anchor station will be updated
}		
If (mode==0b011) {		
MAC_setting	variable	TLV encoded info
}		

MAC_seeting

MAC_setting is a TLV variable that includes the MAC context that may be required by RS members of the Diversity Set in MDHO/FBSS operation. The detailed content (SFID, QoS parameters, parameters for HARQ enabled traffic) is TBD.

6.3.2.3.92 RS_Diversity_Set_Update_RSP message

The RS may transmit a RS_Diversity_Set_Update_RSP message to a MRBS when the RS receives a RS_Diversity_Set_Update_REQ message.

RS_Diversity_Set_Update_RSP is transmitted on RS Basic CID.

RS_Diversity_Set_Update_ _RSP_Message_format() {	**Size**	**Notes**
Management Message Type=XX	8 bits	
ACK IND	2 bits	00: RS accepts diversity set membership 01: RS accepts to be an anchor station

		10: RS denies diversity set membership 11: Reserved
Mode	3 bits	0b000: CQICH allocation info included. 0b001-0b111 reserved
If (ACK_IND == 0b01) {		
If (Mode == 0b000) {		CQICH allocation for the MS included
Temp BSID		
Anchor_IND	1 bit	0b1: RS is the anchor access station 0b0: RS is a diversity set member
If (Anchor IND == 1) {		If RS is set as anchor station
CQICH_ID	Variable	Index to uniquely identify the CQICH resource assigned to the MS after the MS switched to the new anchor station.
Feedback channel offset	6 bits	Index to the fast-feedback channel region of the new Anchor BS marked by UIUC.
Period(p)	2 bits	A CQI feedback is transmitted on the CQICH every 2^p frames.
Frame offset	3 bits	The MS starts reporting at the frame of which the number has the same 3 LSB as the specified frame offset. If the current frame is specified, the MS should start reporting in eight frames.
Duration	3 bits	A CQI feedback is transmitted on the CQI channels indexed by the CQICH_ID for 10×2^d frames. If d == 0b000, the CQI-CH is de-allocated. If d == 0b111, the MS should report until the BS command for the MS to stop.
MIMO permutation feedback cycle	2 bits	0b00 = No MIMO and permutation mode feedback 0b01 = the MIMO and permutation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every four CQICH transmission opportunities allocated to the MS in this message. The first indication is sent on the 4th CQICH transmission opportunity allocated to the MS in this message. 0b10 = the MIMO mode and permutation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every eight CQICH transmission opportunities allocated to the MS in this message. The first indication is sent on the 8th CQICH transmission opportunity allocated to the MS in this message. 0b11 = the MIMO mode and permutation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every 16 CQICH transmission opportunities allocated to the MS in this message. The first indication is sent on the 16th CQICH transmission opportunity allocated to the MS in this message.
}		
}		
}		

[Subclause 6.3.22.3]

6.3.22.3 Macro diversity handover and fast BS switching

[Insert the following text at the end of subclause]

A MDHO/FBSS handover mode may also involve non-transparent RS(s), and the procedures for MDHO/FBSS operation can also be employed in the presence of RS(s) in the diversity set. RS(s) may be included to diversity set in addition to the MRBS(s) and BS(s). A MRBS shall inform its subordinate RS(s) via RS Diversity Set Update REQ message when they are included in a diversity set. The RS may acknowledge with RS Diversity Set Update RSP message to the MRBS. The RSs may relay the MOB_BSHO_REQ/RSP, MOB_MSHO_REQ, and MOB_HO_IND messages between the MRBS and RSs/SS whenever they are generated by MSs or MRBSs.