Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**HARQ methods for two-hop and multi-hop relays**
Date Submitted	**2007-01-08**
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Re:	IEEE 802.16j-06/034: “Call for Technical Proposals regarding IEEE Project 802.16j”
Abstract	Two types of HARQ methods are proposed for both DL and UL systems, and for both two-hop and multi-hop scenarios.
Purpose	For discussion and approval for inclusion of the proposed text into P802.16j baseline document.
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HARQ methods for two-hop and multi-hop relays

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1. Introduction

In this proposal, we introduce efficient HARQ methods for relay based 802.16j downlink (DL) and uplink (UL) systems, and for both two-hop and multi-hop (number of relay nodes is greater than 1) scenarios. This proposal defines the HARQ transmission and retransmission procedures among the base station (BS), relay station (RS), and the mobile station (MS).

It is known that in relay networks, several issues may have great impact on the transmission delay and capacity of the system [1]. By considering these issues, we first propose HARQ retransmission methods with minimum additional complexity introduced to the BS in 802.16 legacy systems. The proposed methods for both DL and UL systems are transparent to the MS, i.e., MS is not aware of any relaying operations. We also provide the alternative HARQ methods to improve the system throughput by introducing additional complexity to the BS. Note that the alternative HARQ method is also transparent to the MS.

2. System Description

In the scope of 802.16j, two-hop is mandatory and multi-hop is optional. In this proposal, we introduce the HARQ methods for both two-hop and multi-hop scenarios. Figure 1 shows a simple two-hop relay (single relay) system. HARQ is performed in the transmission links between MR-BS and RS, MR-BS and MS, and RS and MS, respectively. Figure 2 shows a relay network in which multiple RS's are linked with MR-BS and MS. Obviously, HARQ re-transmission performed among all the links among the RS's, MR-BS, and MS is not an efficient scheme in this scenario.

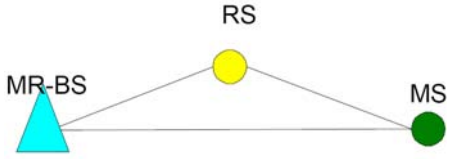

Fig. 1: A two-hop relay system.

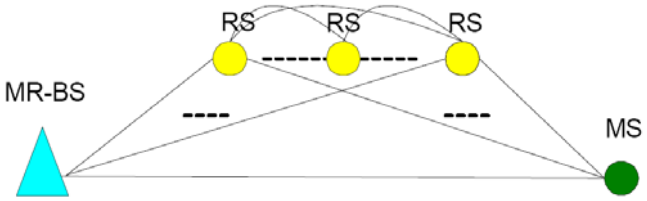

Fig. 2: A multi-hop relay system.

3. Proposed Methods

a. Two-hop system

For DL systems, MR-BS broadcasts the transmission to the RS and the MS. Both the RS and the MS decode the data. The RS sends ACK or NACK to the MR-BS to indicate either successfully decoding or not. MS sends acknowledgement to the RS. If the RS successfully decode the data, it sends ACK to the BS. The BS then stops the transmission. The RS sends retransmission if the RS obtained NACK from the MS. The RS keeps sending the retransmission packets until receiving ACK from MS or maximum number of retransmission is reached. If RS fails to decode the data, it sends NACK to BS and requests the retransmission. BS then sends the retransmission data to both RS and MS. Note that the retransmission can be either the retransmission of the same sequence (chase combining) or incremental redundancy (IR). The transmission scheme is shown in Fig. 3. The UL MAP for ACK/NACK channel is omitted in the plot.

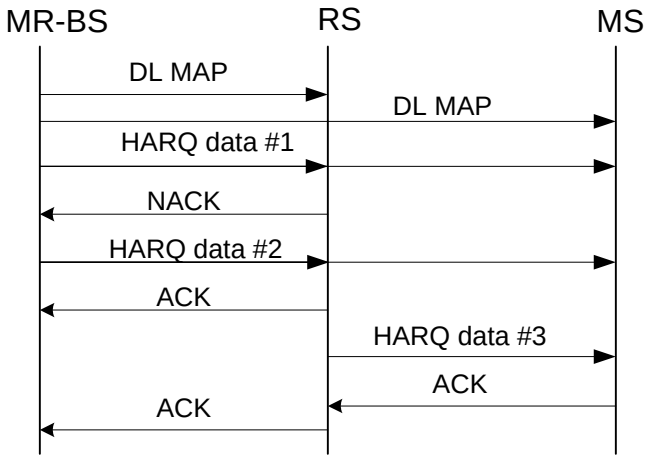

Figure 3 Proposed HARQ for DL two-hop systems.

For UL system, we consider per link HARQ, i.e., MS sends the data to RS, and sends re-transmission data until ACK is received. RS then sends the data to BS and retransmits the data to the BS.

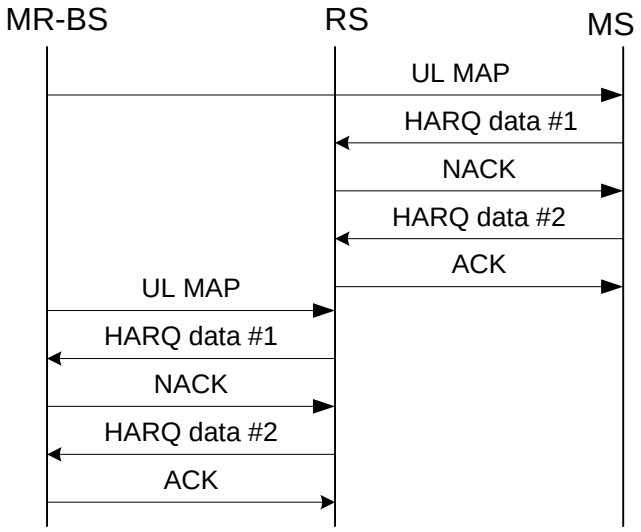

Figure 4 Proposed HARQ for UL two-hop systems.

b. Multi-hop system

In multi-hop systems, instead of considering HARQ in all transmission links, we propose a two-hop based multi-hop HARQ transmission method, i.e., the source node always broadcasting the message to two subsequent receive nodes. The source node stops transmission when it receives ACK from the closest subsequent node. The proposed HARQ for DL transmission multi-hop system is shown in Fig. 5.

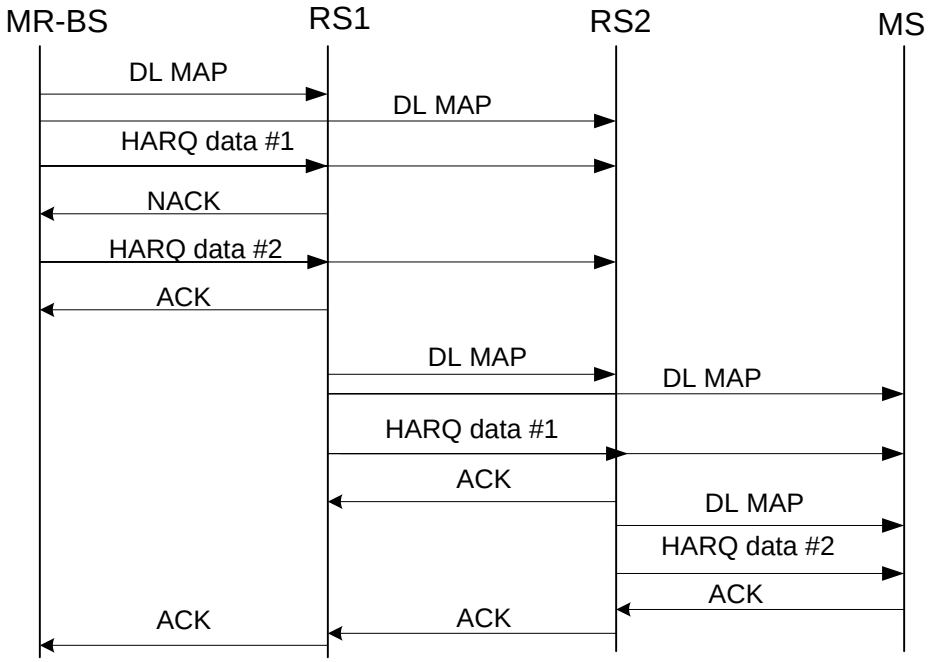

Fig. 5 Proposed HARQ for DL multi-hop systems.

For UL HARQ, the scheme is similar to the DL. But the MS to the first RS is per link HARQ which is similar to the one in two-hop systems as shown in Fig. 4.

It is seen that with above proposed HARQ scheme, the MS is not aware of any relay operations. The additional complexity introduced to the MS-BS is very small.

4. Alternative Proposed Methods

If iterative decoding can be employed at MR-BS and RS's, i.e., the receive node can decode the data from the superposition of two streams with iterative soft interference cancellation, we propose the following alternative HARQ schemes.

In DL multi-hop system, both the MR-BS and RS1 send the retransmission data to the RS2 even after RS1 successfully decodes the data. RS2 then decodes data from MR-BS by combining information received from MR-BS in a form of single streaming sequence during phase one and from both MR-BS and RS1 in a form of superpositions during phase two. Similarly, we can employ this scheme for the UL systems, as shown in Fig. 6. Here, the IR-HARQ is preferred.

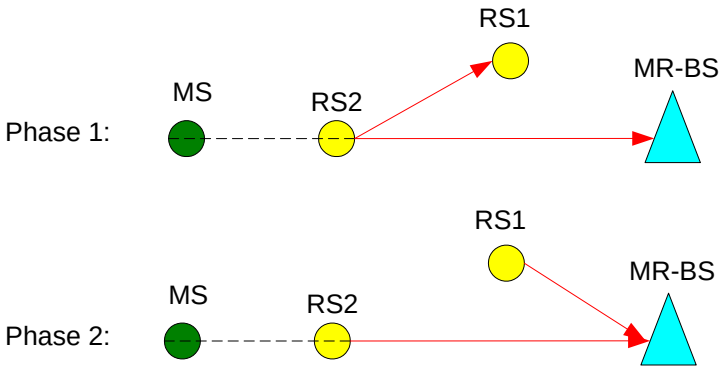

Fig. 6. Alternative HARQ methods for UL multi-hop systems.

5. Text Proposal

Insert a new subclause 6.3.17.5:

6.3.17.5. HARQ for Multihop-Relay

To provide reliable transmission and improve the throughput, HARQ is employed for the relay systems.

Insert a new subclause 6.3.17.5.1 :

6.3.17.5.1 DL HARQ

MB-BS informs the RS about transmissions. When the BS sends the transmission to the MS, both RS and MS decode the data. If RS successfully decode the data, it sends ACK to the BS. The BS then stops the

transmission. If RS fails to decode the data, it sends NACK to MR-BS and requests for the retransmission. BS then sends the retransmission data to both RS and MS. The RS sends retransmission data if RS obtained NACK from the MS.

Insert a new subclause 6.3.17.5.2:

6.3.17.5.2 UL HARQ

MS sends the transmission to RS. If RS fails to decode the data, it sends NACK to MS. MS sends the re-transmission data until ACK is received. RS then sends the data to MR-BS and retransmits the data to the BS.

References

[1] IEEE C802.16j-06/292, “HARQ Mechanisms in Multi-hop Relay”