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Re:	IEEE 802.16j-06/034: “ Call for Technical Proposals regarding IEEE Project 802.16j”
Abstract	This contribution describes the HARQ procedure for multi-hop relaying system.
Purpose	This contribution is submitted for discussion and adoption in 802.16j.
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HARQ for Multi-hop Relaying System

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1 Introduction

In response to the IEEE 802.16j TG Call for Technical Contributions, this document proposes a MAC procedure to support HARQ in multi-hop relaying system.

In a MMR cell, there exist different types of RS because of the different usage scenario [1]. From the MS point of view, we can define 2 types of RS. One is the transparent RS, which doesn't transmit preamble and MAP signal, or just transmit the same preamble and MAP signal with its superior anchor station, the other is Non-transparent RS, which generate and send its own preamble and MAP signal. So, Non-transparent RS act as a BS to MS, and MS can not sense the existence of transparent RS at all. Because Non-transparent RS can generate its own MAP information, so Non-transparent is a high capability RS, and has the ability of resource scheduling, it can be the anchor station of a transparent RS (anchor station controls its subordinate transparent RS).

In HARQ procedure, transmission and retransmission resource should be allocated for the corresponding MS and RS. Therefore, the HARQ procedure of the transparent RS is different from that of the non-transparent RS for the capability variety of resource scheduling.

2 Problem Statement

A typical example of the multi-hop systems is shown in Figure 1, in which RS1 and RS2 are non-transparent RS, and RS3 is a transparent RS. For non-transparent RS, hop-by-hop HARQ is preferred for the simplicity and efficiency. However, as to transparent RS, end-to-end HARQ is more suitable for the lacking of resource scheduling capability. As shown in Figure 1, HARQ between MS2 and RS2 is end-to-end based, while RS3 is transparent to MS2.

For hop-by-hop non-transparent HARQ, legacy 16e HARQ remains unchanged for access link, e.g. HARQ between MS1 and RS2. As to relay link, legacy 16e mechanism can be reused with some optimization.

For end-to-end transparent HARQ, a new HARQ procedure should be defined because legacy one does not support end-to-end solution. In this contribution, an end-to-end transparent HARQ procedure is provided.

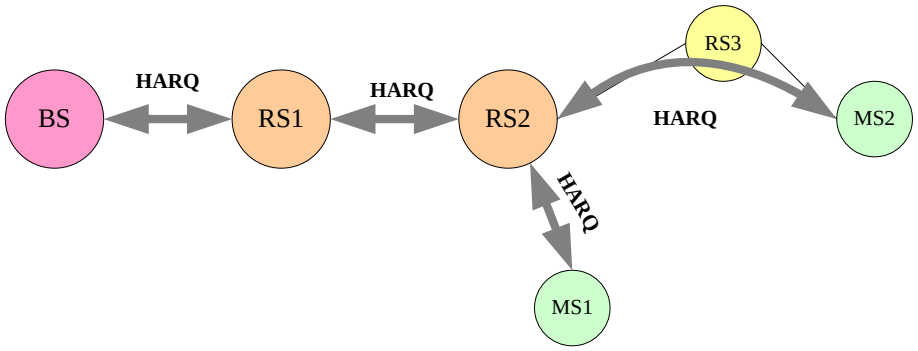

Figure 1 HARQ in multi-hop systems

3 Proposed HARQ Procedure

3.1 End-to-End Transparent HARQ

As defined above, a transparent RS doesn't transmit preamble and MAP signal, or transmit the same preamble and MAP signal with its superior anchor station. So a MS attached to the transparent RS may receive preamble and MAP signal from the anchor station directly. However, when a MS accesses to a transparent RS, the MS adjusts its uplink power to this RS via ranging procedure. Therefore, the anchor station can not guarantee the uplink signal receiving directly from MS.
As shown in Figure 1, HARQ between MS2 and RS2 is end-to-end transparent HARQ, and this will be used as an example in the following discussion.

3.1.1 Downlink HARQ procedure

When RS2 relays downlink HARQ burst to MS2, RS2 first send the burst to RS3, and then indicate the burst transmission to MS2 via DL-MAP, this MAP information may be transmitted by RS3 at the same time. If RS3 received burst correctly, it will relay the burst as DL-MAP indicated, otherwise, no data will be send by RS3 in order to reduce interference. MS2 will receive the burst as the indication of DL-MAP, and send the feedback information follow the method defined in legacy 16e. When RS3 receives the feedback information from MS2, it will generate and send feedback message with three statuses to RS2, including ACK, NAK, and RACK. ACK means MS2 receives burst correctly, while NAK means neither MS2 nor RS3 receives burst correctly. RACK means RS3 receives burst correctly, but MS2 fails to receive the burst. When RS2 get the feedback message, it can tell whether the burst is received correctly by MS2 and RS3, and turn to relevant processing. When feedback is RACK, retransmission from RS3 is performed, other than from RS2. This can save the radio resource. The whole procedure is shown in Figure 2, and the feedback message is shown in Figure 3 and Figure 4.

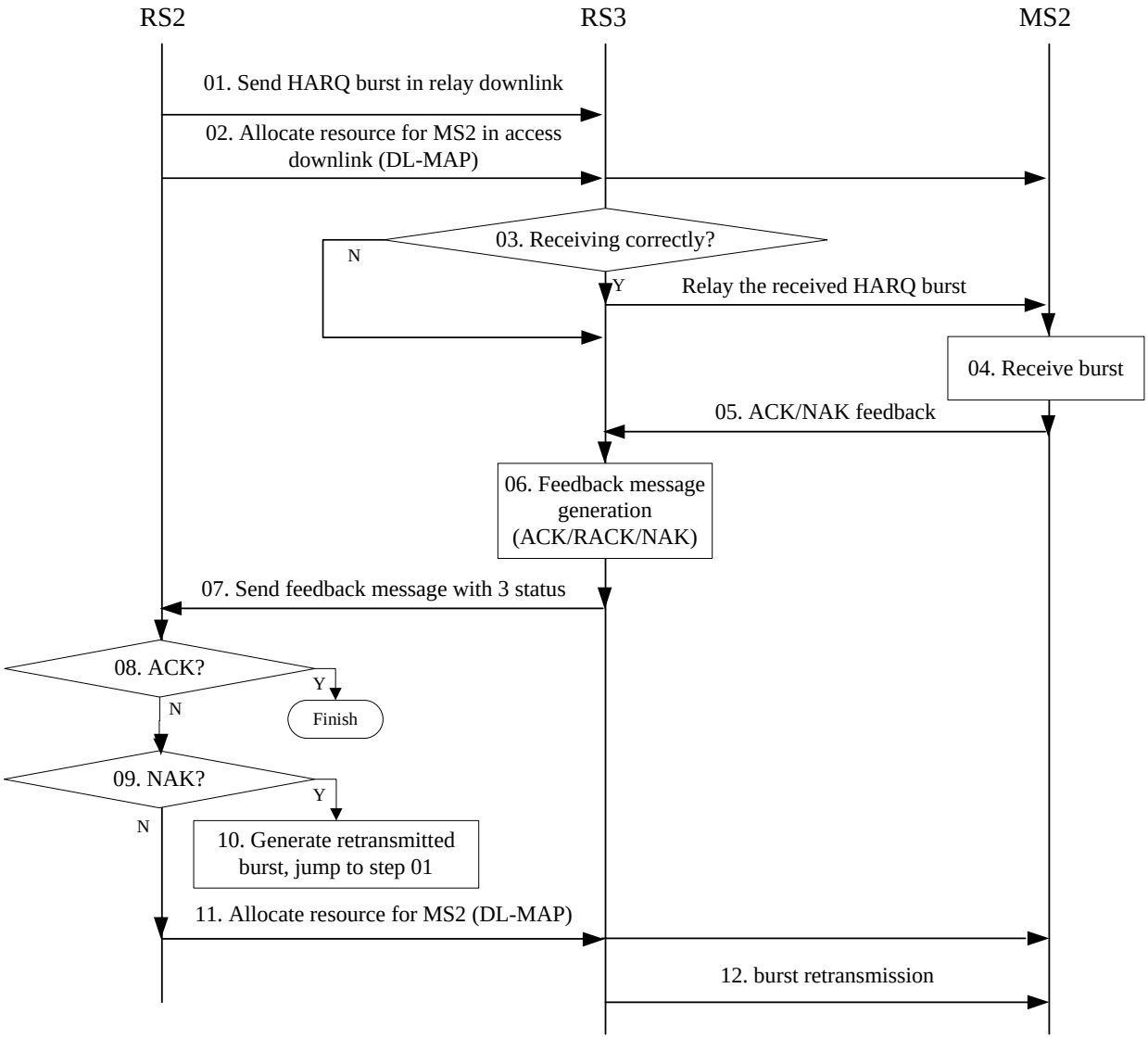

Figure 2 Procedure of downlink HARQ

Message Type	Length of Bitmap1	Bitmap1	Bitmap2

Figure 3 Feedback message with three status

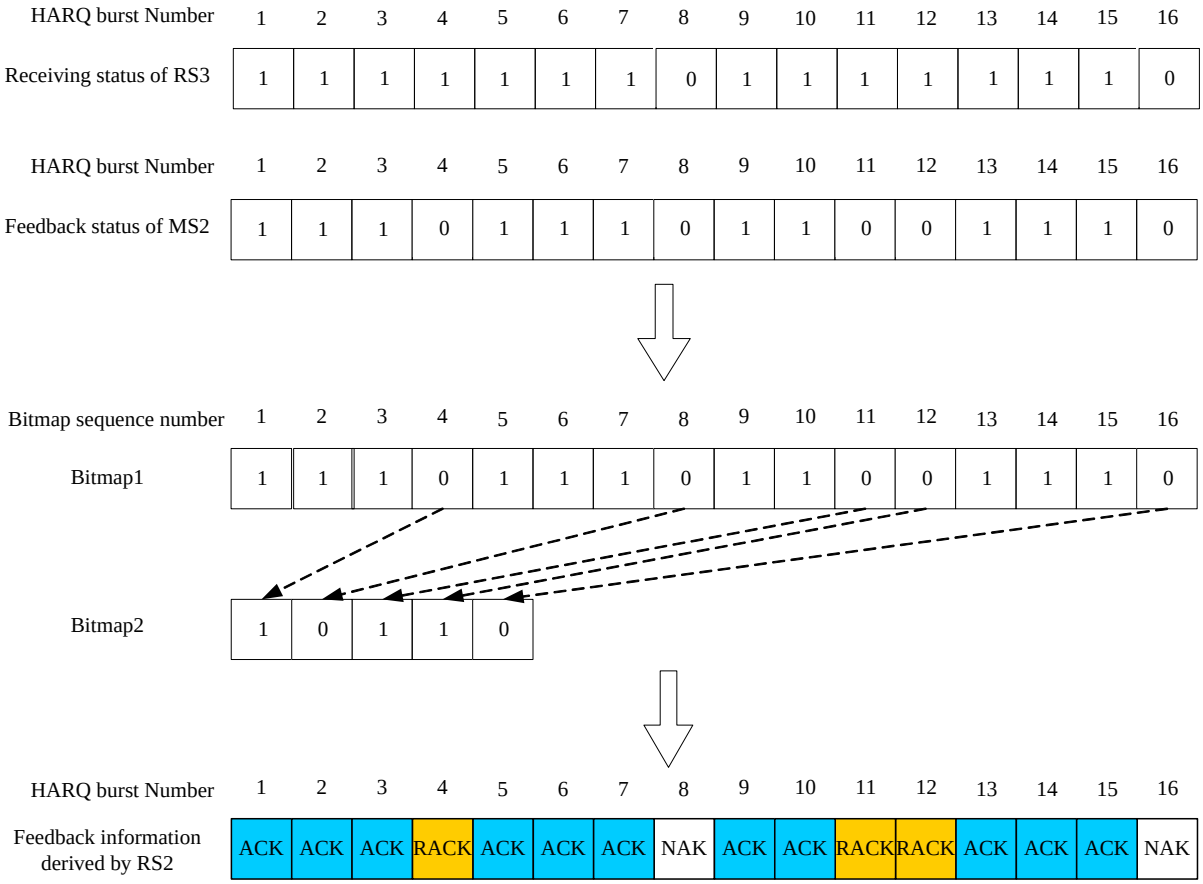

Figure 4 Detailed explanation of three status feedback message

3.1.2 Uplink HARQ procedure

Before MS2 sends HARQ burst to RS2, RS2 allocates uplink resource to MS2 via UL-MAP (RS3 may transmit the same UL-MAP at the same time). RS3 receives the burst transmitted by MS2, and sends the receiving status to RS2. If RS3 receives the burst correctly, it will relay the burst to RS2. Otherwise, no data will be transmitted. RS2 will generate the feedback message to MS2 according to the receiving status of RS3. When the burst is correctly received by RS3, ACK is generated and sent to MS2 by RS2, otherwise, NAK is sent. The processing thereafter is determined according to the receiving status of RS2 and RS3. When the burst is correctly received by RS3, but RS2 is failed, retransmission from RS3 is performed, other than from MS2. The retransmission from RS3 is controlled by RS2. The whole procedure is shown in Figure 5.

In summary, for either uplink or downlink HARQ, as long as the transparent RS between the source station and the destination station receives the packets from the source station correctly, but the destination station is failed at receiving. The burst is retransmitted by the transparent RS at the control of anchor station, other than from the source station.

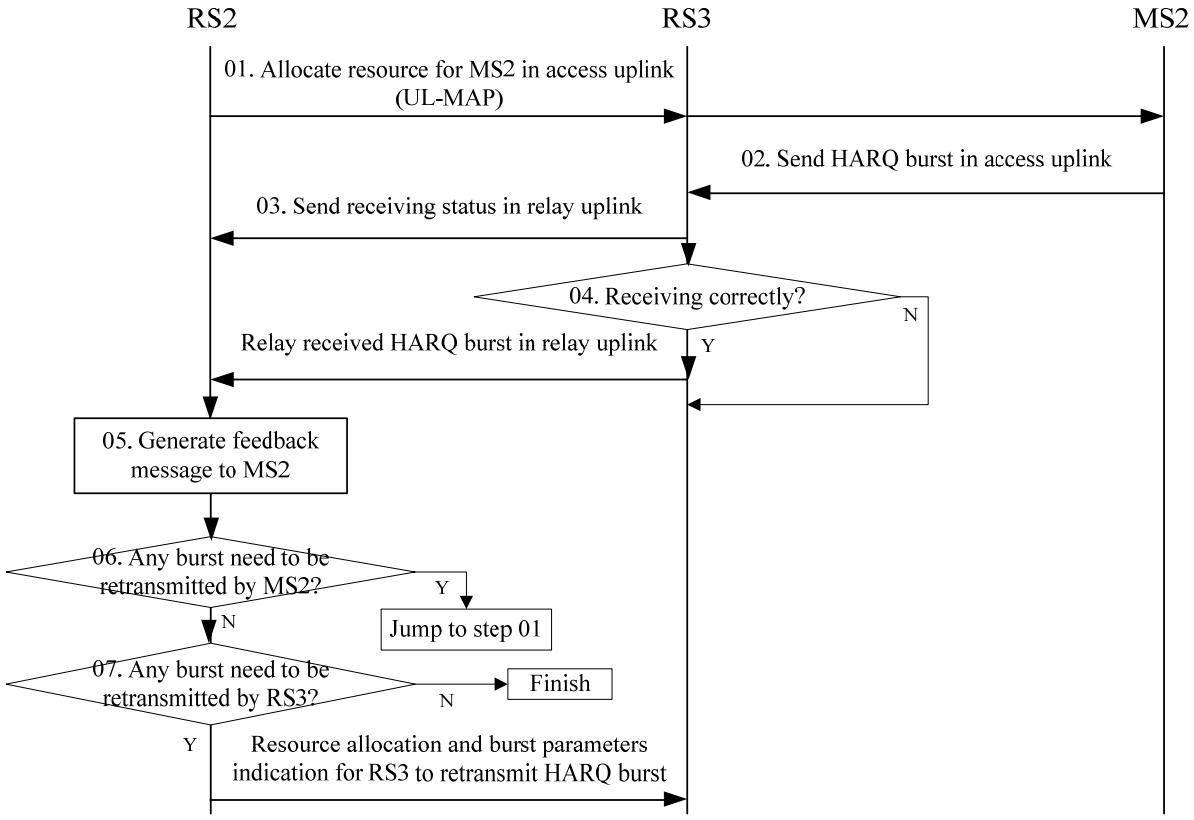

Figure 5 Procedure of uplink HARQ

3.2 Hop-by-Hop Non-Transparent HARQ

For hop-by-hop non-transparent HARQ, legacy 16e HARQ remains unchanged for access link, e.g. HARQ between MS1 and RS2. As to relay link, legacy 16e mechanism can be reused with some optimization.

4 Text Proposal

6.3.17 MAC support for HARQ

[Insert new subclause 6.3.17.1]

6.3.17.1 End-to-End Transparent HARQ

6.3.17.1.1 Downlink HARQ Procedure

When anchor station send downlink HARQ burst to the MS, the anchor station first send the burst to its transparent RS, and then indicate the burst transmission to MS via DL-MAP, this MAP information may be transmitted by the transparent RS at the same time. If the transparent RS received burst correctly, it will relay the burst as DL-MAP indicated, otherwise, no data will be send by the transparent RS in order to reduce interference. MS will receive the burst as the indication of DL-MAP, and send the feedback information follow the method defined in legacy 16e. When the transparent RS receives the feedback information from the MS, it will generate and send feedback message with three statuses to the anchor station, including ACK, NAK, and RACK. ACK means MS receives burst correctly, while NAK means neither MS nor the transparent RS receives burst correctly. RACK means the transparent RS receives burst correctly, but MS fails to receive the burst. When the anchor station gets the feedback message, it can tell whether the burst is received correctly by MS and the transparent RS, and turn to relevant processing. When feedback is RACK, retransmission from the transparent RS is performed, other than from anchor station. This can save the radio resource. The procedure is shown in **Error! Reference source not found.**, and the feedback message is shown in Figure 6 and Figure 7.

Message Type	Length of Bitmap1	Bitmap1	Bitmap2

Figure 6 Feedback message with three status

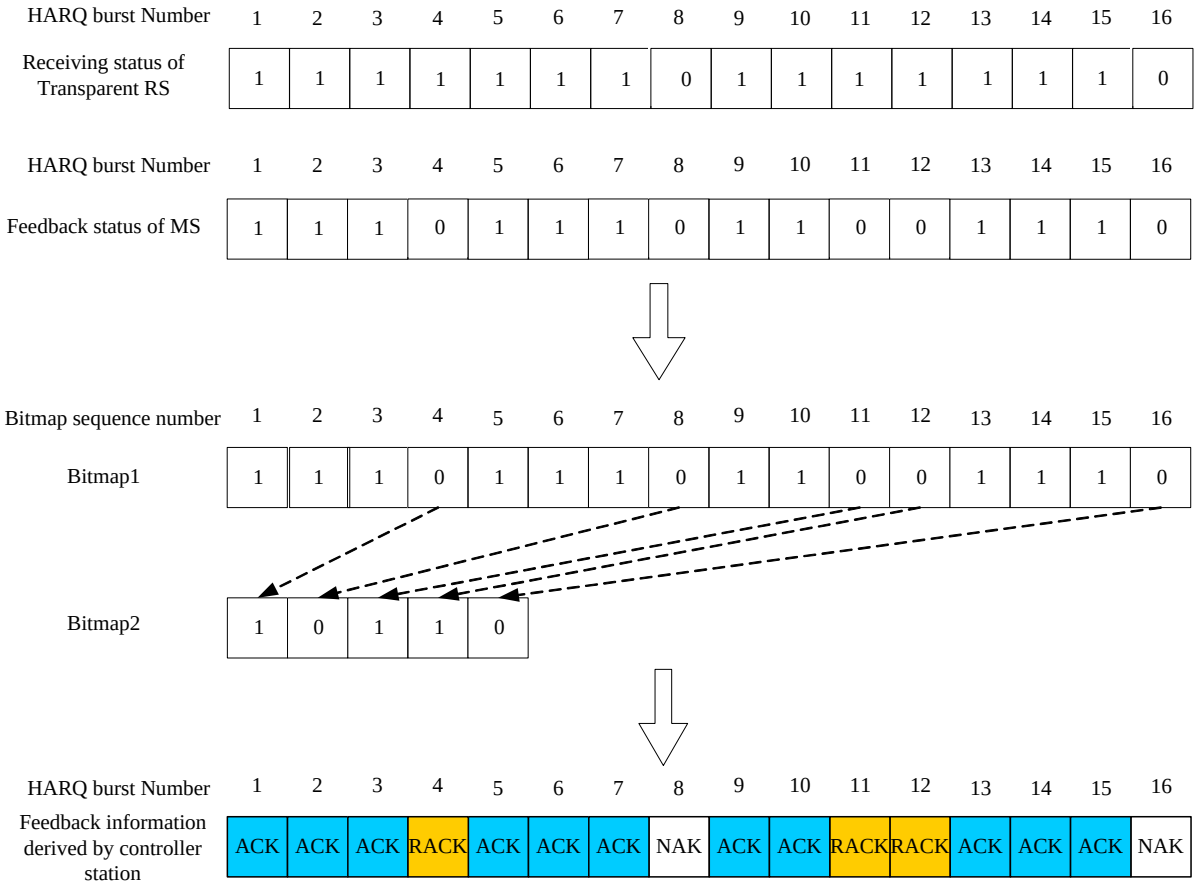

Figure 7 Detailed explanation of three status feedback message

6.3.17.1.1 Uplink HARQ Procedure

Before a MS sends HARQ burst to the anchor station, the anchor station allocates uplink resource to MS via UL-MAP (the transparent RS may transmit the same UL-MAP at the same time). The transparent RS receives the burst transmitted by MS, and sends the receiving status to the anchor station. If the transparent RS receives the burst correctly, it will relay the burst to the anchor station. Otherwise, no data will be transmitted. The anchor station will generate the feedback message to MS according to the receiving status of transparent RS. When the burst is correctly received by the transparent RS, ACK is generated and sent to MS by the anchor station, otherwise, NAK is sent. The processing thereafter is determined according to the receiving status of the anchor station and the transparent RS. When the burst is correctly received by the transparent RS, but the anchor station is failed, retransmission from the transparent RS is performed, other than from MS. The retransmission from the transparent RS is controlled by the anchor station. The procedure is shown in **Error! Reference source not found.**.

In summary, for either uplink or downlink HARQ, as long as the transparent RS between the source station and the destination station receives the packets from the source station correctly, but the destination station is failed at receiving. The burst is retransmitted by the transparent RS at the control of anchor station, other than from the source station.

5 References

[1] Jerry Sydir, et. al., Harmonized Contribution on 802.16j (Mobile Multihop Relay) Usage Models, IEEE 802.16j-06/015.