Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**DL HARQ for non-transparent Relays**	
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Re:	This is in response to the call for proposals 80216j-07_007.pdf
Abstract	This contribution proposes a procedure for handling retransmission of HARQ failure attempts in a relay system.
Purpose	Add proposed spec changes in P802.16j Baseline Document (IEEE 802.16j-06/026)
Notice	
Release	
Patent Policy and Procedures	

Downlink HARQ with Relay

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Introduction

In single hop system, HARQ is performed directly between BS and MS. However, in the relay system, there could be one or more RSs between an MR-BS and an MS. HARQ could be performed in the fashion of hop-by-hop (i.e., between every two adjacent stations - MS-RS2, RS2-RS1 and RS1-MR-BS as shown in Figure 1).

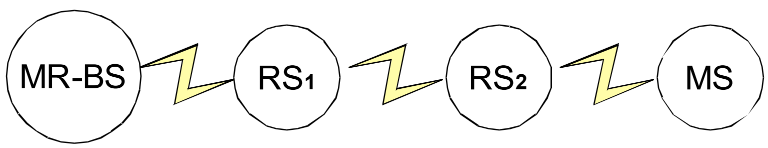

Figure 1: Illustration of Multi Hops in relay System

Both centralized and distributed MAP allocation mechanisms could be adopted in relay system. In centralized MAP allocation, the MR-BS allocates MAP for all the links. Any need for bandwidth request should go to the MR-BS. In distributed MAP allocation, each station allocates MAP for the adjacent link. In centralized allocation, if a HARQ packet transmission failure occurs on a non-adjacent link from MR-BS, then a feedback mechanism is needed for indicating this failure to the MR-BS. So MR-BS can grant bandwidth for retransmission on the effected links.

DL HARQ scheme with centralized scheduling

This contribution suggests a mechanism for indicating the last RS on the relay path that has successfully received the HARQ packet to MR-BS. The feedback indication is sent when the last RS receives NAK from the next station in the relay path. It is not sent when a HARQ packet is successfully transmitted on all the hops. The MR-BS uses this indication and allocates MAP accordingly so the retransmission could start from the last RS and onward. This contribution describes the DL HARQ procedure for non-transparent RS in centralized scheduling model. Contribution [4] describes the DL HARQ and UL HARQ procedure for transparent RS in centralized scheduling model.

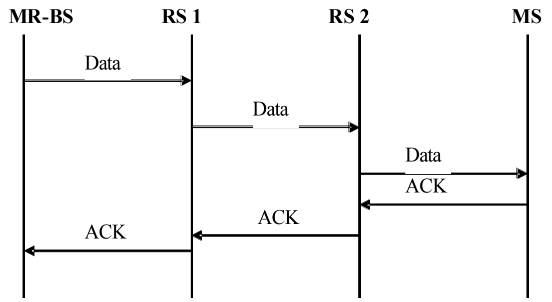

Figure 2. Message Flow for 3-hop DL HARQ (successful case)

In Figure 2, the data (HARQ sub-burst) is transmitted from the MR-BS to RS 1. If RS 1 receives HARQ sub-burst correctly, it forwards the sub-burst to RS 2 and finally to the MS. As a response to a successful reception of the data at the MS, MS generates ACK. This ACK invokes ACK at RS 2 and RS 1 thereafter, which is relayed to the MR-BS. If RS 2 fails to decode the data, it sends NAK to RS1 and RS1 forwards encoded NAK indicating the failure link to the MR-BS.

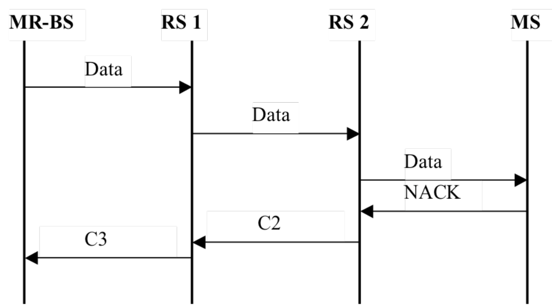

Figure 3. Message Flow for 3-hop DL HARQ (HARQ sub-burst is failed on access link)

In Figure 3, the data is transmitted from the MR-BS to RS 1 and is forwarded to RS 2 and finally to the MS. If HARQ-burst is failed on access link, MS will send NAK back to RS2. RS2, upon receipt of NAK, sends code C2 back to RS1. RS1, upon receipt of code C2, sends Code C3 (C2+1)_to the MR-BS. When MR-BS receives code C3, it can determine that the HARQ-burst is failed 3 hop away (i.e. on the access link) and therefore schedule retransmission from RS2.

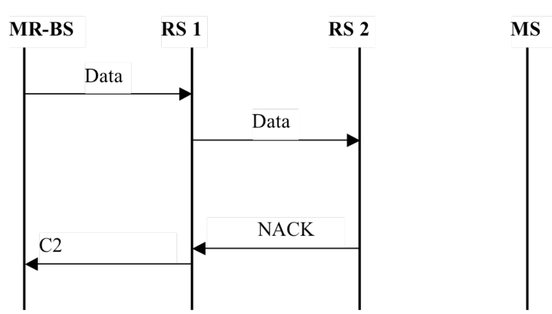

Figure 4. Message Flow for 3-hop DL HARQ (HARQ sub-burst is failed on relay link)

In Figure 4, the data is transmitted from the MR-BS to RS 1 and is forwarded to RS 2. If RS 2 fails to decode the data, it sends NAK to RS1. If RS2 failed to decode HARQ-burst correctly, it does not forward erroneous data to MS. In this case, RS modifies the HARQ-MAP IE such that MS or further downstream RS do not receive the HARQ burst. RS replaces the CID in the HARQ sub-burst IE corresponding to the erroneous packet with its own CID.

When RS1 receives the NAK from RS2, RS1 forwards encoded NAK (C2) indicating the failure link to the MR-BS. When MR-BS receives code C2 for the data, it can determine that the HARQ-burst is failed 2 hop away (i.e. RS1-RS2 link) and therefore schedule retransmission from RS1.

This contribution is suggesting a mechanism that will work on any centralized MAP allocation scheme. It does not suggest a centralized MAP allocation scheme.

Specific text changes

Insert new sub-clause 6.3.17.5

6.3.17.5 DL HARQ support for Relay in centralized scheduling

- MR-BS schedules a HARQ packet on all the links between MR-BS and MS. DL transmission failure on a relay link is indicated by the orthogonal code on the UL ACK Channel, so the MR-BS can schedule the retransmission only for the links that didn't transmit packet in the last attempt.

Insert new sub-clause 6.3.17.5.1

6.3.17.5.1 DL HARQ for non-Transparent RS

DL transmission failure on a relay link shall be indicated by the orthogonal code on the UL ACK Channel. The MR-BS identifies the RS for retransmission with the help of ACK/NACK encoding suggested in table xxx. This does not require each RS on the path and MS to send separate ACK/NAK signals back to the MR-BS. Thus, conserves the bandwidth by utilizing the same ACK channel.

When MR-BS sends the first HARQ attempt, it allocates bandwidth over all the links from the MR-BS to the MS. Each RS on the relay path receives the downlink HARQ packet, and decodes it. If the decoding succeeds, it forwards the HARQ packet to the next hop and wait for UL ACK from the next RS or MS. If the decoding fails, the RS sends code C_1 defined in the table xxx as a NAK back to the previous IS and it will not forward the erroneous packet to next hop. In this case, the RS modifies the DL HARQ sub burst IE in the DL-MAP such that the next receiving station does not receive the erroneous HARQ burst. The RS replaces the CID in the corresponding HARQ sub burst IE with its own basic CID.

When a RS receives code C_0, indicating that the HARQ packet is successfully received by the next station, it sends code C_0 to the previous IS on its UL ACK channel.When a RS receives code C_k, $k \neq 0$, it sends UL ACK code= C_{k+1} on its UL ACK channel. MR-BS upon receipt of k^{th} hop code sequence (C_k) in UL ACK Channel assumes that packet is lost on the link that is the kth hop, and it will schedule retransmission from (k-1)th RS. If MR-BS receives code C_0, it indicates that the HARQ packet is successfully received by SS. If MR-BS receives code C_1, it indicate that the HARQ packet is failed on the first hop.

When the orthogonal encoded UL ACK scheme is employed, the UL ACK channel resources must be assigned so that the UL ACK channel from MS to its previous RS first and upto MR-BS in reverse order of the DL transmission path. If, the MR-BS does not receive ACK code sequence (C_0), in the prescribed number of re-transmissions, both RS and MR-BS will discard the packet and clear the queue. BS can then perform normal signaling as if the packet is not received by MS.

Insert new sub-clause 6.3.17.5.1.1

6.3.17.5.1.1 ACK / NAK Encoding for multi-hop relay

MR-BS needs to identify the failed link over the multi-hop chain in case of HARQ. Therefore new sequences based on Table 301a in section 8.4.5.4.13 are defined in order to uniquely identify the failed link. Further, it should be noted that BS only needs to identify the failed link, i.e. if the HARQ attempt is failed between RS_j and its downstream RS RS_{j+1}, then BS should identify RS_j. For two hop case, only C_0 to C_2 are needed.

Link Distance/Depth	**ACK/NAK 1-bit symbol**	**Vector Indices per Tile Tile(0), Tile(1), Tile(2)**	**Code #**
Any Distance	0 (ACK)	0, 0, 0	C_0
1	1 (NAK)	4, 7, 2	C_1
2	1 (NAK)	3, 5, 1	C_2
3	1 (NAK)	7, 2, 4	C_3
4	1 (NAK)	5, 1, 3	C_4
5	1 (NAK)	6, 2, 3	C_5
6	1 (NAK)	5, 1, 7	C_6
7	1 (NAK)	2, 6, 5	C_7

Table xxx: ACK / NAK Encoding for multi-hop relay

Insert the following text at the end of the subclause

8.4.5.4.25 HARQ ACK region allocation IE

This IE may be used by MR-BS to define an ACK channel region on the R-UL to include one or more ACK channel(s) for RS.

When RS receives HARQ DL sub-burst for relaying to MS at frame i, it shall transmit the encoded ACK/NAK signal through ACK Channel in the ACKCH region at frame (i + n) where n is calculated at each RS according to the following equation.

$$n = H*p + (H+1)*j \quad \ldots\ldots\ldots\ldots\ldots [1]$$

H is defined by "number of hops RS is away from the MS".
p is defined by the "static delay at the RS in number of frames"
j is defined by the "HARQ_ACK_Delay for DL Burst" field in the DCD messages.

In 2-hop case, there is only one RS and n=p + 2*j.

If the frame structure allows relaying either HARQ DL sub-burst or encoded ACK/NAK in the same frame, then the above equation will change. If encoded ACK/NAK is relayed in the same frame, then n=H*p+j. Similarly, if RS can relay the HARQ DL Sub-burst signal in the same frame, then n=p+ (H+1)*j.

References

[1] C802.16j-06_132, "Relaying methods proposal for 802.16j"

[2] C802.16j-06_266r1, "Relay-Assisted Hybrid ARQ"

[3] C802.16j-06_197r1, "HARQ with Relays"

[4] – C802.16j-07_xxx "HARQ for Transparent Relays"