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Re:	IEEE P802.16j/D1: IEEE 802.16j working group letter ballot #28	
Abstract	HARQ methods for 802.16j Mobile Multihop Relay Networks are proposed.	
Purpose	To incorporate the proposed text into the P802.16j/D1 Baseline Document	
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HARQ for RS Groups

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Introduction

Methods for Hybrid HARQ operations for a virtual group of RSs are described. The properties of virtual RS groups are provided in [P802.16j/D1]: (i) The group has a superordinate station, a non-transparent RS or an MR-BS, which is the superordinate station of all members of the group. (ii) All members in the group share the same preamble/FCH/MAP, which is either transmitted by all members, or not-transmitted by any of them. (iii) The superordinate station or MR-BS carry out scheduling/resource control of the group members. (iv) The group can serve only MSs.

If group members do not transmit preamble/FCH/MAP, they monitor the control info as the transparent RSs do; the frame structure is the same as the one for transparent mode described in Section 8.4.4.7.1. If the members transmit the preamble/FCH/MAP, then the frame structure is the same as the one for non-transparent mode described in Section 8.4.4.7.2.

If members do not transmit preamble/FCH/MAP (a transparent VG), the MSs receive the preamble/FCH/MAP directly from the superordinate station of the group. Note that the members of such a group can also be configured to transmit preamble/FCH/MAP (non-transparent VG) which is the same as transmitted by the superordinate station. A non-transparent VG may also be assigned a preamble index that is different from the superordinate station.

We consider the following cases of an RS group (See Figure 1):

1. RS group and the superordinate station of the group transmit different preambles. RS Group members transmit the same preamble/FCH/MAP.
2. The RS group and the superordinate station of the group transmit the same preamble/FCH/MAP.
3. The RS group and the superordinate station of the group share the same preamble but the group members do not transmit preamble/FCH/MAP.

Within an RS group, various data forwarding mechanism is possible. For example:

1. Two RSs in the same group can use the same resources to transmit to two different MSs (some sort of spatial division multiplexing)
2. Some or all members can transmit the same signal at the same resources (macro diversity)

One needs to take the forwarding scheme into account for HARQ operation. For example, the parent shall have the individual decoding statuses from the members that are responsible for the target MS if a subset of group members is associated with the MS traffic.

ACKCH Region Allocation

For the ACK/NAK channel in the presence of multiple RSs, we have the following options:

1. Dedicated ACK/NAK channel: In this case, each RS supporting the HARQ traffic is allocated a different HARQ channel through which an ACK or NAK can be transmitted
2. Shared ACK/NAK channel: In this case, only one ACK channel is allocated and all RSs use this channel. In this case, the options are
 - a. The RSs may transmit only ACK and for any NAK, they do not transmit any signal
 - b. The RSs may transmit only NAK and for any ACK, they do not transmit any signal

Clearly, a shared ACK/NAK is more bandwidth efficient than scheduling a dedicated ACK/NAK channel. On the other hand, with a shared ACK/NAK, it is not possible to figure out the individual decoding statuses from the RSs; we can only know whether there is at least one ACK (Option 2.a), or at least one NAK (Option 2.b).

In this contribution, we propose to use a shared ACK for member RSs to send the decoding status and a dedicated ACK/NAK channel for a *designated member* to forward the ACK/NAK from the subordinate terminal. In this case, MRBS can know whether a re-transmission is required from the members or from the parent.

One problem with the shared ACK/NAK channel is that only either a NAK encoded signal or an ACK encoded signal is transmitted. In this case, if the silence implies an ACK or NAK, that is, if a zero codeword is assumed to indicate an ACK or NAK, the decoding of encoded ACK/NAK message is degraded since the Euclidean distance between an encoded ACK/NAK and zero codeword is half of the distance between any two different encoded ACK/NAK codewords. Thus, one may also prefer to allocate dedicated ACK/NAK channels for each member in the RS group. In this proposal, we suggest either of the ACKCH allocation scheme shall be optional.

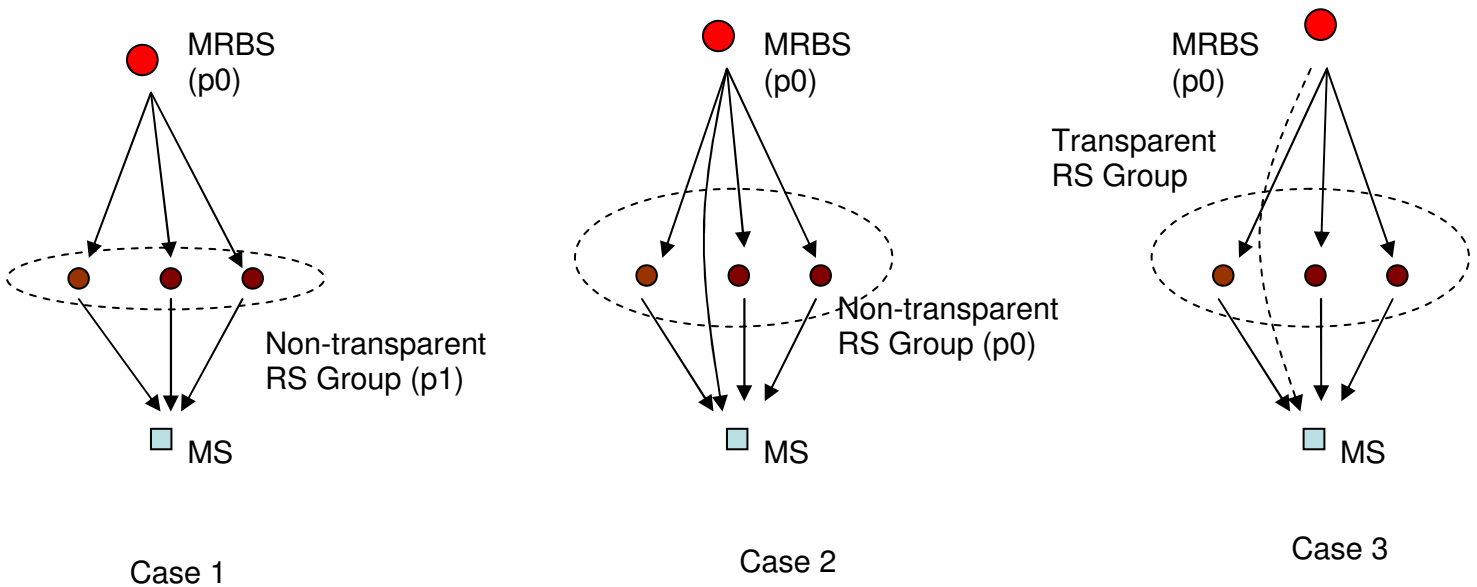


Figure 1 RS group topologies. p0 and p1 refers to the preambles being transmitted by the parent or group.

CQI Feedback from MS

In case of an HARQ over an RS group, the MS may be served by multiple members. In this case, one of the members in the RS group may be designated to forward the CQI information from the MS.

The following amendments will enable HARQ operation in the presence of an RS group in the multihop relay network.

HARQ for RS Group

Case 1: Non-transparent RS Group – Parent and group members transmit different preamble/FCH/MAP¹

DL HARQ

Assume that each member of the RS group is k -hop away from MR-BS, and the superordinate station of the group (from now on called as parent) is at hop $k-1$. We propose an end-to-end HARQ for the multi-hop relay network in the presence of an RS group. For minimal deviation from the current HARQ scheme described for multi-hop relay with non-transparent RSs, we adopt several schemes for Section 6.3.17.4.1.

In DL HARQ for multihop with non-transparent RS, each RS forwards successfully decoded HARQ subburst and waits for ACK/NAK message from downstream. If an error occurs in any RS, that RS sends C_1 as NAK to the superordinate node, which is forwarded upstream by incrementing the index, e.g., if C_k is received, C_{k+1} is transmitted.

In RS group, a member does not know whether any other member has decoded the packet successfully or not. Therefore, each member responsible for the HARQ traffic forwarding should send its decoding status (ACK/NAK) to the parent through the ACK/NAK channel prepared for each of them. In this case, we may use two options: (i) Members only transmit an ACK to the parent in case of a successful decoding, and (ii) each member sends its decoding status on its dedicated HARQ ACK channel. The parent shall monitor the HARQ ACK channels. If it receives at least one encoded ACK message for a subburst (in case of shared ACK, it receives a superposition of ACK and in case of dedicated ACKCH, it receives encoded ACK and encoded NAK messages), no retransmission is required to the RS group members. The parent continues waiting for ACK/NAK message which the designated member RS will forward for the downstream decoding statuses. The member RSs with successful decoding forwards the HARQ burst to the subordinate terminal. If a member decodes the packet incorrectly, it may transmit the pilot tones and null data to the subordinate node. Forwarding of ACK/NAK messages from the subordinate terminal may be carried out by a *designated member RS*. If the designated member receives an ACK or a NAK, it forwards C_0 or C_2 to the parent, respectively. If parent receives C_2 and there is at least one ACK from members decoding statuses, parent forwards C_3 towards MR-BS so that MR-BS schedules a retransmission from RS(s).

If the parent receives nothing for member RSs decoding statuses (when using a shared ACK channel) or all encoded NAK C_1 messages when using dedicated ACK/NAK channel, it sends C_2 to upstream ACK/NAK channel. MRBS may reschedule a re-transmission from the parent.

The resource allocations for DL bursts can be carried out via HARQ DL MAP IE, and the ACK/NAK channels can be allocated via HARQ ACK Region Allocation IE.

¹ Members in the same group transmit the same preamble/FCH/MAP which are different from those transmitted by the parent.

UL HARQ:

Again, assume that the members of the group are k -hop away from MR-BS, and the superordinate station is at hop $k-1$. We propose an end-to-end HARQ for the multi-hop relay network in the presence of an RS group. For minimal deviation from the current HARQ scheme described for multi-hop relay with non-transparent RSs, we can adopt the scheme in Section 6.3.17.5.1.

In UL HARQ for non-transparent RS, if RS can decode the subburst, it sends ACK (C_0) and forwards data burst to the upstream node. If it fails, a NAK is sent with C_1 . Each RS increases the encoded NAK message index it received from subordinate node by 1 if it is not a C_0 . An HARQ_ACKBITMAP_IE is prepared per RS and is sent to the subordinate station.

In the UL HARQ, group members receive HARQ bursts and attempt to decode. To simplify the design, we assign one of the members as the *designated RS for all HARQ related processes* (e.g., data and ACK/NAK decoding/forwarding). That is, we select the member RS whose received UL signal quality is the best (This can be done during network entry, during RS Group configuration, or during normal operation based on any signal measurement report including the periodic ranging, R-ambly measurement, data traffic measurement, etc.). By assigning a designated RS for UL HARQ, the procedure is very similar to the UL HARQ for the MR network with non-transparent RSs (Section 6.3.17.5.1).

Depending on the encoded ACK/NAK, MR-BS may allocate a retransmission (i) from the MS (if MS to RS group transmission fails at the designated RS), (ii) from the designated member of the group (if an ACK from member RSs and parent can not decode successfully), (iii) from the parent (if transmission from parent to its superordinate station fails), or (iv) from any other RSs along the path for which the subburst transmission fails.

Case 2: Non-transparent RS Group – Parent and group members transmit same preamble/FCH/MAP

DL HARQ:

In this case, we may have a direct link between the parent and the MS. The member RSs may assist HARQ whenever they can decode the HARQ subburst without errors. We consider an end-to-end HARQ for this scheme.

Since both parent and member RSs transmit the same preamble/FCH/MAP, the parent needs to inform the member RSs in advance about the HARQ packets and FCH/MAP. An HARQ runs between the parent and the group members, and another HARQ runs in the access zone between the parent/group members and the MS/SS.

MR-BS initially allocates all resources for burst forwarding and ACK/NAK channels along the path. At each hop until the parent RS, the procedure in Section 6.3.17.4.1 is carried by the relay stations.

If the parent decodes the packet successfully, it transmits the HARQ packet to member RSs in a relay zone. Member RSs send the decoding statuses to the parent RS at the UL ACK channel. We may use either a shared ACK channel through which only an ACK is transmitted by the member RS(s), or a dedicated ACK/NAK channel through which each member RS sends its own ACK/NAK status. Subsequently, the parent and member RSs with successful decoding transmit the HARQ packet to the subordinate station in the DL access zone. MS may observe a superposition of HARQ subpacket. In the relay zone of this frame, if the parent is an MR-BS, it

may send a new packet to the member RSs or may re-transmit the HARQ packet to the member RSs depending on the ACK/NAK from member RSs. Note that two separate HARQ process can be enabled: one in the relay zone, and one in the access zone.

If the parent is a non-transparent RS, when it receives a NAK from the MS, it may either forward encoded NAK C_2 or encoded NAK C_3 depending on the decoding status from the member RSs it received for that subburst. If C_2 is sent to upstream, the MR-BS will schedule a re-transmission from parent to member RSs in the relay zone and a re-transmission from parent/group members to the MS in the access zone. If C_3 is sent to upstream, the MR-BS will schedule a re-transmission only from parent/group members to the MS in the access zone.

For HARQ re-transmissions from parent to member RS links, only the member RSs who sent NAK for that sub packet implement the HARQ. For HARQ re-transmissions from parent to the MS, only member RSs with successful decoding re-transmits the HARQ packet to the subordinate node.

UL HARQ:

In this case, we may have a direct link from MS to the parent. Member RSs may assist UL HARQ whenever they have the burst successfully. We consider an end-to-end HARQ for this scheme.

The HARQ starts with MRBS initiating an HARQ sub packet from MS to itself through a multihop RSs.

MS sends the HARQ subburst to the parent. The same burst may be intercepted by the member RSs. The member RSs send their decoding statuses using encoded ACK/NAK to the parent, and if they decode successfully, they store the HARQ subburst for possible transmission. It is possible to use either a shared ACK (e.g., only members with successful decoding send ACK), or a dedicated ACK/NAK channel (e.g., each members sends its decoding status). If the parent decodes the packet successfully, it ignores the ACK/NAK from member RSs and the HARQ process continues as described in Section 6.3.17.5.1; the parent sends an HARQ_ACKBITMAP_IE to the member RSs (in relay zone) and to the MS (in access zone) to clear buffers for that sub packet. If the decoding is not successful at the parent station, the parent controls the ACK/NAK messages from member RSs. If the acknowledgment message(s) from the member RS(s) are all NAK, the parent sends C_2 to the upstream and appropriate BITMAP_IE to the subordinate node. If at least one ACK is received from the member RSs, the parent may send C_1 to the upstream and sends appropriate BITMAP_IE to the MS for clearing the buffer. Thus, MRBS may schedule retransmission from the failing hop.

For example, if the parent receives all NAK from member RSs and can not decode direct burst from MS, the MS is scheduled for retransmission; if the parent receives some ACK from member RSs, retransmissions are performed from the member RSs. Note that this mechanism is partially similar to the UL HARQ assisted by multiple transparent RSs.

When the parent of the group is an MRBS, if parent could not decode the HARQ burst directly received from the MS/SS and member RSs could decode, the MS may be scheduled to continue with a new HARQ packet on the MS- member RSs link while member RSs may be scheduled to retransmit previous HARQ packet on the member RSs - parent link. These links may correspond to different relay zones or resource allocations.

HARQ process from MS to parent (and also to member RSs) takes place on the UL access zone, while HARQ from member RSs to parent takes place in UL relay zone. MRBS initially allocates resources for HARQ ACK BITMAP IE for parent to send to the MS as needed before HARQ UL DELAY deadline expires.

Case 3: Transparent RS Group – Group members do not transmit preamble/FCH/MAP

This case is valid if the parent is an MR-BS, and in this case, the HARQ described in Sections 6.3.17.4.2.2 (RS assisted DL HARQ with multiple transparent RSs) 6.3.17.5.2.1 (RS group assisted UL HARQ) can be followed with minor text amendments indicated below.

Proposed Text Changes

++++Begin Text Changes+++++

[Insert new subclause 6.3.17.4.1.2]

6.3.17.4.1.2 DL HARQ with Non-transparent RS Group

[Insert new subclause 6.3.17.4.1.2.1]

6.3.17.4.1.2.1 Group preamble index different from parent preamble index

End-to-end HARQ is supported for multi-hop relay network with an RS group serving an MS. The MR-BS allocates all resources for the initial transmission of an HARQ packet and the required UL ACK channels. The same encoded ACK/NAK forwarding mechanism shall be employed between the parent and the MR-BS.

In the presence of an RS group serving an MS, a member does not know whether any other serving member decoded the subburst from the parent successfully or not. Therefore, each member that is responsible for forwarding the HARQ traffic shall send its decoding status to the parent. In this case, we may use two options: (i) Members only transmit an ACK to the parent in case of a successful decoding, through a shared ACKCH, and (ii) each member sends its decoding status on its dedicated HARQ ACK channel. The parent shall monitor the HARQ ACK channels. If the parent receives nothing for decoding statuses of the member RSs in a shared ACK channel, or all encoded NAK messages in the dedicated ACK/NAK channels, it sends C_2 to upstream ACK/NAK channel. MR-BS may reschedule a re-transmission starting from the parent.

If the parent receives at least one ACK message for a subburst, no retransmission is required to the RS group members. The parent continues waiting for ACK/NAK message from the subordinate terminal. The member RS(s) with successful decoding forward(s) the HARQ subburst to the subordinate terminal. If a member decodes the packet incorrectly, it may transmit the pilot tones and null data to the subordinate node. Forwarding of ACK/NAK messages from the subordinate terminal shall be carried out by a *designated member RS*. If the designated member receives an ACK or a NAK, it forwards C_0 or C_2 to the parent, respectively. If parent receives C_2 and at least one ACK is received for the members' decoding statuses, parent forwards C_3 towards MR-BS so that MR-BS schedules a retransmission from the member RS(s).

The designated member of the group shall also forward the CQI feedback from the MS to the parent.

[Insert new subclause 6.3.17.4.1.2.2]

6.3.17.4.1.2.2 Group preamble index same as the parent preamble index

If this case, there may be a direct link between the parent and the MS. The member RSs may assist HARQ whenever they can decode the HARQ subburst without errors. End-to-end HARQ is supported for this case.

Since both parent and member RSs transmit the same preamble/FCH/MAP, the parent needs to inform the member RS(s) in advance about the HARQ packets and FCH/MAP. An HARQ may run between the parent and the group members in the relay zone, and another HARQ may run between the parent/group members and the MS/SS in the access zone.

MR-BS shall initially allocate all resources for burst forwarding and ACK/NAK channels along the path. At each hop until the parent RS, the procedure in Section 6.3.17.4.1 is carried by the relay stations.

If the parent decodes the packet successfully, it shall transmit the HARQ subburst to member RSs in a relay zone. Member RSs shall send the decoding statuses to the parent RS at the UL ACK channel. Two options are available: (i) the members transmit only encoded ACK through a shared ACK channel, or (ii) each member RS is allocated a dedicated ACK/NAK channel. Subsequently, the parent and member RSs with successful decoding shall transmit the HARQ packet to the subordinate station in the DL access zone. MS may observe a superposition of HARQ subpacket. In the relay zone of this frame, if the parent is an MR-BS, it may send a new packet to the member RSs or may re-transmit the HARQ packet to the member RSs depending on the ACK/NAK from member RSs. Note that two separate HARQ process can be enabled: one in the relay zone, and one in the access zone.

If the parent is a non-transparent RS, when it receives a NAK from the MS, it may either forward encoded NAK C_2 if it received all NAK from member RSs, or encoded NAK C_3 if it received at least one ACK from the member RS(s). If C_2 is sent to upstream, the MR-BS shall schedule a re-transmission from parent to member RSs in the relay zone and a re-transmission from parent/group members to the MS in the access zone. If C_3 is sent to upstream, the MR-BS shall schedule a re-transmission only from parent/group members to the MS in the access zone. If parent receives an ACK from the MS, it forwards C_0 towards the MR-BS.

For HARQ re-transmissions from parent to member RS links, only the member RSs who sent NAK for that sub packet shall implement the HARQ. For HARQ re-transmissions from parent to the MS, only member RSs with successful decoding shall re-transmit the HARQ packet to the subordinate node.

The CQI feedback from the MS shall be forwarded towards the MR-BS by the parent.

[Change the 4th paragraph in Subclause 6.3.17.4.2.2 as following]

6.3.17.4.2.2 RS assisted HARQ

Multiple transparent RSs can also be involved in the HARQ process. The schedule of source station transmitting a sub-burst to multiple transparent RSs can be signaled by using MR_DL-MAP MONITOR IE which points to the burst to be received by the RSs. The transparent RSs may also be members of a transparent RS group. In this case, the RS Member List Update may be used to associate the members with the HARQ traffic of the MS. If an RS fails to decode the burst correctly, it shall not transmit the erroneous packet to the next hop station. In case of hop-by-hop HARQ involving multiple RSs, HARQ data is scheduled and forwarded to the next hop when MR-BS receives an ACK from at least one of the RSs, and the MR-BS shall schedule one or more RSs that sent ACK to forward the data to the next hop. In case of multiple RSs when the resource is prescheduled for all the links, one of the RSs can be selected as designated RS per hop, which is responsible for forwarding and reporting status to MR-BS in addition to the data forwarding. The designated RS waits for the UL ACK from the next-hop RS or MS after it forwards the HARQ packet or transmits the pilots to the next hop.

[Insert the following text at the end of Subclause 6.3.17.5.1]

If the MS is being served by a non-transparent RS group whose preamble index is different from the parent preamble index, MR-BS shall select one of the members as designated RS, and this RS shall be responsible for all HARQ related operations. The designated member of the group shall also forward the CQI feedback from the MS. The selection of a designated RS is implementation specific.

[Insert new subclause 6.3.17.5.1.1.]

6.3.17.5.1.1 UL HARQ for RS Group transmitting the same preamble index as the parent

In this case, there may be a direct link between the MS and the parent. The member RSs may assist HARQ whenever they can decode the HARQ subburst without errors. End-to-end HARQ is supported for this case. MR-BS schedules an initial transmission of HARQ packet on all the links between the MS and MR-BS. MRBS shall also allocate resources for HARQ ACK BITMAP IE for parent to send to the MS as required before HARQ UL DELAY deadline expires. HARQ process from MS to parent (and also to member RSs) takes place on the UL access zone, while HARQ from member RSs to parent takes place in UL relay zone.

The HARQ starts with MRBS initiating an HARQ sub packet from MS to itself through a multihop relay network. MS sends the HARQ subburst to the parent. The same burst may be intercepted by the member RSs that are responsible for the HARQ traffic. The member RSs shall send their decoding statuses using encoded ACK/NAK to the parent. The members may use either a shared ACK (e.g., only members with successful decoding sends ACK), or a dedicated ACK/NAK channel (e.g., each member sends its decoding status) to inform their decoding statuses. If the parent decodes the subburst from the MS successfully, it shall ignore the ACK/NAK from member RSs and the HARQ process continues as described in Section 6.3.17.5.1; the parent shall send an HARQ ACKBITMAP IE to the member RSs (in a relay zone) and to the MS (in access zone) to clear buffers for that sub packet. If the decoding is not successful at the parent station, the parent shall control the ACK/NAK messages from member RSs. If the acknowledgment message(s) from the member RS(s) are all NAK, the parent shall send C_2 to the upstream and appropriate BITMAP IE to the subordinate node. If at least one ACK is received from the serving member RSs, the parent may send C_1 to the upstream and shall send appropriate BITMAP IE to the subordinate node for clearing the buffer at that node. Thus, MR-BS may schedule retransmission from the failing hop.

When the parent of the group is an MRBS, if parent could not decode the HARQ burst directly received from the MS/SS and member RSs could decode, the MS may be scheduled to continue with a new HARQ packet on the MS-member RSs link while member RSs may be scheduled to retransmit previous HARQ packet on the member RSs-parent link.

The CQI feedback from the MS shall be forwarded towards the MR-BS by the parent.

[Modify Subclause 6.3.17.5.2.1 as following]

6.3.17.5.2.1 RS group assisted HARQ

Multiple transparent RSs can also be involved in the two-hop HARQ process. The schedule of source station transmitting a sub-burst to multiple transparent RSs may be signaled by using Compact UL-MAP MONITOR IE which points to the burst to be received by the RSs. The transparent RSs may also be members of a

transparent RS group. In this case, the CID list from the RS Member List Update message may be used to associate the members with the HARQ traffic of the MS. RSs use shared ACK channel to report status to MR-BS. MR-BS replies an ACK to MS if it receives the ACK from RS; otherwise, it replies NAK to MS. If the MR-BS does not receive the ACK from the RSs, the MR-BS shall arrange data retransmission for the access link. If the MR-BS receives the ACK from the RSs but fails to decode the sub-burst, the MR-BS shall arrange data retransmission for the relay link.