Project	**IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>**	
Title	**DL HARQ for centralized scheduling using data tunneling**	
Date Submitted	**2007-07-05**	
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Re:	This is in response for call for proposals 80216j-07_019.pdf	
Abstract	This contribution proposes a procedure for handling retransmission of HARQ failure attempts in a relay system that operates under centralized scheduling with tunneling.	
Purpose	Review and adopt proposed text changes in P802.16j Baseline Document (IEEE 802.16j-06/026r4)	
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DL HARQ for centralized scheduling using data tunneling

Introduction

The current specifications of the baseline document for RSs does not provide solutions for HARQ reporting under the centralized scheduling with data being tunneled from the MR-BS to MSs via RSs.

A DL data tunnel has its beginning at the MR-BS while the end of the tunnel is at the access RS for the corresponding MSs that are part of the tunnel. Although the tunnel packs multiple MPDUs from different MSs (CIDs), when access RS receives the tunneled MPDU successfully, the ACK/NAK reporting has to include each individual MPDU so that MR-BS can schedule the retransmission of MPDU on the access link.

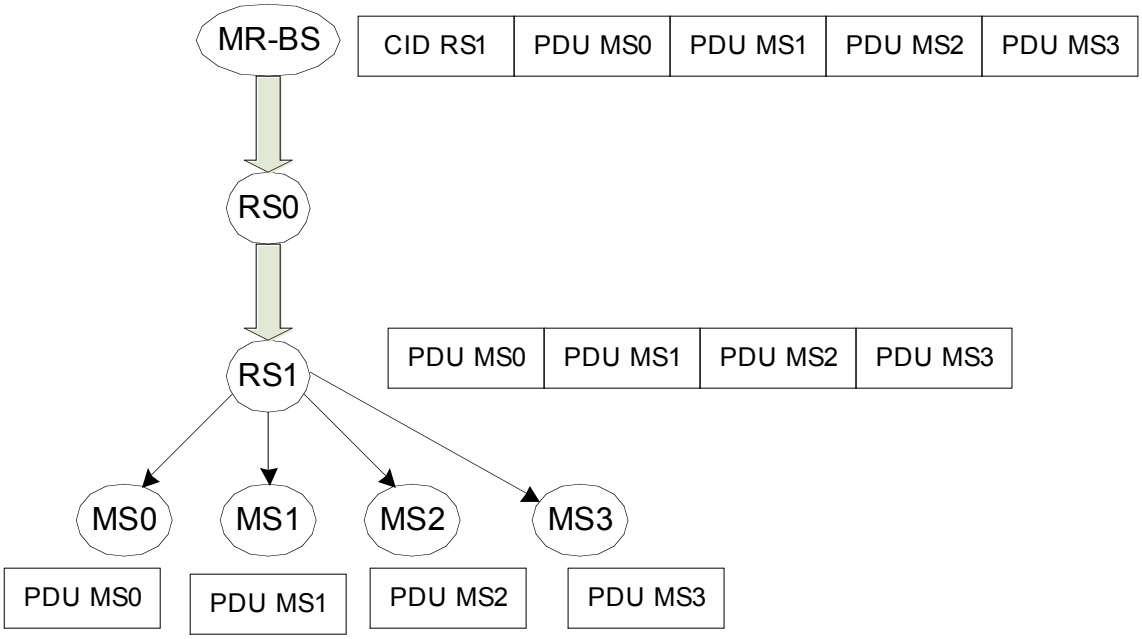

Figure 1. Example of a tunnel transmission for four MSs

An example of a DL tunnel transmission is presented in Figure 1. The MR-BS sets a tunnel with the end at the RS1, via RS0. The tunnel in the example includes the PDUs for 4 MSs. At the end of the tunnel RS1 unpacks the data and delivers each individual PDU according to the instructions received from MR-BS.

It is noticeable that there is an issue of operating a HARQ scheme in this situation because there is a unicast (PTP) connection between MR-BS and RS1 while a multicast (PMP) connection between RS1 and MSs, and all belong to the same tunnel. For the unicast HARQ operation the section 6.3.17.5 of the baseline document can be used. The multicast HARQ operation is described subsequently. If the tunneled packet fails at any intermediate RS that is part of the unicast connection, the MR-BS neglects the multicast HARQ reporting channels. The MR-BS takes into account the multicast HARQ reporting only if the unicast reporting has been successful. The MR-BS reschedules only those multicast transmissions that have failed.

For each established DL tunnel, the MR-BS associates a unicast Tunnel CID for the PTP part of the tunnel, and a number of aggregated HARQ channels for the PMP part of the tunnel. The aggregated HARQ channels shall be simply forwarded by the intermediate RSs, without applying the procedure of incrementing the code (see subsection 6.3.17.5.1). The number of aggregated HARQ channels is given by *ceiling*(M/3), where M is the

number of corresponding MPDUs that have been scheduled for (re)transmission.

The access RS that is at the end of the tunnel, aggregates the individual ACK/NAK reports of each MPDU included in the tunnel that has been scheduled for (re)transmission. The order in which the individual ACK/NAK is included in the aggregation process is based on the updated position index of the MPDU in the tunneled packet. Both the MR-BS and the access RS maintain an updated version of the tunneled packet that shall be used for scheduling the retransmissions. If an MPDU is successfully received by the MS, than both MR-BS and access RS shall update the position indices of the remaining MPDUs of the tunneled packet. The rare event of receiving with errors the aggregated HARQ reports from the access RS by the MR-BS is treated later in this subsection.

Denote by HARQ (Tunnel-CID, i, j) the j-th bit of the i-th bitmap aggregated HARQ channel that belongs to tunnel Tunnel-CID. Indices of the MPDUs in the tunneled packet, as well as i and j in HARQ (Tunnel-ID, i, j) start with zero. The MPDU having the updated position index k (k=0,1, …, M-1) in the tunnel is reported in the bitmap aggregated HARQ channel by the access RS as:

$$\text{HARQ}(\text{Tunnel - CID}, i, j) = \begin{cases} 0 & \text{if MS reports ACK for that MPDU} \\ 1 & \text{if MS reports NAK for that MPDU} \end{cases} \qquad \text{Equation xxx}$$

where i = floor(k/3) and j = k modulo 3.

Each 3-bit aggregated HARQ bitmap uses 1/2 OFDMA slots mapped in a manner similar to the mapping of ACK/NAK channel. Table xxx defines the encoding between the payload bit sequences and the subcarriers modulation for signaling the aggregated HARQ channel.

Table xxx: The aggregated HARQ channel tile encoding.

3-bit aggregated HARQ bitmap	Vector Indices per Tile Tile(0), Tile(1), Tile(2)
000	0, 0, 0
001	1, 1, 1
010	2, 2, 2
011	3, 3, 3
100	4, 4, 4
101	5, 5, 5
110	6, 6, 6
111	7, 7, 7

The MR-BS schedules for retransmission the MPDUs that have been reported by the access RS as being unsuccessful (NAK). In the rare event that the aggregated HARQ reports are received with errors by the MR-BS, the RS shall perform the retransmissions and aggregation as described in this paragraph. If due to error in reception the MPDU_k is rescheduled for transmission although is has been received successful by the MS, then the access RS shall change for the MPDU_k in the HARQ DL-MAP the CID with its own CID and in order to reduce the interference the data may not be transmitted. If due to error in the reception of the aggregated HARQ reports by the MR-BS the MPDU_m is not rescheduled for transmission although is has not been received successful by the MS, then the access RS shall consider the MPDU_m as being delivered successful to the MS.

As an example, consider the case where the access RS has to deliver four MPDUs that belong to a tunnel id Tid. Assume that only the MPDU_2 has been received successful. The RS reports two aggregated bitmaps (ceiling(4/3)=2) HARQ(Tid,0,:)=[110] and HARQ(Tid,1,:)=[100] and sends them to MR-BS. Assume that due

to channel errors, the MR-BS receives the bitmaps [101] and [100]. Thus the MR-BS reschedules for transmission $MPDU_0$, $MPDU_2$ and $MPDU_3$. Because $MPDU_2$ has been already received successful, the access RS will change the CID with its own CID and the corresponding bit in the aggregated HARQ bitmap is set to zero. Also, because $MPDU_1$ has not been scheduled for retransmission, due to the error in reception by MS-BS, the RS disregards this MPDU. Thus, the access RS retransmits $MPDU_0$ and $MPDU_3$. If both MPDUs have been received successful, the aggregated HARQ(Tid,0,:) = [000] bitmap corresponds in order to $MPDU_0$, $MPDU_2$ and $MPDU_3$.

Specific text changes

[Insert new sub clause 6.3.17.4.5]

6.3.17.4.5 DL HARQ for tunnelling

A DL data tunnel has its beginning at the MR-BS while the end of the tunnel is at the access RS for the corresponding MSs that are part of the tunnel. Although the tunnel packs multiple MPDUs from different MSs (CIDs), when access RS receives the tunneled MPDU successfully, access RS unpacks the data and delivers each individual MPDU according to the MAPs received from MR-BS.

When HARQ is enabled for the tunnels, HARQ operation is composed of HARQ process on the relay link and HARQ process on the access link. HARQ operation on the relay link (between MR-BS and access RS) shall follow section 6.3.17.4.1 along with additional procedure described subsequently.

When access RS receives the HARQ burst correctly, it unpacks the tunneled MPDU and perform the HARQ operation on the access link. The HARQ ACK/NAK reporting has to include each individual MPDU so that MR-BS can schedule the retransmission of MPDU on the access link. MR-BS shall configure additional HARQ ACK/NAK channels from access RS all the way back to MR-BS to report the MS's HARQ ACK/NAK signals so that MR-BS can schedule the retransmission of corresponding HARQ burst on the access link.

If the tunneled HARQ burst fails at relay links, the MR-BS neglects the MS's HARQ ACK/NAK channels. The MR-BS takes into account the access link HARQ ACK/NAK reporting only if the relay link HARQ ACK/NAK reporting has been successful. The MR-BS reschedules only those HARQ burst transmissions on the access link that have failed.

When access RS receives the HARQ burst correctly, it shall aggregate the HARQ ACK/NAK signals from MSs according to table xxx and transmit to super-ordinate RS. When intermediate RS receives ACK signal for the HARQ burst on the relay link, it shall forward the received aggregated HARQ ACK/NAK signals to upstream RS/MR-BS. MR-BS assigns the number of aggregated HARQ channels per RS using aggregated-HARQ ACK region allocation IE. The number of aggregated HARQ channels is given by *ceiling*(M/3), where M is the number of concatenated MPDUs in a tunnel or number of corresponding MPDUs that have been scheduled for (re)transmission.

The access RS that is at the end of the tunnel, aggregates the individual ACK/NAK reports of each MPDU included in the tunnel that has been scheduled for (re) transmission. The order in which the individual ACK/NAK is included in the aggregation process is based on the updated position index of the MPDU in the tunneled packet. Both the MR-BS and the access RS maintain an updated version of the tunneled packet that shall be used for scheduling the retransmissions. If the MS successfully receives an MPDU, than both MR-BS and access RS shall update the position indices of the remaining MPDUs of the tunneled packet.

HARQ (Tunnel-CID, i, j) denotes that the j-th bit of the i-th bitmap of the aggregated HARQ channel that belongs to tunnel CID. The indices of the MPDUs in the tunneled packet, as well as i and j in HARQ (Tunnel CID, i, j) start with zero. The MPDU having the updated position index k (k=0,1, …, M-1) in the tunnel is reported in the bitmap aggregated HARQ channel by the access RS as:

$$\text{HARQ(Tunnel - CID},i,j) = \begin{cases} 0 & \text{if MS reports ACK for that MPDU} \\ 1 & \text{if MS reports NAK for that MPDU} \end{cases} \qquad \text{Equation xxx}$$

where i = floor(k/3) and j = k modulo 3.

Each 3-bit aggregated HARQ bitmap uses 1/2 OFDMA slots mapped in a manner similar to the mapping of ACK/NAK channel. Table xxx defines the encoding between the payload bit sequences and the sub carriers modulation for signaling the aggregated HARQ channel.

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011	3, 3, 3
100	4, 4, 4
101	5, 5, 5
110	6, 6, 6
111	7, 7, 7

The MR-BS schedules retransmission of the MPDUs that have been reported by the access RS on the aggreagated HARQ channel as being unsuccessful (NAK). In the rare event that the aggregated HARQ reports are received with errors by the MR-BS, the RS shall perform the retransmissions and aggregation as described subsequently.

If due to error in reception of aggregated HARQ ACK/NAK channel, the $MPDU_k$ is rescheduled for transmission although is has been received successful by the MS, then the access RS shall change for the $MPDU_k$ in the HARQ DL-MAP the CID with its own CID and in order to reduce the interference the data may not be transmitted. If due to error in the reception of the aggregated HARQ ACK/NAK channel by the MR-BS the $MPDU_m$ is not rescheduled for transmission although is has not been received successful by the MS, then the access RS shall consider the $MPDU_m$ as being delivered successful to the MS.

[Insert new sub clause 8.4.5.4.xx]

8.4.5.4.xx Aggregated-HARQ ACK region allocation IE

This IE may be used by the MR-BS/RS to define a UL region to include one or more aggregated HARQ ACK channel(s). The IE format is shown in Table yyy. Aggregated HARQ ACK channel structure is same as defined in sub clause 8.4.5.4.25.

RS shall transmit the aggregated HARQ ACK/NAK signals in the same frame where it transmits its own ACK/NAK signal for the tunneled HARQ burst (sub clause 6.3.17.4.1).

Table yyy: Aggregated-HARQ ACK region allocation IE

Syntax	Size	Notes
Aggregated-HARQ ACK region allocation IE() {	-	-
Extended-2 UIUC	4 bits	Aggregated-HARQ ACK region allocation IE() = TBA
Length	8 bits	Length in bytes
OFDMA symbol offset	8 bits	-
Subchannel offset	7 bits	-
No. OFDMA symbols	5 bits	-
No. subchannels	4 bits	-
N_CID	8 bits	-
For (i = 0; i < N_CID; i++) {		
RCID_IE()	Variable	Tunnel CID
N_ACK_channels	8 bits	No. of aggregated HARQ ACK channels are allocated to RS to transmit MS's HARQ ACK/NAK.
}	-	-
Padding	Variable	-
}	-	-

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"

[5] C802.16-07_185r6, "HARQ in Multi-hop Relay System"