Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Transmission Scheme of MAC Management Message towards a RS Group in multi-hop relay System**
Date Submitted	**2007-01-08**

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Re:	This is in response to the call for proposal, 80216j-06_034.pdf, sent out by 802.16j TG.
Abstract	This contribution proposes two transmission schemes for the MAC management message sent from MMR-BS towards a group of RSs. The relevant changes to the specification are also defined
Purpose	Add proposed spec changes.
Notice	
Release	
Patent Policy and Procedures	

Transmission Scheme of MAC Management Message towards a RS Group in multi-hop relay System

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Nokia

1. INTRODUCTION

In single-hop system, the MAC management messages are transmitted between BS and MS. However, in the multi-hop relay system, where one or more RSs are introduced between MMR-BS and MS, additional MAC management messages (termed as MAC-Mng-Msgs) are defined and used between MMR-BS and RSs. These MAC-Mng-Msgs may include but are not limited to routing messages to deliver path information to RS group, RS configuration messages, measurement messages etc. In certain circumstances, the MMR-BS sends the MAC-Mng-Msg to a group of RSs with the same or similar content. As an example, the MMR-BS may define and distribute the mapping information between an established relay path and connection IDs for the flows that will be routed through the specified path. Such mapping information is the same for every RS on the defined relay path.

Multiple transmission schemes can be used to transmit the MAC-Mng-Msg with the same or similar content from a MMR-BS to a group of RSs (termed as RS-Group in this contribution). A typical example of a RS-Group is a group of RS on a relay path between the MMR-BS and a MS. As shown in Figure 1, RS1, RS2 and RS3 that are on the relay path between MMR-BS and all the MSs directly attached to RS3 consist of RS-Group1, while RS4, RS5 and RS6 that are on the relay path between MMR-BS and all the MSs directly attached to RS6 consist of RS-Group2.

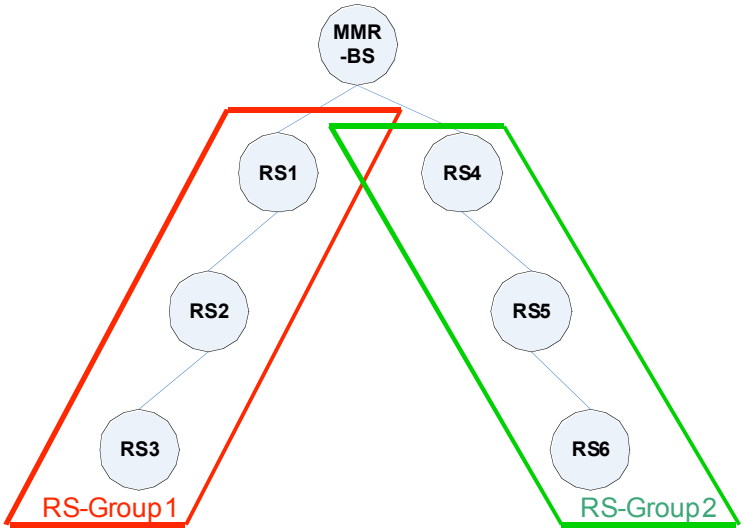

Figure 1 Example of RS-Group in 802.16j System

This contribution proposes three schemes for MMR-BS to transmit MAC-Mng-Msg to a RS-Group, followed by the recommendation of the schemes to be applied for different application scenarios.

2. TRANSMISSION SCHEME FOR MAC-MNG-MSG TO A RS-GROUP

2.1 End-to-End Unicast

MMR-BS unicasts the MAC-Mng-Msg to each RS in the RS-Group. The response message (if required) from each RS is unicast directly to the MMR-BS. The unicast messages are protected by the SA (Security Association) established between each RS and the MMR-BS.

Such end-to-end unicast scheme is simple and straightforward. MMR-BS just transmits the MAC-Mng-Msg to the respective RS just as all the other type of MAC management messages defined in IEEE Std 802-16-2004 and 802.16e-2005. However, the overhead introduced by this scheme is non-trivial especially if the number of RSs on one relay path is large. For example, as shown in Figure 2, the MAC-Mng-Msg marked in RED is targeting at RS1 and is only transmitted over the MMR-BS-RS1 link. However, the MAC-Mng-Msg marked in YELLOW is targeting at RS2 and is transmitted over MMR-BS-RS1 link and RS1-RS2 link. The MAC-Mng-Msg marked in PURPLE is targeting at RS3 and is transmitted over MMR-BS-RS1 link, RS1-RS2 link and RS2-RS3 link. The overhead introduced by this scheme is not trivial.

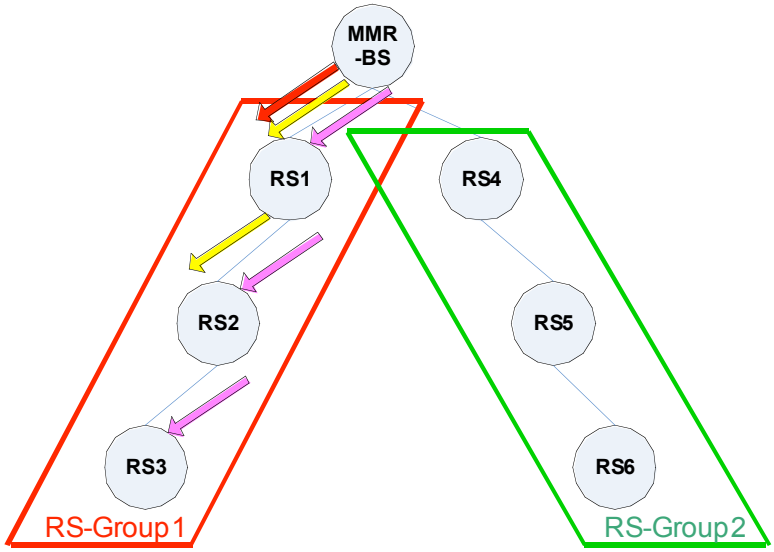

Figure 2 End-to-End Unicast MAC-Mng-Msg to RS-Group1

2.2 Hop-by-Hop unicast with end-to-end response

The MAC-Mng-Msg is unicast from MMR-BS to the first RS on the specified path or from one RS to its subordinate neighboring RS and processed by each RS in the RS-Group. Upon receiving the MAC-Mng-Msg, each RS replies with a response directly targeting to the MMR-BS. The detailed procedure is listed as following. Figure 3 is used as an example to illustrate the procedure.

- When a MMR-BS sends a MAC-Mng-Msg to a RS-Group, it generates the MAC-Mng-Msg, which includes the message information, the path id that identifies the path to which all the RSs in the RS-Group belong, and optional detailed path information that contains an ordered list of RSs on the path and is only present in the Path-Update-REQ message. The MAC-Mng-Msg is protected by the SA established between MMR-BS and the first RS on the path.
- When a RS receives a MAC-Mng-Msg from its superordinate neighbor, it first processes the message.
    - If the processing fails, it immediately sends a response with the Failure confirmation code back to MMR-BS and then aborts the process.

- If the processing succeeds, the RS then obtains the path id in the message, and then retrieves the path information based on the path id and finds out the next RS to which it needs to further transmit the MAC-Mng-Msg. The detailed path information could be obtained from the MAC-Mng-Msg if available and should be recorded by the RS for further use; otherwise, it is retrieved based on the path-id using the record the RS obtained from the previous operation. The RS also sends a response with the Success confirmation code back to MMR-BS. If the RS (e.g., RS2) has a subordinate neighbor on the path, it then regenerates the MAC-Mng-Msg using the same information it received from its superordinate neighbor on the path and unicasts it to its subordinate neighbor on the path. The MAC-Mng-Msg is protected by the SA established between the RS and its subordinate neighbor.

- MMR-BS should maintain individual timer (MAC-Mng-Msg-RES-Timer) for the response from each RS on the path. The value of MAC-Mng-Msg-RES-Timer for each RS varies and depends on the possible transmission and processing latency between MMR-BS and the RS. Such latency could be estimated for example based on the number of hops between MMR-BS and the RS.
  - If the MMR-BS receives a response from a RS within the corresponding MAC-Mng-Msg-RES-Timer but with a Failure confirmation code, or doesn't receive a response from the RS within the corresponding MAC-Mng-Msg-RES-Timer, the MMR-BS determines that the RS doesn't receive the MAC-Mng-Msg and may fail the chained operation due to error processing or link loss. The MMR-BS may reissue the MAC-Mng-Msg and directly send it to the first failure RS. The message is protected by the SA established between MMR-BS and the failure RS. The processing of such message follows the same procedure described above.

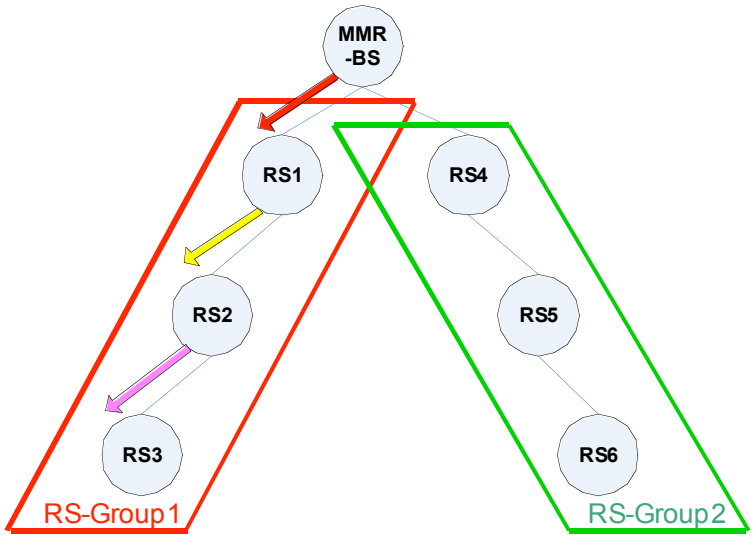

Figure 3: Hop-by-Hop Unicast MAC-Mng-Msg to RS-Group1

2.3 Hop-by-hop Unicast with Hop-by-hop Response

The MAC-Mng-Msg is unicast from MMR-BS to the first RS on the specified path or from one RS to its subordinate neighboring RS. The response to the MAC-Mng-Msg is generated by the last RS on the path and sent to its superordinate neighboring RS. Such response is processed by each RS on the path and forwarded to its superordinate neighbor until reaching the MR-BS. The detailed procedure is listed as following. Figure 3 is used as an example to illustrate the procedure.

- When a MMR-BS sends a MAC-Mng-Msg to a RS-Group, it generates the MAC-Mng-Msg, which includes the message information, the path id that identifies the path to which all the RSs in the RS-Group belong, and optional detailed path information that contains an ordered list of RSs on the path

and is only present in the Path-Update-REQ message. The MAC-Mng-Msg is protected by the SA established between MMR-BS and the first RS on the path.

- When a RS receives a MAC-Mng-Msg from its superordinate neighbor, it first processes the message.
    - If the processing fails, it immediately sends a response with the Failure confirmation code back to its superordinate neighbor together with its RSID in the Failure-Station-RSID TLV, and then aborts the process.
    - If the processing succeeds, the RS then obtains the path id in the MAC-Mng-Msg, and then retrieves the path information based on the path id and finds out the next RS to which it needs to further transmit the MAC-Mng-Msg. The path information could be obtained from the MAC-Mng-Msg if available; otherwise, it is retrieved based on the path-id using the record the RS obtained from the previous operation.
        - If the RS (e.g., RS2) has a subordinate neighbor on the path, it then regenerates the MAC-Mng-Msg using the same information it received from its superordinate neighbor on the path and unicasts it to the subordinate neighbor. The new MAC-Mng-Msg is protected by the SA established between the two RSs.
        - If the RS (e.g., RS3) doesn't have a subordinate neighbor on the path (i.e., it is the last station on the path), it sends a response to its superordinate neighbor on the path with the Success confirmation code.
- MMR-BS and each RS that sends a MAC-Mng-Msg to its subordinate neighbor should maintain a timer (MAC-Mng-Msg-RES-Timer) for the response. The value of MAC-Mng-Msg-RES-Timer depends on the possible transmission and processing latency between the transmission station (i.e, MMR-BS or an intermediate RS) and the last RS on the path. Such latency could be estimated for example based on the number of hops between the transmission station and the last RS on the path.
    - If an intermediate RS hasn’t received a response from its subordinate neighbor within its MAC-Mng-Msg-RES-Timer, it then sends a response to its superordinate neighbor with the Failure confirmation code together with the Last-Station-RSID TLV set to its own RSID. The response received after the MAC-Mng-Msg-RES-Timer will be simply dropped by the RS.
    - If an intermediate RS receives a response from its subordinate neighbor within its MAC-Mng-Msg-RES-Timer, the following two cases apply:
        - If the confirmation code is Success, the RS copies the confirmation code and the Last-Station-RSID TLV from the received response to a new response and sends it to its superrdinate neighbor.
        - If the confirmation code is Failure, the RS copies the confirmation code and the Failure-Station-RSID TLV from the received response to a new response and sends it to its superordinate neighbor.

      The new response is protected by the SA established between the RSs.
    - If the MMR-BS receives a response from its subordinate neighbor within its MAC-Mng-Msg-RES-Timer, the following two cases apply:
        - If the confirmation code is Success, the MMR-BS assumes that the process succeeds.
        - If the confirmation code is Failure, the following two cases apply.
            - If the Failure-RS-ID TLV is present, the MMR-BS assumes that the processing of the MAC-Mng-Msg at the RS identified by the RSID carried in the Failure-RS-ID TLV fails.
            - If the Last-RS-ID TLV is present, the MMR-BS considers that the MAC-Mng-Msg is lost over the link between the RS identified by the RSID carried in the Failure-RS-ID TLV and its subordinate neighbor.

      In both cases, the MMR-BS may reissue the MAC-Mng-Msg and directly send it to the RS identified by the RSID carried in the Failure-RS-ID TLV or Last-RS-ID TLV. The message is protected by the SA established between MMR-BS and the identified RS. The processing of such message follows the same procedure as described above except that

the RS sends the response to the MAC-Mng-Msg will be directly sent to the MMR-BS other than its superordinate neighbor on the path.

2.4 Comparison

The End-to-end unicast scheme is simple and straightforward. However, the overhead introduced by this scheme is non-trivial especially if the number of RSs on one relay path is large. Therefore, this scheme is more applicable to the scenario where the number of RSs on a relay path is small (e.g., 2-3 hop relay) or the RS is with low capability. This scheme applies to the system where SA association exists only between MMR-BS and RS.

The Hop-by-hop unicast with end-to-end response scheme reduces a lot of bandwidth overhead especially when the relay path contains a large number of RSs, however at the price of processing complexity in the RSs. Therefore, this scheme is more applicable to the scenario where a large number of high-capability RSs are present on a single relay path. This scheme applies to the system where SA association exists not only between MMR-BS and RS but also between neighboring RSs.

The Hop-by-hop unicast with hop-by-hop response scheme reduces even more bandwidth overhead compared with the hop-by-hop unicast with end-to-end response scheme, however introduces even higher complexity in the RSs and MR-BS. Therefore, this scheme is more applicable to the scenario where a large number of high-capability RSs are present on a single relay path. This scheme applies to the system where SA association exists not only between MMR-BS and RS but also between neighboring RSs.

The transmission scheme to be used can be decided by the MMR-BS based on the application scenario. MMR-BS indicates the type of the scheme by setting the Transmission Type field to the correspondent value in the MAC-Mng-Msg it issues.

3. CHANGES TO THE SPECIFICATION

Insert new subclause 6.3.25

6.3.25 Transmission Scheme for MAC Management Message toward RS Group in 802.6j System

Three transmission schemes can be used to transmit the MAC management message with the same content from a MMR-BS to a group of RSs (termed as RS-Group), as described in the following sections. The MAC management messages that use such transmission scheme are listed in Table T1. The MMR-BS decides the type of transmission scheme and sets the appropriate value in Transmission Type field of the related MAC management message.

Table T1 – MAC Management Messages Targeting to a RS Group

MAC Management Message	Reference
PATH-Update-REQ	TBD

6.3.25.1 End-to-End Unicast

MMR-BS unicasts the MAC management message to each RS in the RS-Group. The response message from each RS is unicast directly to the MMR-BS. The unicast messages are protected by the SA established between each RS and the MMR-BS.

If such scheme is used to transmit the MAC management message, the Transmission Type field in the MAC management message shall be set to End-to-end unicast.

6.3.25.2 Hop-by-Hop Unicast with End-to-End Response

The MAC management message is unicast from MMR-BS to the first RS on the specified path or from one RS to its subordinate neighbor RS on the specified path, and processed by each RS. Upon receiving the MAC management message, each RS replies with a response, if required directly towards the MMR-BS. The detailed procedure is listed as following.

- When a MMR-BS intends to send a MAC management message to a RS-Group, it generates the MAC management message, which includes the message information, the path id that identifies the path to which all the RSs in the RS-Group belong, and optional detailed path information that contains an ordered list of RSs on the path and is only present in the Path-Update-REQ message. The MAC-Mng-Msg is protected by the SA established between MMR-BS and the first RS on the path.
- When a RS receives a MAC management message from its superordinate neighbor, it first processes the message.
    - If the processing fails, it immediately sends a response with the Failure confirmation code back to MMR-BS and then aborts the process.
    - If the processing succeeds, the RS then obtains the path id in the message, and then retrieves the path information based on the path id and finds out the next RS to which it needs to further transmit the MAC management message. The detailed path information could be obtained from the MAC management message if available and should be recorded by the RS for further use; otherwise, it is retrieved based on the path-id using the record the RS obtained from the previous operation. The RS also sends a response with the Success confirmation code back to MMR-BS. If the RS has a subordinate neighbor on the path, it then regenerates the MAC management message using the same information it received from its superordinate neighbor on the path and unicasts it to its subordinate neighbor on the path. The MAC management message is protected by the SA established between the RS and its subordinate neighbor.
- MMR-BS should maintain individual timer (MAC-Mng-Msg-RES-Timer) for the response from each RS on the path. The value of MAC-Mng-Msg-RES-Timer for each RS varies and depends on the possible transmission and processing latency between MMR-BS and the RS. Such latency could be estimated for example based on the number of hops between MMR-BS and the RS.
    - If the MMR-BS receives a response from a RS within the corresponding MAC-Mng-Msg-RES-Timer but with a Failure confirmation code, or doesn't receive a response from the RS within the corresponding MAC-Mng-Msg-RES-Timer, the MMR-BS determines that the RS doesn’t receive the MAC-Mng-Msg and may fail the chained operation due to error processing or link loss. The MMR-BS may reissue the MAC management message and directly send it to the first failure RS. The message is protected by the SA established between MMR-BS and the failure RS. The processing of such message follows the same procedure described above.

If such scheme is used to transmit the MAC management message, the Transmission Type field in the MAC management message shall be set to Hop-by-hop unicast with end-to-end response.

6.3.25.2 Hop-by-Hop Unicast with Hop-by-hop Response

The MAC management message is unicast from MMR-BS to the first RS on the specified path or from one RS to its subordinate neighbor RS on the specified path, and processed by each RS. The response to the MAC management message is generated by the last RS on the path and sent to its superordinate neighboring RS. Such response is processed by each RS on the path and forwarded to its superordinate neighbor until reaching the MR-BS. The detailed procedure is listed as following.

- When a MMR-BS sends a MAC management message to a RS-Group, it generates the message, which includes the message information, the path id that identifies the path to which all the RSs in the RS-Group belong, and optional detailed path information that contains an ordered list of RSs on the path and is only present in the Path-Update-REQ message. The MAC-Mng-Msg is protected by the SA established between MMR-BS and the first RS on the path.
- When a RS receives a MAC management message from its superordinate neighbor, it first processes the message.
    - If the processing fails, it immediately sends a response with the Failure confirmation code back to its superordinate neighbor together with its RSID in the Failure-Station-RSID TLV, and then aborts the process.
    - If the processing succeeds, the RS then obtains the path id in the MAC management message, and then retrieves the path information based on the path id and finds out the next RS to which it needs to further transmit the message. The path information could be obtained from the message if available; otherwise, it is retrieved based on the path-id using the record the RS obtained from the previous operation.
        - If the RS has a subordinate neighbor on the path, it then regenerates the MAC management message using the same information it received from its superordinate neighbor on the path and unicasts to its subordinate neighbor. The new message is protected by the SA established between the two RSs.
        - If the RS doesn't have a subordinate neighbor on the path (i.e., it is the last station on the path), it sends a response to its superordinate neighbor on the path with the Success confirmation code.
- MMR-BS and each RS that sends a MAC management message to its subordinate neighbor should maintain a timer (MAC-Mng-Msg-RES-Timer) for the response. The value of MAC-Mng-Msg-RES-Timer depends on the possible transmission and processing latency between the transmission station (i.e, MMR-BS or an intermediate RS) and the last RS on the path. Such latency could be estimated for example based on the number of hops between the transmission station and the last RS on the path.
    - If an intermediate RS hasn't received a response from its subordinate neighbor within its MAC-Mng-Msg-RES-Timer, it then sends a response to its superordinate neighbor with the Failure confirmation code together with the Last-Station-RSID TLV set to its own RSID. The response received after the MAC-Mng-Msg-RES-Timer will be simply dropped by the RS.
    - If an intermediate RS receives a response from its subordinate neighbor within its MAC-Mng-Msg-RES-Timer, the following two cases apply:
        - If the confirmation code is Success, the RS copies the confirmation code and the Last-Station-RSID TLV from the received response to a new response and sends it to its superrdinate neighbor.
        - If the confirmation code is Failure, the RS copies the confirmation code and the Failure-Station-RSID TLV from the received response to a new response and sends it to its superordinate neighbor.

      The new response is protected by the SA established between the RSs.
    - If the MMR-BS receives a response from its subordinate neighbor within its MAC-Mng-Msg-RES-Timer, the following two cases apply:
        - If the confirmation code is Success, the MMR-BS assumes that the process succeeds.
        - If the confirmation code is Failure, the following two cases apply.
            - If the Failure-RS-ID TLV is present, the MMR-BS assumes that the processing of the MAC management message at the RS identified by the RSID carried in the Failure-RS-ID TLV fails.
            - If the Last-RS-ID TLV is present, the MMR-BS considers that the MAC management message is lost over the link between the RS identified by the RSID carried in the Failure-RS-ID TLV and its subordinate neighbor.

In both cases, the MMR-BS may reissue the MAC management message and directly send it to the RS identified by the RSID carried in the Failure-RS-ID TLV or Last-RS-ID TLV. The message is protected by the SA established between MMR-BS and the identified RS. The processing of such message follows the same procedure as described above except that the RS sends the response to the MAC management message will be directly sent to the MMR-BS other than its superordinate neighbor on the path.

4. SUMMARY

This contribution proposes three schemes for transmission of MAC management message from the MMR-BS to a group of RS. Each scheme has its advantage and disadvantage, and could be employed in different types of scenarios, as recommended in this contribution as well. The changes to the specification are also specified in this contribution.

5. REFERENCE

[1] C802.16j-07_031.pdf, Path Management in multi-hop relay System, Haihong Zheng, Yousuf Saifullah and Shashikant Maheshiwari, Nokia