Re: IEEE 802.16j-06_034: “Call for Technical Proposals regarding IEEE Project P802.16j”

Abstract

Two typical multi-hop HARQ mechanisms, active Multi-hop Relaying (MR) HARQ and passive MR HARQ, are proposed in this document. The active MR HARQ, supporting functions such as high mobility of the RS, CID update and traffic congestion, is a mechanism on the per-hop basis, and fewer resources are required for HARQ retransmissions. The passive MR HARQ is a multi-hop mechanism for simplicity, and the cooperative relay can be implemented with it.

Purpose

This document is provided as the input for the IEEE802.16j.

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I. Introduction

In relay based wireless communication systems, the efficiency of HARQ (Hybrid ARQ) mechanism is critical owing to its great impact on the transmission delay and the system capacity [1-2]. The intention of this proposal is to develop efficient HARQ retransmission mechanisms adapted to relay based 802.16j systems and their certain functions by the collaboration between relay stations (RS) and base stations (BS).

As illustrated in Figure 1, two kinds of HARQ mechanisms are proposed for different application scenarios and environments. The first one is the active Multi-hop Relaying (MR) HARQ which is a per-hop mechanism performed over a single hop to compensate for the in-between fast fading and shadowing, and therefore the use of this mechanism allows for the high mobility of the RS, i.e., metro; the second is the passive MR HARQ which is a multi-hop HARQ mechanism performed at the ends of multi-hop links, and in this case, much more stable wireless channels are expected and the design of the RS is relatively simpler than the previous one. In addition, it is easier for RS with the active MR HARQ to perform CID change for the purpose of traffic congregation.

This proposal focuses on mechanisms and implementations regardless of HARQ coding and combining techniques, and both soft combining and Incremental Redundancy (IR) combining are supported. These schemes apply to both uplink and downlink.

II. System Description

1. Active MR HARQ

In this mechanism, the per-hop HARQ is performed over each single hop. During each hop, the RS reports to the BS “actively” by a certain message whenever an ACK or a NACK is received, and then the BS correspondingly allocates the resources for the following HARQ retransmission. The principle and procedure of this mechanism is illustrated in Figure 2, where typical 3-hop HARQ procedures in both uplink and downlink are given as examples.

As shown in Figure 2, only the packets which are possibly correct after HARQ combining or whose retransmissions reach their maximum will be forwarded. For example, the RS receives an uplink packet correctly while an “NACK” is received from the BS, that means the errors happened within the hop between the RS and the BS, and then the RS goes on with retransmission and informs the MS of the correct reception with an “ACK”. In this case, it is the BS that allocates the resources for HARQ retransmissions exclusively.

To avoid serious delay due to relaying and retransmission, multiple HARQ retransmissions are proposed to be scheduled within one frame for time diversity if free resources are enough for hops with no MS involved. The support of the BS is expected in this scheme.
Furthermore, the use of the per-hop HARQ retransmission allows for the different CIDs for the RS and the MS. That means this mechanism can support some special functions of the RS, such as traffic congregation.

2. Passive MR HARQ

Suppose CID is unchanged in the RS, the passive MR HARQ mechanism is expected to be simpler than the active HARQ.

In this mechanism, the number of hops to the destination for the multi-hop HARQ depends on whether the RS correctly receives the initial or combined packet to achieve the flexible and reliable transmission. If CRC is failed at the RS for the initial transmission, the multi-hop HARQ is performed between the source and the destination until the packet after combining at the RS is correct. Otherwise, the multi-hop HARQ is employed between the RS and destination to recover the original data. ACK/NACK message is only initiated by destination, and the RS is responsible to forward the ACK message or invert the NACK to ACK message in
accordance with its CRC verification. No additional messages are required. A 2-hop example of the passive MR HARQ is illustrated in Figure 3.

For the initial transmission of HARQ, the RS performs forwarding regardless of its CRC result. As shown in Figure 3, when HARQ retransmission is received by the RS, it is then combined with the previous receptions. In the case of Chase combining, the combined packet is forwarded no matter whether it is error-free or not. In the case of IR combining the RS forwards this correct packet only if the combined packet is error-free. Otherwise, the original received HARQ retransmission or the combined packet will be forwarded. This procedure continues until the destination correctly receives the packet or the maximum allowed retransmission number is reached.

As a multi-hop HARQ mechanism, the BS keeps requesting the MS to perform HARQ retransmission until its correct reception. Therefore, some resources might be wasted if the correct packet is received in the RS but not received in the BS. However, no extra message is required in this mechanism to inform the BS of the statuses of all intermediate nodes and cooperative relaying can be supported in this mechanism.

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![Fig.3: The passive MR HARQ mechanism in uplink](image)

III. Summary

Two complementary multi-hop HARQ mechanisms, active MR HARQ and passive MR HARQ, are proposed for different scenarios and environments. The active HARQ is a mechanism on the per-hop basis to allow for high mobility of the RS and special functions, i.e., CID update and traffic congregation, and fewer resources are required for HARQ retransmissions. The passive MR HARQ is a multi-hop mechanism with limited intelligence, so that the RS is simple and used in the stable environments. In addition, cooperative relay can be implemented with the latter one.

IV. Proposed Text Changes

6.3.2.3 MAC Management messages

*Change the Table 14 as indicated:*
Two kinds of HARQ control IE are located in DL/UL MAP_IE. One is HARQ_Control_IE for MS and the other is MR_HARQ_Control_IE for RS. Both formats include encoding/decoding information for HARQ enabled DL/UL bursts, and are presented in the MAC frame.

In MR_HARQ_Control_IE, two HARQ mechanisms, active Multi-hop Relaying (MR) HARQ and passive MR HARQ, are alternative under the indication of Syntax “MHH”.

[Insert Table 94b as indicated (note that the original Table 94 is changed to be Table 94a)]

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefix</td>
<td>1 bit</td>
<td>0 = Temporary disable MR HARQ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = enable MR HARQ</td>
</tr>
<tr>
<td>AI_SN</td>
<td>1 bit</td>
<td>HARQ ID Seq. No</td>
</tr>
<tr>
<td>SPID/Reserved</td>
<td>2 bits</td>
<td>Subpacket ID when IR is defined by the FEC mode, otherwise reserved (encoded 0b00)</td>
</tr>
<tr>
<td>ACID</td>
<td>4 bits</td>
<td>HARQ CH ID</td>
</tr>
<tr>
<td>MHH</td>
<td>1 bit</td>
<td>0 = active MR HARQ is enabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = passive MR HARQ is enabled</td>
</tr>
<tr>
<td>Reserved</td>
<td>3 bits</td>
<td>Shall be set to zero</td>
</tr>
</tbody>
</table>

MH

Indicates which multi-hop HARQ is used, active MR HARQ or passive MR HARQ

[Insert new sub-clause and Table 101f as follows]
HQ_INFO_Message_Format () {
  CID 16 bits Indicates the link with this CID which is achieved from MS involved within current HARQ retransmission attempt
  CRC verification result 1 bit 0 = ACK_Info 1 = NACK_Info
}

Section 6.3.17.4 HARQ mechanism in multi-hop 802.16j networks

HARQ is performed over each hop based on a stop-and-wait protocol. Two complementary HARQ mechanisms, active MR HARQ and passive MR HARQ, are used on the distinct purposes, but they are compatible to each other in both transparent and non-transparent relays.

Section 6.3.17.4.1 Active MR HARQ mechanism

Fundamentally the active MR HARQ is a per-hop HARQ mechanism which allows for CID update and high mobility of RS. The principle and process of this mechanism are shown in Figure 130ja and 130jb. Its key feature is that besides the “ACK/NACK” reply, the intermediate RS is expected to transmit the associated “ACK/NACK information” to the BS.

Figure 130ja: The active MR HARQ principle and process in the uplink
In uplink, MS transmits its packet through a certain radio channel which is allocated by the BS and broadcasted in the previous DL-MAP. The RS receives and decodes this packet exclusively if no cooperative relay is taken into account. If the received packet passes the CRC verification after HARQ combining, the S-RS then replies the MS an “ACK” after a fixed delay defined by HARQ_ACK_Delay for UL burst which is specified in DCD message (see Table 358), and meanwhile an “ACK_Info” is forwarded to the BS if there are more than two hops. Otherwise, if this packet fails in CRC verification, a “NACK” is sent to the MS within the duration defined by HARQ_ACK_Delay for UL_burst and an associated “NACK_Info” is then sent to the BS. Due to the stop-and-wait protocol, the retransmissions are only sent after receiving a NACK for the previous transmission or the ACK has not been received within the duration defined by HARQ_ACK_Delay. The similar process happens in the multi-hop links.

In downlink, the process is similar to that of the uplink case except that it is the sender that transmits the HARQ_result_message (HQ_INFO) which comes from the received ACK or NACK. Therefore, the BS is kept monitoring the HARQ processes of each hop and consequently allocates the resources for HARQ retransmission.

Section 6.3.17.4.2 Passive MR HARQ mechanism

The passive MR HARQ is a multi-hop mechanism in which the forward is performed at RS no matter whether the correct packet is received or not in the intermediate RS. This mechanism is dedicated for data forwarding with/without CID change along the route. Both the transparent and non-transparent relay can be supported by this passive MR HARQ mechanism.

The principle and process of the passive MR HARQ is illustrated in Figure 130jc.
In both uplink and downlink, the source transmits its packets to RS. The RS forwards the packet to the destination. ACK is sent back to the source via hops from the destination after a fixed delay defined by HARQ_ACK_Delay for UL or DL burst which is specified in DCD message, if the received packet succeeds in the CRC verification. Otherwise, NACK signal is transmitted. Those intermediate RSs simply forward ACK/NACK replies.

Only when a NACK is received for the previous HARQ attempt or an ACK is not received properly, the retransmission is conducted by the source. The intermediate RS performs HARQ combining and CRC verification. If the combined packet passes the CRC verification, the associated RS will play the role of the source in the following HARQ retransmission attempt to send the error-free packet, and also reply ACK signal to the source. Otherwise, the combined packet is forwarded to the next hop for Chase Combining, and the original received HARQ retransmission or the combined packet is forwarded to the next hop for Incremental Redundancy.

The use of the passive MR HARQ mechanism allows for the implementation of cooperative relay even within the intermediate hops.

Reference