Project	**IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>**
Title	**Cooperative HARQ for IEEE 802.16m: UL Mode**
Date Submitted	**2008-10-31**
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Re:	TGm SDD: Relay IEEE 802.16m-08/040: Call for Comments and Contributions on Project 802.16m System Description Document (SDD)
Abstract	This document describes relay-based HARQ techniques for 802.16m uplink (UL) in order to realize cooperative diversity and power efficiency advantages of cooperative relaying techniques for throughput and reliability improvement. In particular, we propose cooperative hop-by-hop HARQ and cooperative relay-assisted HARQ schemes with dynamic selection of modes based on simultaneous reception by multiple cooperating terminals.
Purpose	For consideration and adoption into the 16m SDD document.
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Cooperative HARQ for IEEE 802.16m: UL Mode

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A. Introduction:

This document describes relay-based HARQ techniques for 802.16m uplink in order to realize cooperative diversity and power efficiency advantages of cooperative relaying techniques for throughput and reliability improvement. In particular, we propose cooperative hop-by-hop HARQ and cooperative relay-assisted HARQ schemes with dynamic selection of modes based on simultaneous reception by multiple cooperating terminals. Further introductory technical discussion on cooperative HARQ techniques can be found in the following contribution:

O. Oyman et. al., "Cooperative HARQ for IEEE 802.16m: DL Mode", IEEE C802.16m-08/1278

Uplink HARQ Procedure:

We propose the following two cooperative HARQ schemes, to be used under two-hop relaying:

- **Cooperative Hop-by-hop HARQ for 802.16m** – A fixed two-hop relay protocol involving MS -> {Multiple RSs} -> BS links and no direct MS-BS data link considerations. Different hops execute HARQ independently of each other. In the first hop, a cooperator set is formed from the multiple RS terminals which are able to receive the transmitted signals. In the second hop, a selected RS from the cooperator set that is able to successfully decode the transmitted signal conveys the signal to the BS. A multi-hop version of the protocol is left FFS.

- **Cooperative RS-assisted HARQ for 802.16m** – One or more RSs monitor the HARQ burst transmitted from MS to BS (since RSs know UL-MAP) and a selected RS is used to transmit data only upon reception of a NACK message from MS regarding transmission over MS -> BS link. In other words, in order to reduce the resource retransmission of HARQ bursts, a selected RS from the set of cooperating RSs retransmits the HARQ burst instead of MS if one or more RSs have the correct HARQ burst.

B. Proposed Text:

[Insert the following text into section 15 of the SDD:]

15.X.3.2 Uplink (UL)

This subsection describes UL HARQ with multi-hop relay support using cooperative transmission techniques. In this context, the cooperative hop-by-hop HARQ and cooperative RS-assisted HARQ schemes are described separately.

15.X.3.2.1. *Cooperative Hop-by-Hop HARQ:*

In cooperative hop-by-hop HARQ, the MS transmits data to a set of RSs. The BS then coordinates the RSs in performing a collaborative reception, and selects a single RS to forward the data to the BS. HARQ retransmissions are performed separately on each hop.

In order to perform cooperative hop-by-hop HARQ, the BS first selects and notifies the set of RSs which will listen to the UL transmission from the MS and cooperate to perform the transmission to the BS. This selection can be made and signaled for each transmission or on a slower timescale. See section 15.X.3.3 for more details on the selection process. ***[Note to editors: the section on collaborator selection is proposed in contribution C80216m-08_1278]*** Following the selection of cooperators, the BS notifies the RSs in the cooperator set of the allocation for UL transmission of MS. The RS to which the MS is associated is also notified of the allocation and transmits the MAP IE which notifies the MS of the allocation. The MS transmits in the specified allocation and the RSs in the cooperator set attempt to decode the transmission The BS allocates resources for the RS(s) to transmit a message indicating whether they successfully received the transmission. The BS receives the ACK/NACK messages from each RS in the cooperator set. It sends a message to the RS to which the MS is attached with an indication of whether the data will need to be retransmitted. The RS with which MS is associated sends an ACK/NACK message to the MS based on the indication that it received from the BS. If none of the RSs in the cooperator set have successfully receive the data, the BS schedules another allocation and the MS retransmits the data and the process repeats.

When at least one RS has successfully received the data, the BS selects a single RS to transmit the data on the next hop in a non-cooperative manner even if more than one RS received the data correctly. The BS schedules an allocation in which the selected RS will transmit the burst and notifies this RS of the transmission scheme which BS has determined for the transmission and of the allocation (the frame and slots within the frame). If the BS does not successfully receive the data, it schedules another allocation and a selected RS retransmits the data and the process repeats. This scheme can be extended to operate in a multi-hop topology. This extension is left for further study.

15.X.3.2.2. *Cooperative RS-assisted HARQ:*

In cooperative RS-assisted HARQ, the BS receives data from the MS directly and directs a set of RSs to receive the transmission as well. If the BS does not successfully receive the transmission, the BS then coordinates the RSs in performing a collaborative reception and possibly selects a single RS to retransmit the data to the BS.

In order to perform cooperative RS-assisted HARQ, the BS first selects and notifies the set of RSs which will listen to the UL transmission by the MS. See section 15.X.3.3 for more details on the selection process. ***[Note to editors: the section on collaborator selection is proposed in contribution C80216m-08_1278]*** Following the selection of cooperators, the BS notifies the MS and RSs in the cooperator set of the UL allocation in which the MS is to transmit. The BS allocates resources for the RS(s) to transmit a message indicating whether they successfully received the transmission. The MS transmits the burst and the BS and RSs in the selected set attempt to receive this transmission. The RSs send ACK/NACK messages to the BS to notify it if they successfully received the data. If the BS receives the transmission successfully, no retransmissions are performed. If the BS does not receive the data correctly, it selects either the MS or one of the RSs from the cooperator set that was able to correctly decode the signal to retransmit the burst. The BS schedules an allocation in which the MS or selected RS will transmit and notifies the RS or the MS of the allocation (the frame and slots within the frame). If the burst was not received successfully, the BS schedules another retransmission.

An example message flow is depicted in Figure 1 for the cooperative RS-assisted HARQ scheme. Another example for the cooperative hop-by-hop HARQ scheme is depicted in Figure 2.

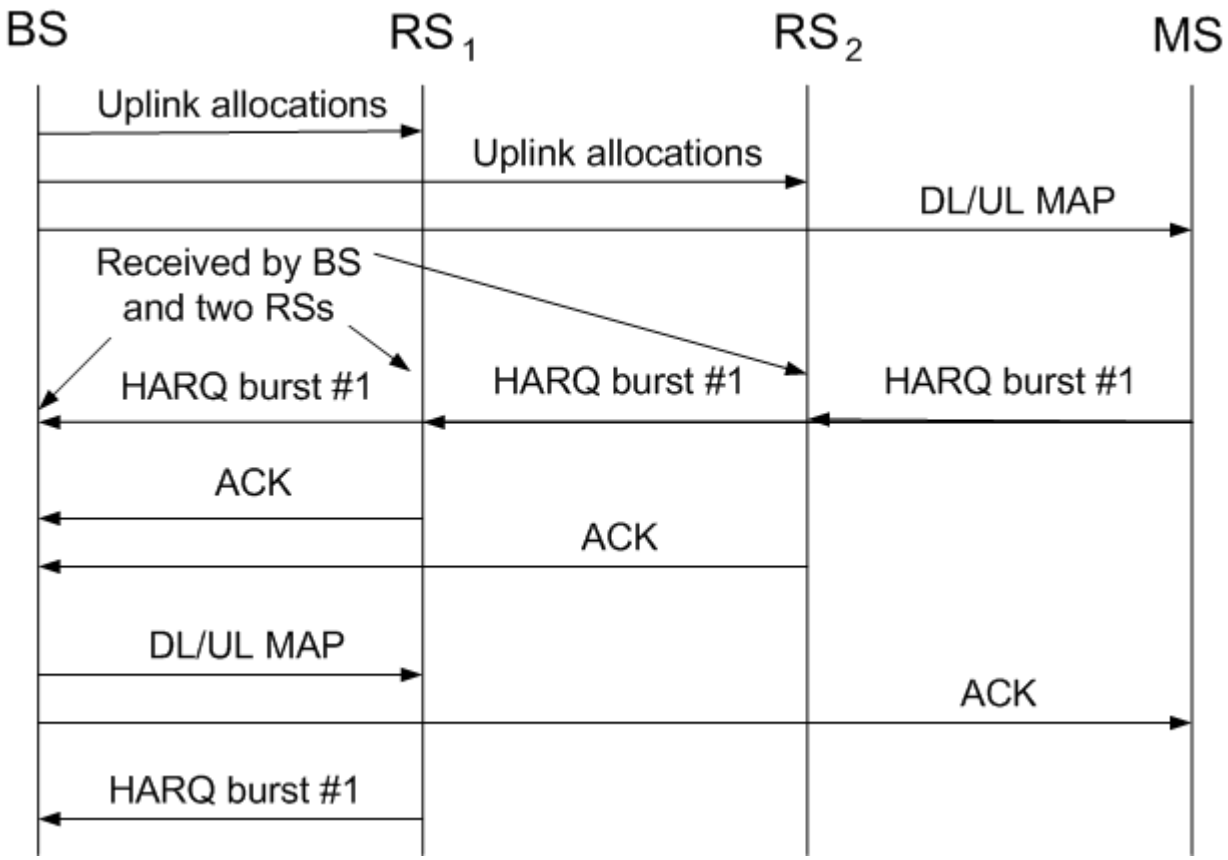

Figure 1 – *An example cooperative RS-assisted HARQ message flow. Here, we assume uplink transmission with cooperative reception by two RSs.*

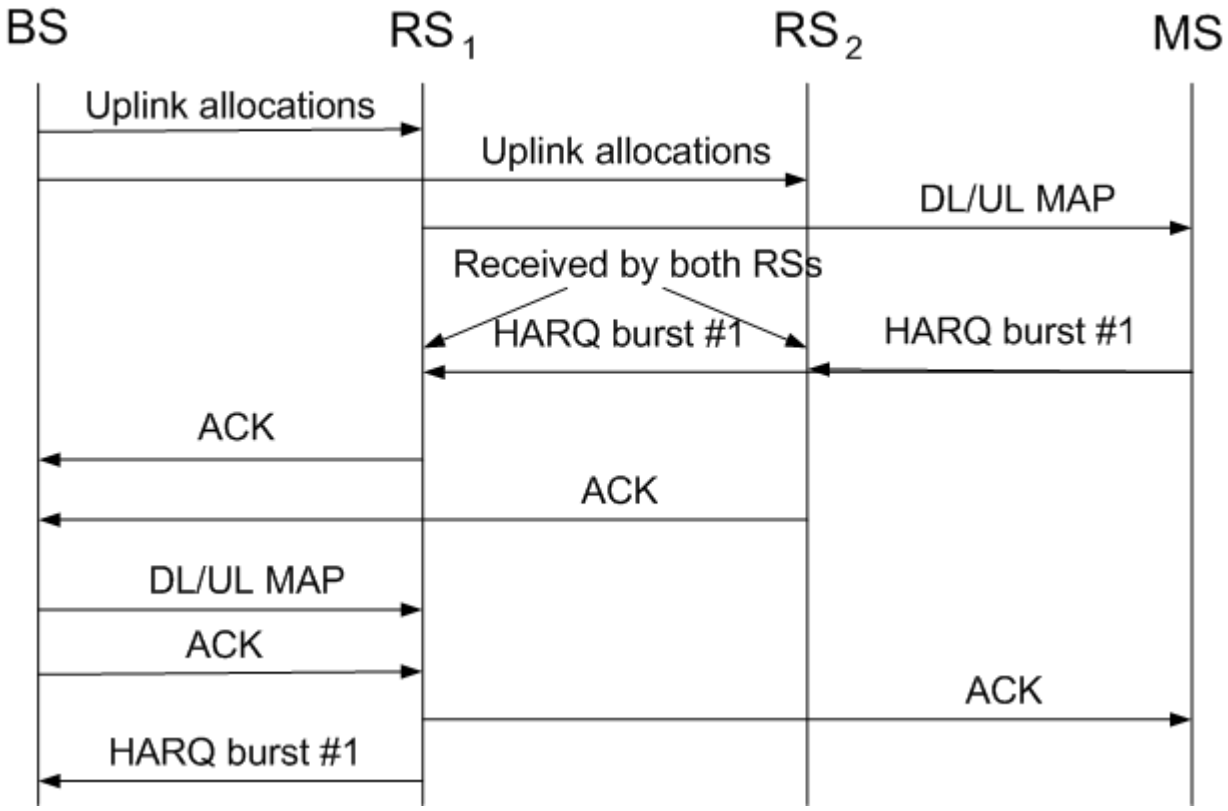

Figure 2 – *An example cooperative hop-by-hop HARQ message flow. Here, we assume uplink transmission with cooperative reception by two RSs.*