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Re:	This is in response to the call for proposals 80216j-06_027.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-06/034)

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DL HARQ with Relays

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).

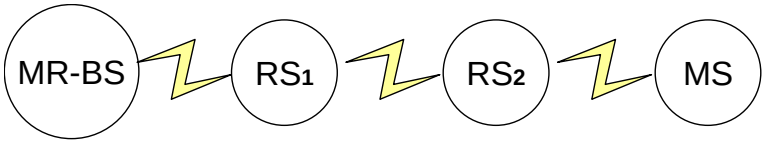

Figure 1: Illustration of Multi Hops in relay System

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 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 indication is only 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.

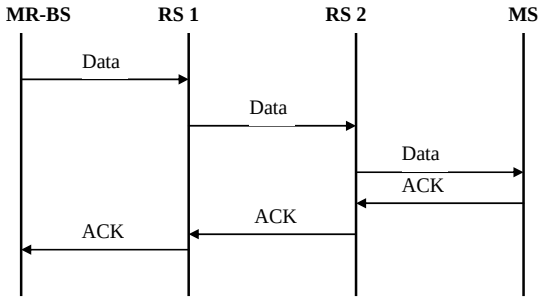

Figure 2. Message Flow for 3-hop DL HARQ

In Figure 2, the data is transmitted from the MR-BS to RS 1 and is forwarded to RS 2 and finally to the MS. As a response to a successful reception of the data at the MS, ACK is generated by MS. This ACK invokes as response a respective positive acknowledgement ACK generated at RS 2 and RS 1 thereafter, which is relayed

to the MR-BS. If RS 2 fails to decode the data, it sends NACK to RS1 and RS1 forwards encoded NACK indicating the failure link to the MR-BS.

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 while UL transmission failure on a relay link is indicated to MR-BS in a HARQ RS report, so the MR-BS can schedule the retransmission only for the links that didn't transmit packet in the last attempt. The mechanism is different for UL and DL, and it is described below. It is also described for the following cases:

- DL HARQ for non-Transparent RS
- DL HARQ for Two Hop Transparent RS

Insert new sub-clause 6.3.17.5.1

6.3.17.5.1 DL HARQ for non-Transparent RS

RS receives HARQ sub-burst from MR-BS or previous RS for relaying to MS or next RS and replies ACK/NAK signal through ACK channel in the R-UL. When the RS receives the HARQ sub-burst correctly, the RS forwards the sub-burst toward the MS and memorizes it for retransmission. When the RS does not successfully receive the HARQ sub-burst, the RS shall not forward the sub-burst.

MR-BS may allocate multiple UL ACKCH for RS, one of which is used to send ACK/NACK of that RS and others are used to relay ACK/NACK of its subordinate RSs or MS. In case of m-hop relay, the number of UL ACKCH between MR-BS and 1st RS will be m.

DL transmission failure on a relay link may 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 fails, the RS sends code C_1 defined in the table xxx as a NAK back to the previous RS/MR-BS. If the decoding succeeds, it forwards the HARQ packet to the next hop and wait for UL ACK from the next RS or MS. When it receives code C_0, indicating that the HARQ packet is successfully received by the next RS or MS, the RS sends code C_0 to the previous RS or MR-BS on its UL ACK channel. If the RS receives code C_k, $k \neq 0$, it will send 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/MS. 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 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 new sub-clause 6.3.17.5.2

6.3.17.5.2 DL HARQ for Two Hop Transparent RS

RS receives HARQ sub-burst from MR-BS for relaying to MS and replies ACK/NAK signal through ACK channel prepared by MR-BS. When the RS receives the HARQ sub-burst correctly, the RS forwards the sub-burst to the MS and saves it for possible retransmission. When the RS does not successfully receive the HARQ sub-burst, the RS shall not forward the sub-burst.

It is also possible for MR-BS to send the first transmission to the MS directly. In the same time, MR-BS informs the RS about the transmissions it needs to monitor. The RS, having information on downlink resource allocations sent in DL-MAP for MS, monitors the HARQ sub-burst transmission sent to MS by MR-BS directly and attempts to decode it. When the RS receives the HARQ sub-burst correctly, the RS saves it for possible retransmission.

When retransmission of the HARQ sub-burst is needed, MR-BS decides whether the MR-BS or RS retransmits the HARQ sub-burst based on the status of HARQ sub-burst at the RS. If RS has the correct HARQ sub-burst,

MR-BS notifies RS to retransmit the HARQ sub-burst to MS by using HARQ_DL_MAP_IE, and RS retransmit the HARQ sub-burst to MS.

Insert new sub-clause 6.3.17.5.2.1

6.3.17.5.2.1 ACK / NAK Signaling for two-hop transparent RS

MR-BS needs to recognize the status of HARQ sub-burst at RS and MS. MR-BS allocates space of ACK channel on UL sub-frame for RS and MS, and receives ACK or NAK through ACK channel from RS and MS separately. If MR-BS receives ACK from RS and NAK from MS, MR-BS makes RS retransmit HARQ sub-burst. If MR-BS receives NAK from RS, MR-BS retransmit HARQ sub-burst by itself.

It is also possible to configure RS to relay UL ACKCH of MS to MR-BS using encoded ACK/NAK based on table xxx. In this case, when MR-BS received the code C_1 from RS, MR-BS retransmits HARQ sub-burst by itself. When MR-BS received the code C_2 from RS, RS retransmits HARQ sub-burst instead of MR-BS.

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.

RS receives HARQ DL sub-burst for relaying to MS at frame *i* shall transmit the ACK/NAK signal through the ACK Channel in the ACKCH region at frame (*i*+*j*). The frame offset *j* is defined by the "HARQ ACK Delay for DL Burst" field in the UCD message.

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

$$n = H*p + (H+1)*j$$

H is defined by "number of hops RS is away from the MS".
p is defined by the "processing 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/NACK in the same frame, then the above equation will change. If encoded ACK/NACK 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.

Section 6.3.2.3.43.4 HARQ control IE

[Insert new field in table 94 (HARQ control IE format) as indicated:]

Syntax	Size	Notes
RSH	1 bit	0 = RS-assisted HARQ is enabled 1 = RS-assisted HARQ is disabled

[Insert new subclause 6.3.2.3.43.6.10 and add table:]

Section 6.3.2.3.43.6.10 Compact_DL-MAP MONITOR IE

The Compact_DL-MAP MONITOR IE provides the list of CIDs of the MS whose transmissions need to be monitored in the DL part of the current frame and relayed in the next frame to the MS.

Syntax	Size	Notes
Compact_DL-MAP_IE() {		
DL-MAP Type = 7	3 bits	
DL-MAP subtype	5 bits	
Number of CIDs	4 bits	Number of CIDs in the IE
for(i=0; i<Number of CIDs; i++) {		
CID(i)	16 bits	The CIDs of the connections that RS shall monitor in the current frame
}		
}		

References

- C80216j-06_12, “DL HARQ method for user-transparent relaying”
- C80216j-06_132, “Relaying methods proposal for 802.16j”
- C80216j-06_266r1, “Relay-Assisted Hybrid ARQ”
- C80216j-06_197r1, “HARQ with Relays”