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Title	**DL HARQ method for user-transparent relaying**
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Re:	This contribution is response to call for technical proposal (IEEE 802.16j-06/027)

Abstract	This contribution proposes the method of DL HARQ processing for user-transparent relying.

Purpose	For discussion and approval of inclusion of the proposed text into the P802.16j baseline document.

	herein.
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DL HARQ method for user-transparent relaying

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Introduction

This contribution introduces Down Link HARQ processing for transparent type of RS, where the RS does not transmit a preamble, FCH or MAP, and BS receives signal of ACK channel from MS directly.
In order to reduce the resource for retransmission of HARQ data, RS retransmits HARQ data instead of MR-BS, if RS has correct HARQ data.

The proposal presented here has the following advantages:

• The proposed DL procedure is transparent to the MS: the MS is not aware of any relaying operations.

• No further complexity is introduced into the system. Furthermore, HARQ mechanisms (except for the acknowledgments from RS organization) remain the same, since it is transparent to the MS whether the information comes from the RS or the BS.

Whilst the Down Link HARQ processing introduced does require changes to the existing BS specification, it does not require any changes to the MS/SS as described in IEEE Std. 802.16.

Proposed method

Transparent relaying

In transparent relaying system, RS relays only user data. As shown in figure 1, MS receives a preamble, FCH or MAP directly from MR-BS, and receives user data via RS. It is also possible to configure MS to receive data from RS only for HARQ retransmissions. On uplink, MR-BS receives signal of ACK channel from MS directly which is used for control HARQ retransmission.
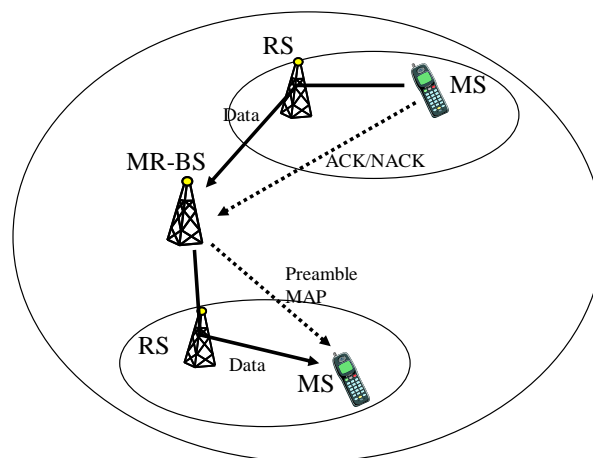

Figure 1 transparent relaying

Figure 2 shows the example of HARQ processing sequence. Since the delay of RS processing is assumed, RS does not relay HARQ data #1 in the same frame where RS receives it. And RS relays HARQ data #1 agreeing to DL MAP for MS sent by MR-BS. MR-BS receives ACK or NACK from MS directly through ACK channel.
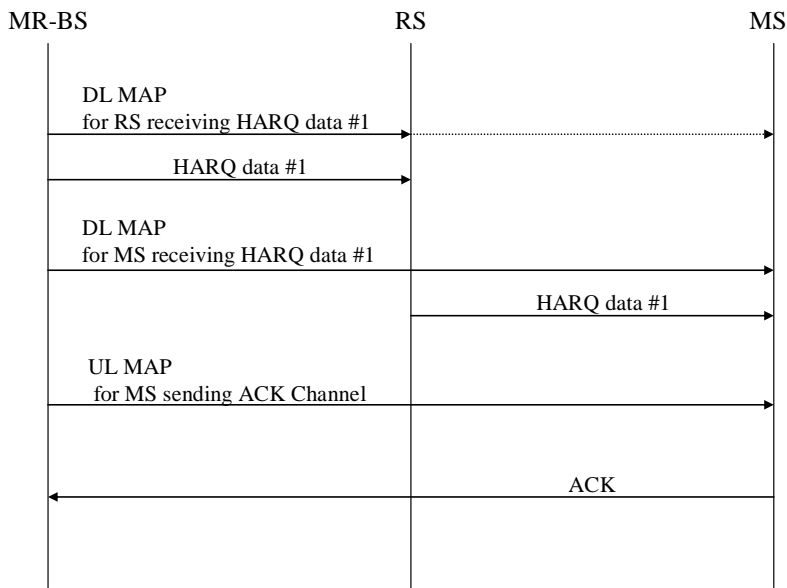

Figure 2 DL HARQ processing

Retransmission HARQ data from RS

When MR-BS receives NACK from MS directly, the retransmission of the related HARQ data is needed. It is assumed that if RS has received HARQ data correctly, the retransmission from RS instead of MR-BS is efficient for radio resource. In this document, RS memorizes correct HARQ data when RS receives it from MR-BS, and RS retransmits HARQ data to MS instead of MR-BS, if needed.

MR-BS   RS   MS

DL MAP
for RS receiving HARQ data #1

HARQ data #1

DL MAP
for MS receiving HARQ data #1

UL MAP
for RS sending ACK Channel

HARQ data #1

ACK

UL MAP
for MS sending ACK Channel

NACK

DL MAP
for RS receiving HARQ data #1
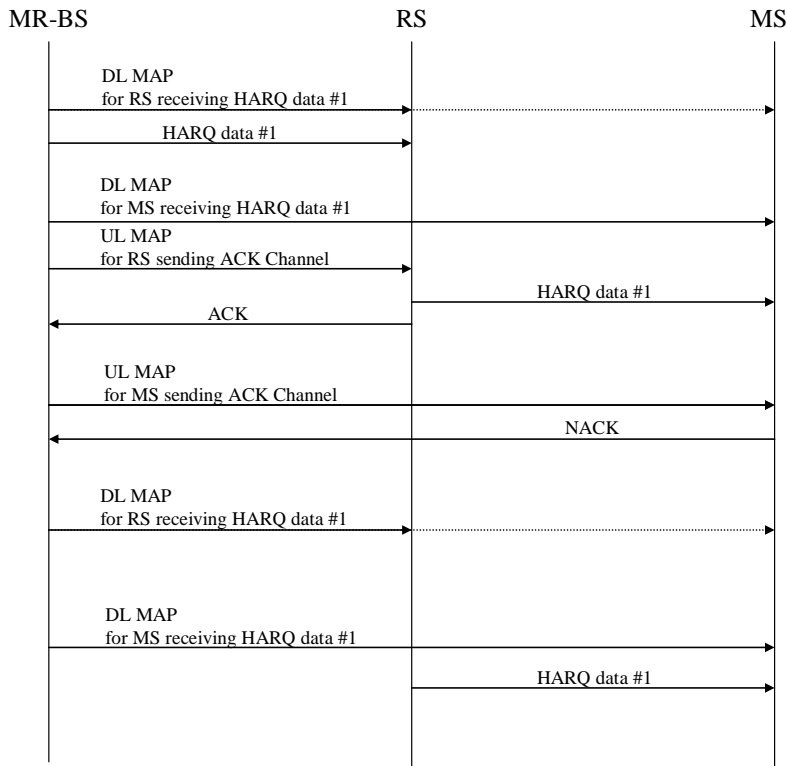
DL MAP
for MS receiving HARQ data #1

HARQ data #1

Figure 3 Proposed DL HARQ processing

Figure 3 shows the example of retransmission HARQ data from RS. In this proposal, ACK channel for RS is prepared by BS, and when RS receives HARQ data from BS, RS decodes it and replies ACK or NACK through prepared ACK channel to BS. When RS receives correct HARQ data from BS, RS memorizes it for retransmission.

This example shows the case where error is occurred in the link between RS and MS, RS replies ACK to BS, and MS replies NACK to BS. Since RS replies ACK to BS, BS recognizes that RS can retransmit HARQ data, then BS requests for RS by using DL MAP to retransmit HARQ data to MS instead of BS.

While, RS has received error HARQ data from BS may not transmit it to MS to avoid interference to other cell, and replies NACK to BS.

In the case where the BS transmits data to the MS for the first transmission, the RS can listen it as well. Furthermore, the RS can decode the data received from the BS and forward it to the MS if a retransmission is necessary. The MS combines both received transmissions. Within this scenario, both chase combining (CC) and incremental redundancy (IR) could be implemented. Since it is preferred to have the RS forwarded the data only if it decodes the message correctly, the RS needs to send an acknowledgement back to the BS. If the RS fails to decode the message, the next retransmission will come from the BS directly and the RS can listen again to improve its decoding performance for that packet. This enables the RS to have another opportunity to forward the data to the MS in the case that the MS requires further retransmissions. Figure 4 shows this procedure.
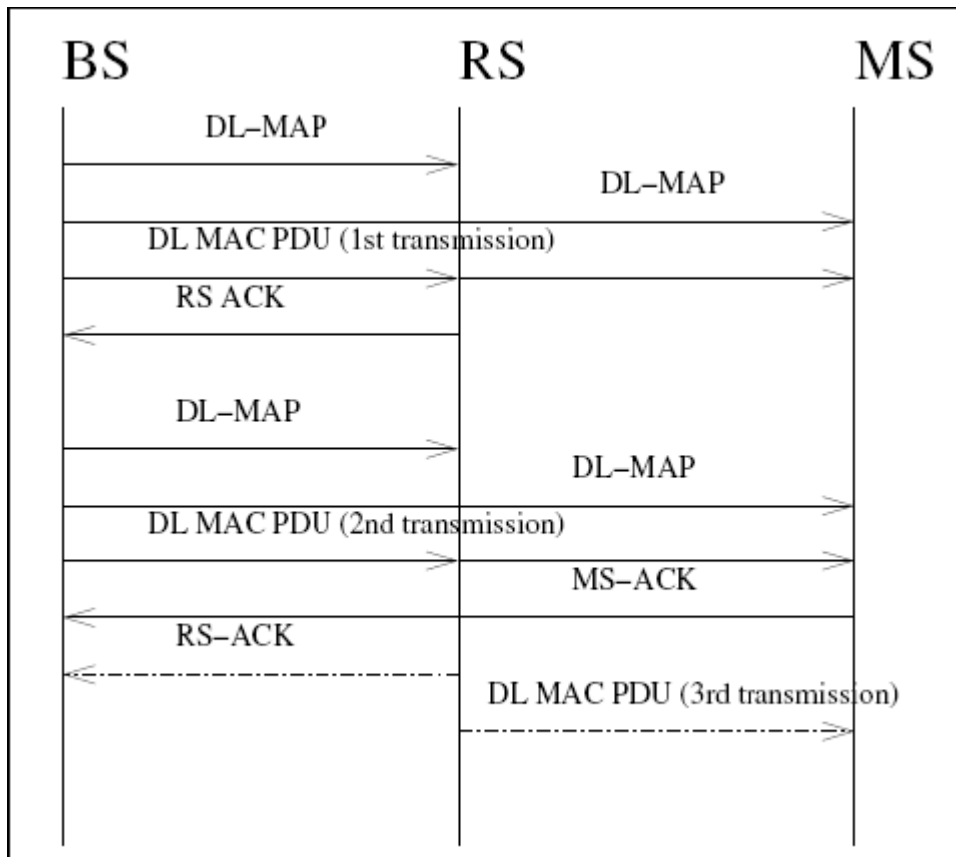
Figure 4 Relay-assisted HARQ where the RS fails to decode the first transmission.

Specific text changes

Insert the following text at the end of the subclause
6.3.17.2 DL ACK/NAK signaling

For retransmission from MR-BS to RS, a dedicated PHY layer ACK channel is allocated in the R-UL.

Insert a new subclause 6.3.17.4
6.3.17.4 DL HARQ for MR

RS receives HARQ sub-burst from MR-BS for relaying to MS 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 to the MS and memorizes it for preparing to retransmit it. 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 try to decode the transmission as well.

 MR-BS decides whether the MR-BS or RS retransmits the HARQ sub-burst based on the received ACK/NAK information from the RS and MS, . When MR-BS receives ACK signal from RS and NAK signal from MS, MR-BS notifies RS to retransmit HARQ sub-burst by using HARQ_DL MAP_IE.

 This process is transparent to the MS because the MS does not need to know that one transmission comes from the BS or the RS

The HARQ data is sent from MR-BS to RS in relay link and RS relays the data to MS in access link. Alternatively, the RS, having the information on downlink resource allocations sent in DL-MAP for MS monitors the data transmission sent to MS and attempts to decode it. The MR-BS allocates space for the acknowledgment of the RS. Depending on the acknowledgment of the RS, there are two possible cases. In the first case, if the RS replies with an ACK (meaning that the data has been correctly decoded at the RS), within the next frame, the BS will allocate space for the RS to send the HARQ data to the MS and at the same time the BS will allocate the space for the MS to acknowledge the received data. This process is illustrated in Figure 1. In the second case, if the RS replies with NACK (meaning that the RS was not able to decode the data during the first transmission), the BS will repeat the first transmission attempt to both the RS and MS during a second frame. Within this second frame, the BS will allocate the space for the MS to acknowledge the second transmission. This process is illustrated in Figure 2. Additionally, at this point, the BS can also allocate the space for the RS to acknowledge second transmission. This will enable the RS to forward the data to the MS in the case the MS is still not able to decode the data after the second direct transmission from the BS. The process are shown in Figures 1.
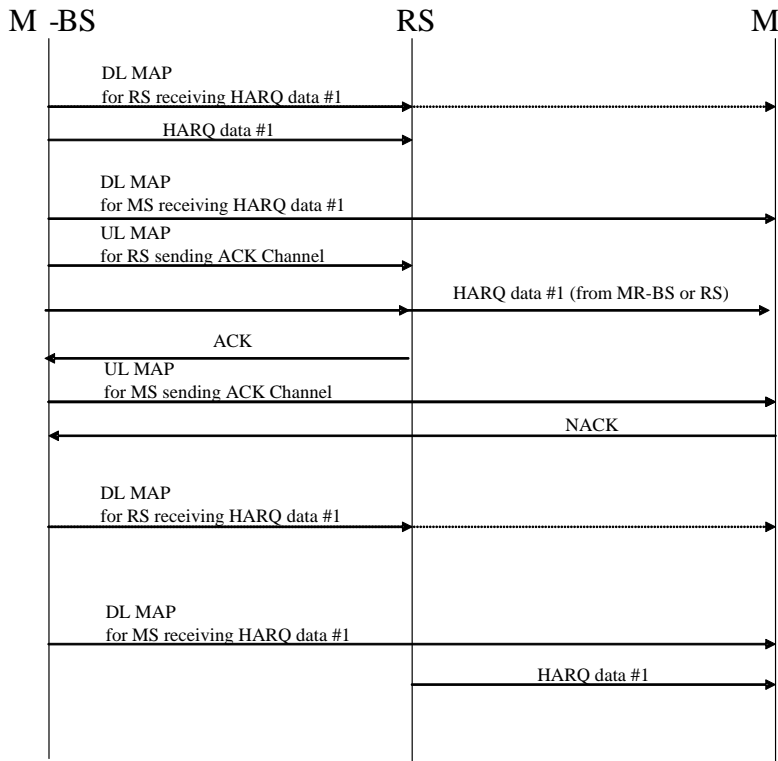
Figure 1. DL Relay-assisted HARQ processing

Insert the following text at the end of the subclause
8.4.5.4.21 HARQ DL MAP IE

 When the MR-BS decides to make the RS retransmit HARQ data packet to MS, the MR-BS shall transmit this IE without transmission of the HARQ sub-burst to the RS. Since RS has correct HARQ sub-burst, the information about length of sub-burst in this IE (e.g. duration) is to be zero. RS receives this IE which relates to correct sub-burst memorized by RS and retransmits the sub-burst to MS instead of MR-BS. The MR-BS also transmits the HARQ_DL_MAP_IE to the MS with the correct information about the length and location of HARQ sub-burst that is transmitted by the RS.

Insert the following text at the end of the subclause
8.4.5.4.13 UL ACK Channel

 This channel shall be supported by RS. RS transmits ACK or NAK feedback for HARQ sub-bursts on the R-DL

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.

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

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

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