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Title	Relay Combining HARQ for 802.16j
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Re:	This document is in response to call for technical proposals IEEE 802.16-06/27
Abstract	This document describes HARQ procedures when relays are used.
Purpose	This contribution is submitted for discussion and adoption in IEEE 802.16j
Notice	
Release	
Patent Policy and Procedures	

Relay Combining HARQ for 802.16j

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1. Introduction

This contribution proposed a new hybrid ARQ scheme for 802.16j. Its main idea is to employ the diversity or code combining function at relay station to provide the high reliable communication. For this scenario, the source sends a message to the relay station and relay forwards the received signal to the destination. If a retransmission is needed from the destination, the source retransmits the message and relay combines the current message with the previous message and then retransmits the combined signal to the destination. At the same time, the destination also combines the received signal with the previous signal. Thus the end-to-end reliability is obtained.

The proposal presented here has the following advantages:

- ✧ The combining function is transparent to the MS: the MS is not aware of any relaying operations.
- ✧ No further complexity is introduced into the system. Only simple combing circuit just like add operation is needed. Furthermore, no modification on the normal ARQ is done. The same block size and block sequence number are used over multi-hop links.
- ✧ This proposal can be employed in any current frame structure.
- ✧ In this proposal, the BS controls the RS and MS, thus it’s very easy to synchronize with BS for RS.
- ✧ The proposal can greatly reduce the block error rate and improve the link throughput.

2. Retransmission Policies [1-2]

There are two basic retransmission policies for multi-hop relay structure. One is the Base Station (BS) controlled. This means that the NAK/ACK is only feed back from BS or Mobile Station (MS). The Relay Station (RS) informs BS of retransmission need. The data transmission and NAK/ACK feedback involved multi-hop path. The block size and sequence number for mapping into physical frame is used in multi-hop links. Another is the BS, RS controlled. This means that the ACK/NAK can be transmitted from BS/MS or RS. BS handles retransmission direct to BS and MS. RS handles retransmission for MS connected to it. Because of independent processing to retransmission, the block size and sequence number for BS transmission and RS transmission may be different. Furthermore, if the RS moves to other places, the MS will can not access it. Then the data buffered at RS to MS can not be recovered for ever.
From the description about two retransmission policies, we think the first is simple and can achieve high reliable communications; therefore our improved method is based on the first policies.

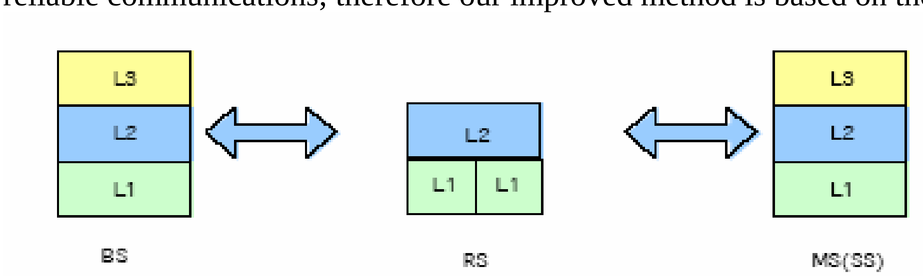

Figure 1 Protocol stack for BS controlled HARQ

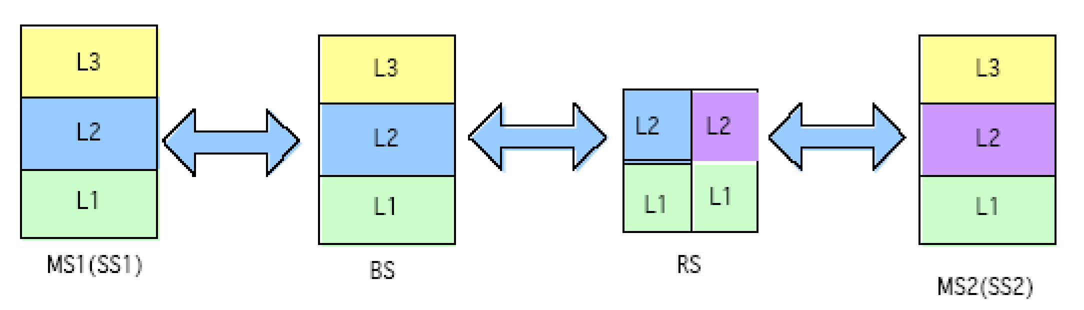

Figure 2 Protocol stack for BS, RS controlled HARQ

3. Proposed relay combining HARQ for 802.16j

The proposed relay combining HARQ procedure is shown in Figure 3. The communication process can be described as the following.

- ✧ For uplink transmission, based on the UL MAP, the MS transmits the original data to RS.
- ✧ Based on the UL MAP for RS, the RS verifies received data and forwards it to BS at the uplink transmission from RS to BS even if the verification is failed
- ✧ If error is detected at the BS, the NACK is fed back to RS, otherwise the ACK is fed back to RS at the downlink transmission based on DL MAP in frame structure.
- ✧ RS will forwards the ACK or NACK to the MS in the downlink transmission from RS to MS.
- ✧ MS will transmit the new data or retransmit the data according to the ACK or NACK. If NACK is received, MS will retransmit the data, and the RS will combine it with the original data based on the UL MAP which informs the combining scheme, new or retransmission, user ID and so on. Then the RS will verify the combined signal and forward it to the BS at the uplink transmission from RS to BS even if the verification is failed. In addition, the BS will combine the retransmitted data with the original data and feed back ACK/NACK to RS after CRC.

From above description and the procedure figure, we can see that combining function at the RS can improve the link between MS and RS for uplink. The proposal can also be employed in downlink. In the procedure, the chase combining and incremental redundancy both can be used at RS and MS. The procedure can find out the detailed HARQ scheme from HARQ UL MAP IE in table 302j in sub-clause 8.4.5.4.24. First based on HARQ UL MAP IE in table 302j, we find out the HARQ mode. Then corresponding to different modes such as chase, IR, we find out the corresponding IE format. For chase combining mode, we refer the table 302k for AI-SN which indicates new or retransmission, however for Incremental Redundancy, we refer the table 302I for AI-SN and SPID which indicates the different redundancy versions.

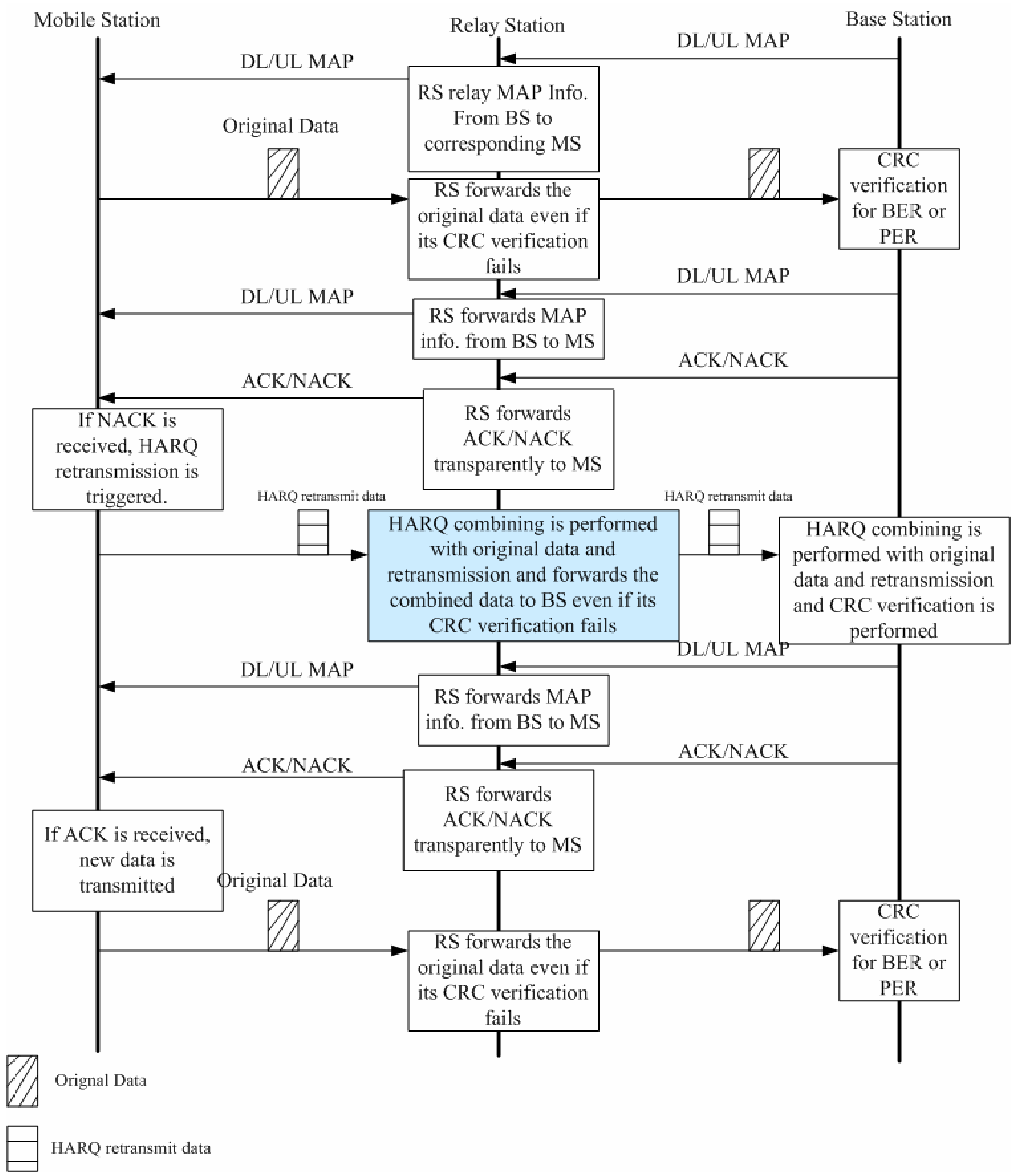

Figure 3. Proposed relay combining HARQ procedure

Table 302j—HARQ UL MAP IE *(continued)*

Syntax	Size	Notes
If (Allocation Start Indication == 1) {	—	—
OFDMA Symbol offset	8 bits	This value indicates start Symbol offset of subsequent sub-bursts in this HARQ ULMAP IE
Subchannel offset	7 bits	This value indicates start Subchannel offset of subsequent sub-bursts in this HARQUL MAP IE
Reserved	1 bit	Shall be set to zero.
}	—	—
N sub Burst	4 bits	Indicates the number of bursts in this UL MAP IE
For (i =0 ;i < N Sub-burst; i++){		
If (Mode == 000) {		
UL HARQ Chase Sub-Burst IE ()		
} else if (Mode== 001) {		
UL HARQ IR CTC Sub-Burst IE ()		
} else if (Mode== 010) {		
UL HARQ IR CC Sub-Burst IE ()		
} else if (Mode== 011) {		
MIMO UL Chase HARQ Sub-Burst IE ()		
} else if (Mode== 100) {		
MIMO UL IR HARQ Sub-Burst IE ()		
} else if (Mode== 101) {		
MIMO UL IR HARQ for CC Sub-Burst IE ()		
} else if (Mode == 110) {		
MIMO UL STC HARQ Sub-Burst IE ()		
}		
}		
}	—	—
Padding	*variable*	Padding to byte; shall be set to 0
}	—	—

Table 302k—UL HARQ Chase sub-burst IE format

Syntax	Size	Notes
HARQ Chase UL Sub-Burst IE {	—	—
RCID IE()	*variable*	—
Dedicated UL Control Indicator	1 bit	—
If (Dedicated UL Control Indicator ==1) {	—	—
Dedicated UL Control IE ()	*variable*	—
}	—	—
UIUC	4 bits	—
Repetition Coding Indication	2 bits	0b00 – No repetition coding 0b01 – Repetition coding of 2 used 0b10 – Repetition coding of 4 used 0b11 – Repetition coding of 6 used
Duration	10 bits	—
ACID	4 bits	—
AI_SN	1 bit	—
ACK disable	1 bit	When 'ACK Disable' == 1, the allocated sub-burst does not require an ACK to be transmitted by the BS in the HARQ ACK BITMAP (see 8.4.5.3.22). In this case, no bit position is allocated for the sub-burst in the HARQ ACK BITMAP. For the burst, MS shall not perform HARQ retransmission and ignore ACID, AI_SN and SPID, which shall be set to '0' by BS if they exist.
Reserved	1 bit	—
}	—	—

Table 302l—UL HARQ IR CTC sub-burst IE format

Syntax	Size	Notes
HARQ IR CTC UL Sub-Burst IE {	—	—
RCID IE()	*variable*	—
Dedicated UL Control Indicator	1 bit	—
If (Dedicated UL Control Indicator ==1) {	—	—
Dedicated UL Control IE ()	*variable*	—
}	—	—
N_{EP}	4 bits	—
N_{SCH}	4 bits	—
SPID	2 bits	—
ACID	4 bits	—
AI_SN	1 bit	—
ACK disable	1 bit	When 'ACK Disable' == 1, the allocated sub-burst does not require an ACK to be transmitted by the BS in the HARQ ACK BITMAP (see 8.4.5.3.22). In this case, no bit position is allocated for the sub-burst in the HARQ ACK BITMAP. For the burst, MS shall not perform HARQ retransmission and ignore ACID, AI_SN and SPID, which shall be set to '0' by BS if they exist.
Reserved	3 bits	—
}	—	—

In order to evaluate the proposed relay combining HARQ, we compare it with the conventional HARQ for 802.16j in terms of block error rate (BLER) and spectral efficiency as shown in Figure 4 and Figure 5.In our compute simulation, the block fading channel is considered. The QPSK and convolutional code with code rate 1/2 are used. In addition, the maximum allowed retransmission number is set to 3. Path loss is not considered because the HARQ is mainly affected by the fading. The results show that the proposed relay combining HARQ can greatly decrease the BLER and improve the throughput. About 2dB power saving can be saved for proposed HARQ.

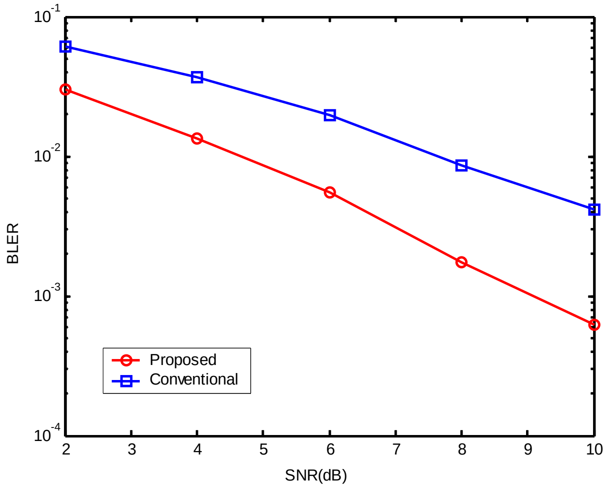

Figure 4. BLER vs SNR for different HARQ schemes

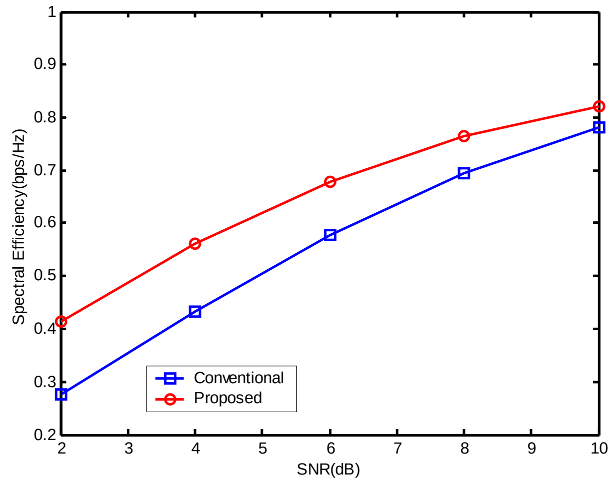

Figure 5. Spectral efficiency vs SNR for different HARQ schemes

5. The implementation of relay combining HARQ for RS

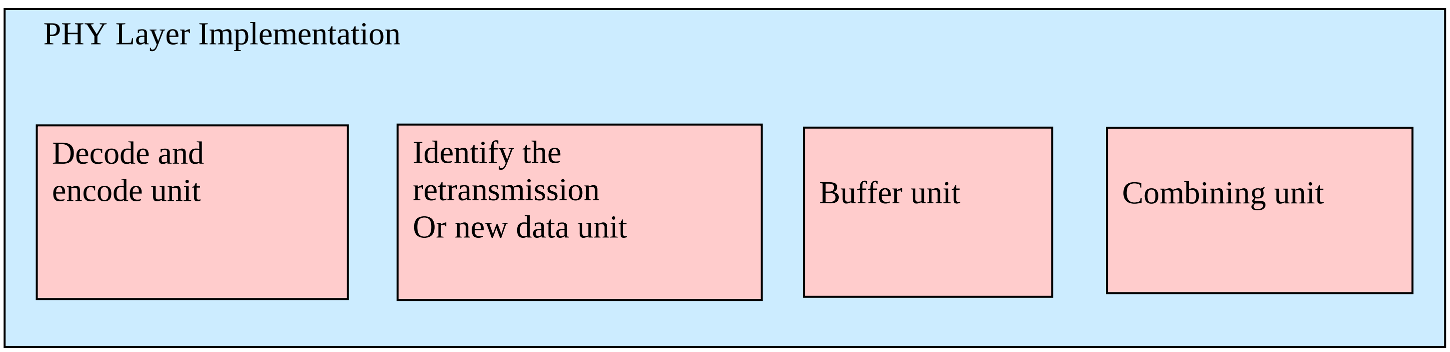

Figure 6. RS implementation units.

In order to implement combining function for RS, it needs the above units as shown in Figure 6. It means that RS has the following functions:

- Buffer the received data.
- RS checks whether the received data is retransmission or not based on DL MAP of frame structure.
- RS combines the received multiple copies.
- RS estimates the channel information between BS and RS.

Reference

[1] C80216mmr-05_028 Open problems in Mobile Multi-hop Relay System.

[2] C80216j-06_029 Usage scenario considerations for 802.16 relay.

[3] IEEE Std 802.16e-2005, IEEE standard for local and metropolitan area networks Part 16: Air Interference for Fixed and Mobile Broadband Wireless Access Systems.