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Title	UL HARQ for non-transparent Relays	
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Source(s)	Haihong Zheng, Yousuf Saifullah, Shashikant Maheshwari Nokia 6000 Connection Drive, Irving, TX	Voice: 972 894 5000 Fax: haihong.1.zheng@nokia.com , shashikant.maheshwari@nokia.com , Yousuf.saifullah@nokia.com
	Junichi Suga Fujitsu Laboratories Ltd. Kamikodanaka 4-1-1, Kawasaki, 211-8588, Japan	Voice: +81-44-754-2811 Fax: +81-44-754-2786 Email : suga.junichi@jp.fujitsu.com
	Michiharu Nakamura Fujitsu Laboratories LTD 5-5, Hikarinooka Yokosuka, Japan. 239-0847	Voice: +81-46-839-5371 Fax: +81-46-839-5560 Email : michi@labs.fujitsu.com
	Aik Chindapol, Jimmy Chui, Hui Zeng Siemens Corporate Research 755 College Road East, Princeton, NJ, USA	Voice: +1 609 734 3364 Fax: +1 609 734 6565 Email: aik.chindapol@siemens.com
	Byung-Jae Kwak, Suchang Chae, Young-il Kim ETRI 161, Gajeong-Dong, Yuseong-Gu, Daejeon, Korea 305-350	Voice: +82-42-860-6618 Fax: +82-42-861-1966 bjkwak@etri.re.kr
	Kyu Ha Lee Samsung Thales San 14, Nongseo-Dong, Giheung-Gu, Yongin, Gyeonggi-Do, Korea 449-712	Voice: +82-31-280-9917 Fax: +82-31-280-1562 Email: kyuha.lee@samsung.com
	Yanling Lu, Ting Li Hisilicon Technologies	Juyanling@hisilicon.com
	David Comstock, John Lee, Shang Zheng, Aimin Zhang Huawei Technologies No.98, Lane91, Eshan Road, Shanghai, P.R.C	dcomstock@huawei.com Voice: +1 858 735 9382

Eugene Visotsky
Motorola, Inc.
1301 E. Algonquin Road
Schaumburg, IL 60196

eugenev@motorola.com

Youngbin Chang
Samsung Electronics Co., Ltd.
416 Maetan-3, Suwon, 442-600, Korea

Voice: +82-31-279-5519
Email: yb.chang@samsung.com

Re:	This is in response to the call for proposals 80216j-07_07r2.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-06/026r2)
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UL HARQ with Relays

Haihong Zheng, Yousuf Saifullah, and Shashikant Maheshwari - Nokia

Junichi Suga, and Michiharu Nakamura - Fujitsu

Aik Chindapol, and Jimmy Chui – Siemens

Byung-Jae Kwak, Suchang Chae, Young-il Kim - ETRI

Kyu Ha Lee - Samsung Thales

Yanling Lu, Ting Li - Hisilicon

David Comstock, John Lee, Shang Zheng, Aimin Zhang – Huawei

Eugene Visotsky - Motorola

Problem Description

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](#)).

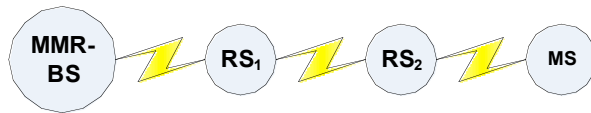


Figure 1: Illustration of Multi Hops in relay System

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.

UL HARQ scheme with centralized scheduling

This contribution suggests a mechanism for retransmitting a failed UL HARQ attempt only on the failed links, instead of retransmitting again from the MS. This is achieved by indicating the last RS on the relay path to MR-BS, which has successfully received the UL HARQ packet. The MR-BS uses this indication and allocates MAP accordingly so the retransmission could start from the last RS and onward. If the MR-BS receives the HARQ packet successfully, it doesn't allocate MAP for retransmission.

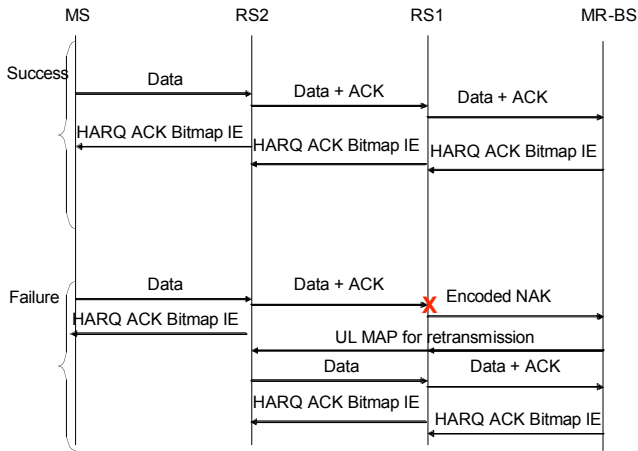


Figure 2. Message Flow for 3-hop UL HARQ

MR-BS allocates UL-MAP for transmitting HARQ burst on the access link. On the relay links, it also allocates a per hop HARQ ACK channel along with the HARQ packet burst allocation. The per-hop HARQ ACK channel carries the status of reception at the last RS. If the HARQ packet is received correctly on all the links, each subsequent RS sends ACK. If the HARQ packet is received incorrectly at an RS, it will not forward the incorrectly received packet to next hop RS, instead it will send encoded NAK to the next RS in the per hop HARQ ACK channel as in table xxx. The receiving RS first looks at the per hop ACK channel. If it receives encoded NAK (other than ACK), it discards any information received in the HARQ burst, and sends encoded NAK to the next Infra Station (IS). If RS receives the encoded NAK C_x ($x \neq 0$) then it will send the encoded NAK C_{x+1} to next hop RS/BS. If BS receives encoded NAK C_x then it knows that packet is failed on $x+1$ hop from MR-BS, therefore it will schedule retransmission only on the failed links.

If RS/MR-BS receives ACK on the per hop ACK channel, it decodes the HARQ burst. Figure 2 illustrates a successful and a failure case.

The access RS sends HARQ ACK bitmap IE as in current 16e spec to the MS for acknowledging received HARQ bursts. Similarly receiving RS/MR-BS sends HARQ ACK bitmap IE to the transmitting RS for acknowledging received HARQ burst. This helps RS to clear its buffer accordingly. This contribution describes the HARQ procedure for UL only. It is suggesting a mechanism that will work on any centralized MAP allocation scheme. It does not suggest a centralized MAP allocation scheme.

Specification changes

+++++ Begin +++++
Insert new sub-clause 6.3.17.5.1.1

6.3.17.5.1.1 ACK / NAK Encoding for multi-hop relay for UL HARQ

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 upstream RS RS_{j+1} , then BS should identify RS_j . For two hop case, only C_0 to C_1 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 for UL HARQ

Insert new sub-clause 6.3.17.6

6.3.17.6 Relay support for UL HARQ in centralized scheduling

MR-BS schedules a HARQ burst on all the links between MS and MR-BS. UL transmission failure on a relay link is indicated to the MR-BS. In case of a HARQ transmission failure on a link, the MR-BS schedules the retransmission only for the failed links that didn't transmit the burst in the last attempt.

Insert new sub-clause 6.3.17.6.3

6.3.17.6.3 UL HARQ for non-transparent RS

When MR-BS schedules a HARQ attempt, it allocates bandwidth over all the links from the MS to the MR-BS. It also allocates bandwidth for the ACK/NAK channel on the relay links between access RS and MR-BS. Each RS on the relay path receives the uplink HARQ burst, and decodes it. If the decoding succeeds, it forwards the HARQ burst to the next IS along with an ACK. If the decoding fails, the RS only sends an encoded NAK to the next IS. In case of multiple hop, each subsequent RS in the path places encoded NAK according to table xxx. In case of two hops, encoded NAK is not needed. Encoded NAK informs MR-BS where the packet transmission was unsuccessful. If RS receives the encoded NAK C_x ($x \neq 0$) then it will send the encoded NAK C_{x+1} to next hop RS/MR-BS. If MR-BS receives encoded NAK C_x then it knows that packet is failed on $x+1$ hop from MR-BS, therefore it will schedule retransmission only on the failed links. The MR-BS sends UL-MAP accordingly, allowing retransmission from the last RS onwards, thus, retransmitting only on the links that didn't relay the HARQ burst successfully.

The receiving RS first looks at the per hop ACK channel. If it receives encoded NAK, it discards any information received in the HARQ, and sends encoded NAK to the next Infra Station (IS). If it receives ACK, it decodes the HARQ burst.

The MS behavior is unchanged with the introduction of RS.

The ACK/NAK is sent in HARQ ACK Bitmap IE. Each RS also generates per hop HARQ ACK bitmap IE for its received HARQ bursts. Each receiving RS/MR-BS keeps its mapping, and generates its HARQ ACK bitmap accordingly. The MR-BS allocates the resource to transmit HARQ ACK bitmap IE from each RS. The receiver of the bitmap clears the buffer corresponding to the ACK bits in the bitmap, and saves the buffer corresponding to the NAK bits.

8.4.5.4.25 HARQ ACK region allocation IE

[Insert the following text at the end of the subclause]

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.

In case of non-transparent RS, RS receives HARQ UL sub-burst, from MS or sub-ordinate RS for relaying to MR-BS at frame *i*. It shall transmit the ACK/NAK signal through the ACK Channel in the ACKCH region along with the UL MS HARQ sub-burst at frame (*i+k*). RS shall transmit the ACK/NAK signal according to the order of UL HARQ sub-burst in the UL-MAP. The frame offset *k* is defined by the "HARQ ACK Delay for UL Burst for MR" field in the UCD message.

[Insert the following table after table 302t]

Table 302xx—HARQ ACKCH region allocation for UL MS Data IE

Syntax	Size	Notes
HARQ ACKCH Region for UL Relay IE() {		
Extended-2 UIUC	4 bits	0xYY
Length	8 bits	Length in bytes
OFDMA Symbol offset	8 bits	
Subchannel offset	7 bits	
No.OFDMA symbols	5 bits	
No.subchannels	4 bits	
}		

+++++ End +++++