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Re:	This is in response to the call for proposal, 80216j-06_027.pdf, sent out by 802.16j TG.	
Abstract	This contribution proposes initial topology discover procedure and path management procedures in multi-hop relay system. The path management procedures include path calculation, path advertisement and path selection. The relevant changes to the specification are also defined	
Purpose	Add proposed spec changes.	
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Topology Discover and Path Management in multi-hop relay System

Haihong Zheng, Yousuf Saifullah and Shashikant Maheshwari

Nokia

1. INTRODUCTION

In single hop system, MS directly attaches to BS, and therefore BS knows the 1-hop path to the MS. In the multi-hop relay system, there could be one or more RSs between an MMR-BS and an MS. However, there is no existing mechanism for the MMR-BS to determine the topology and the relay path between an MS and itself. As an example (shown in Figure 1), MMR-BS only knows that MS attaches to the system after the initial ranging of the MS but not the entire topology as well as the relay path through RS1 and RS2 between the MS and itself.

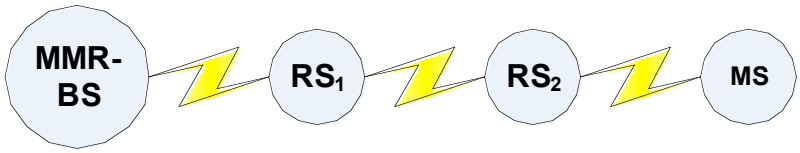

Figure 1: Example Topology in multi-hop relay System

The knowledge of the topology or path to/from an MS by MMR-BS and RS is required to support different features, such as scheduling, path selection (if multiple paths to/from MS exist), etc. However, maintaining path could produce significant system overhead, especially if it is designed as a separate procedure with its own signaling. Therefore, a simple and light-weight topology discovery and path management mechanism is needed for multi-hop relay system. This contribution proposes a simple and light-weight topology discovery and path management scheme for multi-hop relay system along with the relevant changes to the standard to support such scheme. The proposed topology discovery procedure is light-weighted because it enhances the existing procedures, such as ranging, instead of adding a new procedure. In addition, the path management solution is coordinated by the MMR-BS which requires less complexity in the RSs.

2. TOPOLOGY DISCOVERY/UPDATE AND PATH MANAGEMENT

2.1 Initial Topology Discovery

While a new station (RS or MS) attempts initial entry to a network, it sends an initial RNG-REQ message to the MMR-BS with the CID field in the MAC header set to Initial ranging CID (0x0000). With slight enhancement to the initial ranging procedure, the MMR-BS can derive the topology between the newly attached station and itself.

The topology discovery procedure is conducted together with initial ranging as defined below.

- When a MS or RS (termed as RSi in this section) conducts its initial ranging, it sends an initial RNG-REQ (i.e., with the CID = Initial ranging CID).
- When a RS (termed as RSj in this section) receives an initial RNG-REQ (i.e., with the CID = Initial ranging CID), it includes the complete RNG-REQ message into an Encapsulated-RNG-REQ TLV and its id into an Attached_RS_ID TLV, generates an Encapsulated-RNG-REQ message and sends it to the MMR-BS over its basic CID.
- When a RS receives an Encapsulated-RNG-REQ message, it simply forwards it to the next hop.

- When a MMR-BS receives an initial RNG-REQ from a MS or RSi, it determines that the MS or RSi sending the RNG-REQ directly attaches to itself and is just one hop away.
- When a MMR-BS receives an Encapsulated-RNG-REQ message, it retrieves the original RNG-REQ sent from the MS or RSi from the Encapsulated-RNG-REQ TLV and the id of the RS (i.e., RSj) from the Attached_RS_ID TLV. The MMR_BS then determines that the MS or RSi attaches to the system via the RSj identified by the RS-ID. Since MMR-BS is already aware of the topology between RSj and itself using the same mechanism as defined in this section, it establishes the topology between the MS or RSi and itself.
- After processing the Encapsulated-RNG-REQ from RSj and the RNG-REQ from the RSi, the MMR-BS replies the MS or RSi with a RNG-RSP, encapsulates it into an Encapsulated-RNG-RSP and sends it to RSj.
- When a RS receives an Encapsulated-RNG-RSP message targeting to itself, it retrieves the original RNG-RSP from the Encapsulated-RNG-RSP TLV and forwards it to the correspondent MS; otherwise, the RS just simply forward it to the next hop.

2.2 Topology Update

The topology established during initial network entry of the MS or RS could be changed due to events such as mobility including handover, network re-entry or location update. It is assumed that these mobility related procedures should be able to provide update to the MMR-BS with the new topology information. Separate procedure for topology update procedure is not required.

2.3 Path Calculation

Assuming all the radio links in the multi-hop relay system is duplex link, then based on the topology information obtained from topology discovery or update process as discussed in section 2.1 and 2.2, MMR-BS makes centralized calculation for the path between MMR-BS and MS for both uplink and downlink direction. The two end points of a path associated to an MS are MMR-BS and the RS to which the MS directly attaches. Therefore, if two MSs attach to the same RS directly, these two MSs could share the same path between MMR-BS and the RS to which they directly attach. The algorithm and criteria to be used to calculate the path based on the topology is out of the scope of this contribution.

2.4 Path Advertisement

When a new path is calculated and determined as discussed in section 2.3 for RS, MMR-BS advertises the complete path information to all the RSs on that path by sending a PATH-ADV-REQ message (with the Action-Type field set to ESTABLISH) with a uniquely assigned path id. The complete path information and the path id are carried in the Path-Information TLV and Path-Id TLV respectively.

If the MMR-BS decides to cancel an existing path, it sends PATH-ADV-REQ message (with the Action-Type field set to CANCEL) with a Path-Id TLV. The RSs receiving the PATH-ADV-REQ message with the Action-Type field set to CANCEL should remove the associated record for the path specified by the path id and replies with a PATH-CAC-RSP message.

The transmission schemes of the PATH-ADV-REQ are specified in [1]. The type of transmission scheme to be used depends on the application scenarios as described in [1]. Note that in the case of type of the transmission scheme to be used is Hop-by-Hop unicast with end-to-end response, the Basic-CID-Information TLV that contains the basic CID of each RS on the path should be included in the PATH-ADV-REQ message. An intermediate RS uses such information to obtain the basic CID used by the next hop on the path and sends the PATH-ADV-REQ message.

2.5 Path Selection

After calculating and advertising the paths as discussed in section 2.3 and 2.4, MMR-BS maintains all the possible paths. When a new connection is established for an MS, the MMR-BS selects one or more path to carry the traffic for the new connection. When multiple paths exist between the MMR-BS and a MS, the metrics for the MMR-BS to select one or more particular path include but are not limited to link condition, hop count, load condition, overall delay, etc. The metrics of each radio link are obtained by the MMR-BS through the means that are not covered in this contribution.

In order to inform all the RSs on the selected paths of the traffic information, the MMR-BS sends PATH-SEL-REQ message to all the RSs on the selected path. Such PATH-SEL-REQ message contains the CIDs of the connections that will be routed through the specified path, the path-id carried in the Path-ID TLV and optionally the SFID and the QoS requirement for each of the associated service flow. When a RS on the path receives the PATH-SEL-REQ message, it retrieves the CIDs and path id information, which will be used to route the traffic in the future for the specified CID using the path specified in the Path Advertisement process. If the SFID and the QoS requirement are also present for the certain connection, the RS also record such information that will be used for scheduling the traffic for the specified CID. Each RS then replies with the PATH-SEL-RSP message to the MMR-BS.

If the MMR-BS decides to cancel an existing mapping between a path and one or more CID, it sends a PATH-SEL-REQ message (with the Action-Type field set to CANCEL) to the associated path group, which includes the Path-Id and the affected CIDs. The RSs receiving the PATH-SEL-REQ with the Action-Type field set to CANCEL should remove the record of the mapping between the Path-ID and the associated CIDs, and won't use such information to route the subsequent packets carried over the specified CIDs.

The transmission schemes of the PATH-SEL-REQ are specified in [1]. The type of transmission scheme to be used is determined by the MMR-BS and depends on the application scenarios as described in [1].

2.6 Illustration of Topology Discovery and Path Management Procedures

Using the topology illustrated in Figure 1 as an example, Figure 2 shows the initial topology discovery and path management procedure of a multi-hop relay system.

- When RS1 attempts to conduct initial ranging, it sends regular RNG-REQ. After receiving a regular RNG-REQ, the MMR-BS determines that RS1 directly attaches to it. MMR-BS then sends the RNG-RSP to RS1. The other initial network entry procedures remain the same as MS.
- When RS2 attempts to conduct initial ranging, it sends regular RNG-REQ. After receiving a regular RNG-REQ, RS1 encapsulates the RNG-REQ into an Encapsulated-RNG-REQ together with its identifier RSID1 and sends it to the MMR-BS using its basic CID. Upon receiving the Encapsulated-RNG-REQ and furthermore the RNG-REQ from RS2, the MMR-BS determines that RS2 attaches to RS1 directly. It generates a RNG-RSP for RS2 and then encapsulates it into an Encapsulated-RNG-RSP and sends to RS1 using RS1's basic CID. Upon receiving the Encapsulated-RNG-RSP, RS1 extracts the RNG-RSP and sends it to RS2. The other initial network entry procedures remain the same as MS.
- After obtaining the topology between MMR-BS and RS2 during RS2 initial network entry procedure, the MMR-BS determines a path between RS2 and itself. It advertises the path to all the RSs on the path by sending PATH-ADV-REQ (with the Action-Type field set to ESTABLISH). The transmission mechanism of PATH-ADV-REQ message depends on application scenarios as defined in [1] and the hop-by-hop unicast scheme is used here as an illustration. Each RS receiving the PATH-ADV-REQ replies with a PATH-ADV-RSP.
- When MS attempts to conduct initial network entry, it sends a regular RNG-REQ to RS2. RS2 encapsulates the RNG-REQ into an Encapsulated-RNG-REQ together with its identifier RSID2 and

sends it to the next hop RS1 using its basic CID. RS1 will just simply forward it to the MMR-BS. Upon receiving the Encapsulated-RNG-REQ and furthermore the RNG-REQ, the MMR-BS determines that MS attaches to RS2 directly. It then calculates the relay path to be used toward MS (in this example, it's the relay path MMR-BS – RS1 – RS2), and then generates the basic and primary management CID for the MS. In order to inform all the RSs on the path of the routing information and optionally the service flow requirement for the basic and primary management CID, the MMR-BS sends PATH-SEL-REQ (with the Action-Type field set to ESTABLISH) to all the RSs on the path. The transmission mechanism of PATH-SEL-REQ message depends on application scenarios as defined in [1] and the hop-by-hop unicast scheme is used here as an illustration. Each RS receiving the request replies with a PATH-SEL-RSP. The further traffic sent over the basic and primary management CID will be routed through the multi-hop relay system by each RS through the identified path. The MMR-BS then generates a RNG-RSP for MS and then encapsulates it into an Encapsulated-RNG-RSP and sends to RS2 using RS2's primary management CID. Upon receiving the Encapsulated-RNG-RSP, RS2 extracts the RNG-RSP and sends it to the MS. The other initial network entry procedures remain the same.

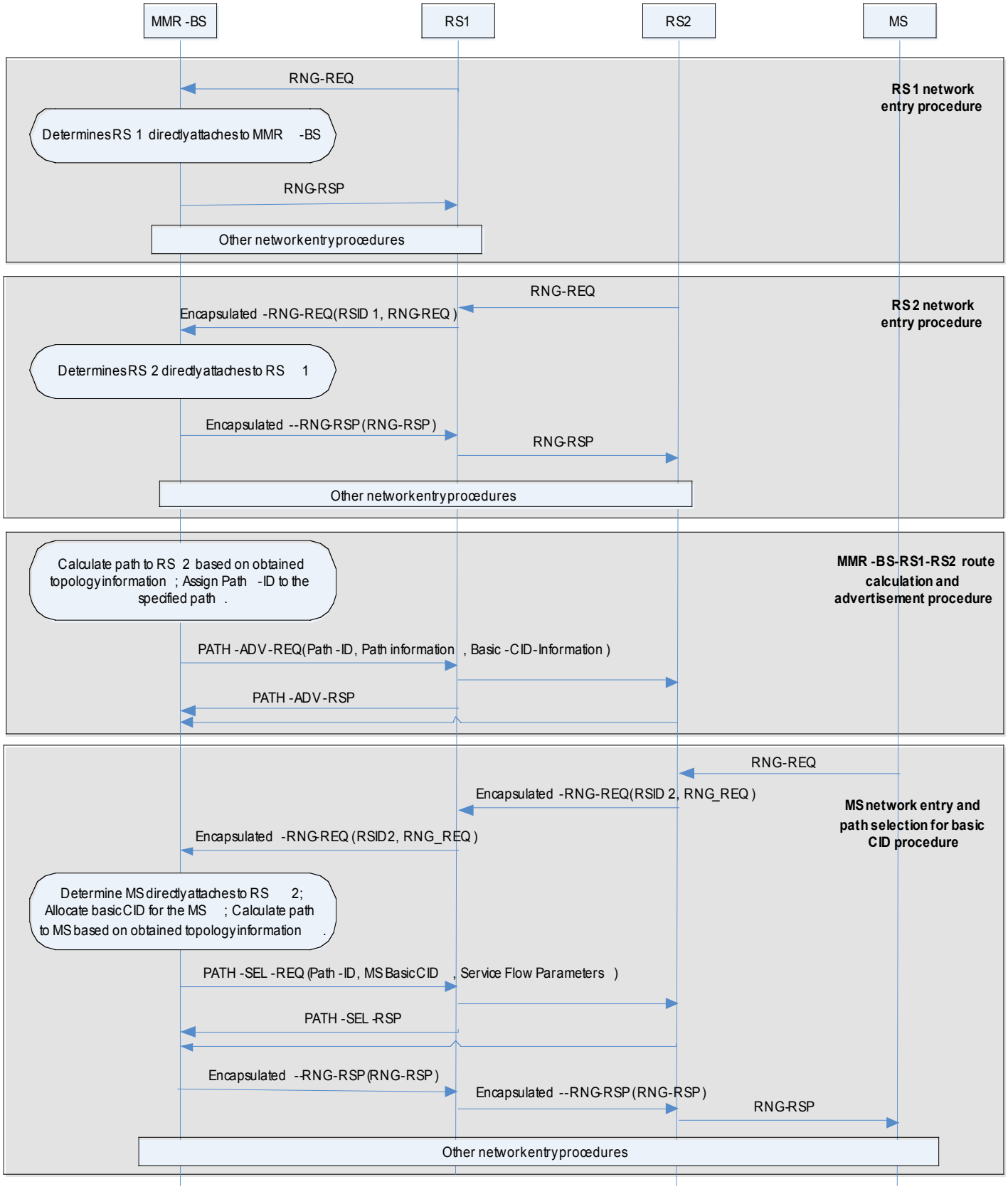

Figure 2: Illustration of Topology Discovery and Path Management Procedures During Network Entry

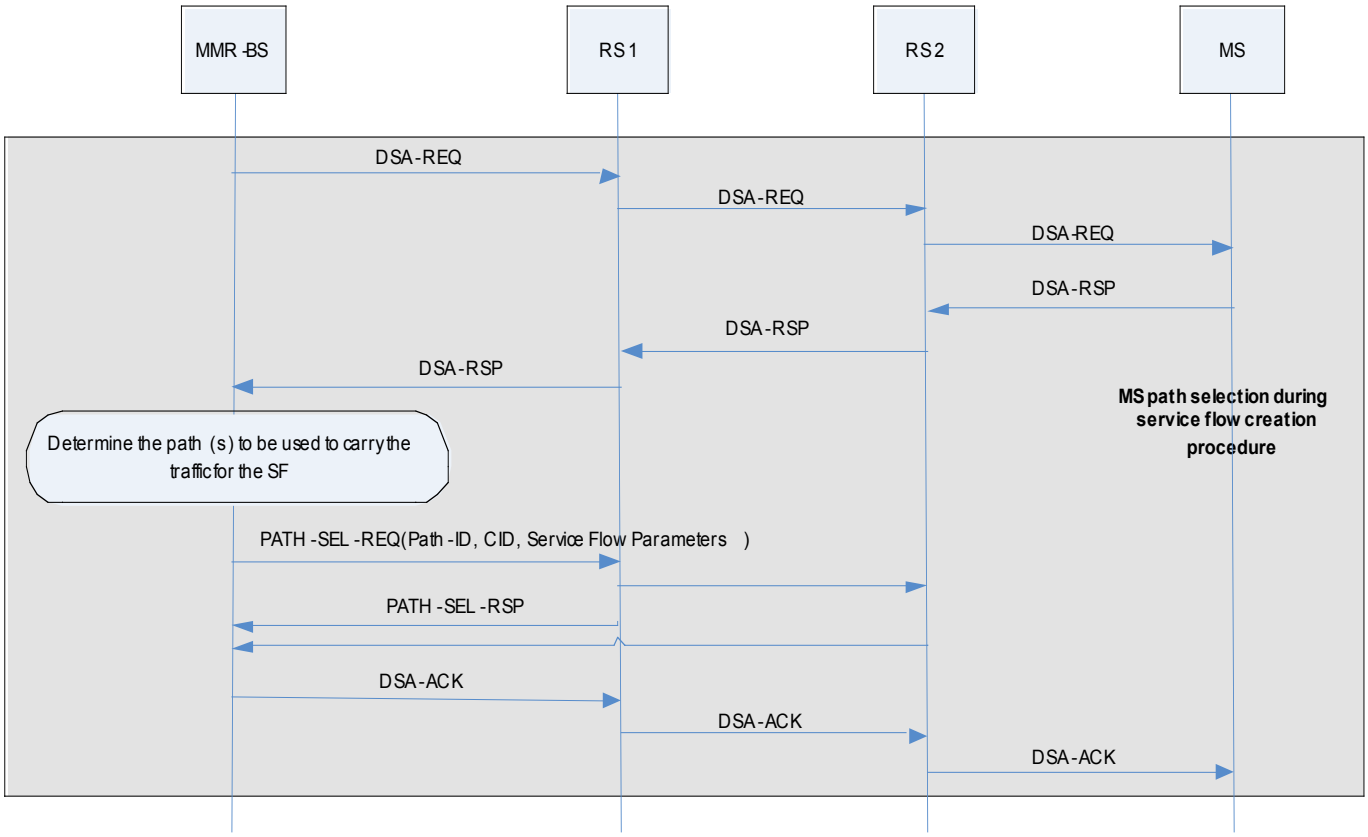

Figure 3: Illustration of Path Selection Procedures During Service Flow Creation

As another example, Figure 3 shows the path selection procedure in multi-hop relay system during the MMR-BS initiated service flow creation procedure.

- When MMR-BS wishes to establish an uplink or downlink dynamic service flow, it sends DSA-REQ. The DSA-REQ is forwarded by RS1 and RS2 to the MS. MS then responds with DSA-RSP, which is also forwarded by RS2 and RS1 to the MMR-BS.
- Upon receiving a successful DSA-RSP, the MMR-BS determines the path(s) to be used to carry the service flow. It then sends PATH-SEL-REQ including the selected Path-ID, the CID associated with the service flow and optionally the service flow parameter set to all the RSs on the path. The transmission mechanism of PATH-SEL-REQ message depends on application scenarios as defined in [1] and the hop-by-hop unicast scheme is used here as an illustration.
- Upon receiving the PATH-SEL-REQ, each RS on the path obtains the mapping between the Path-ID and CID, which will be used to route the traffic for the specified service flow. The service flow parameters can be used for the RS to schedule the traffic for the specified service flow accordingly. The RS then responds with a PATH-SEL-RSP.
- The MMR-BS completes the transaction by sending the acknowledgement message DSA-ACK to the MS.

2.7 Fault Case

In the case that there is no path information associated with a received CID (other than initial ranging CID) due to the events such as MMR-BS or RS fault or failure, the following two cases apply:

- If the traffic is over uplink, the RS should send management message to MMR-BS to report the error. Meanwhile, Depending upon the implementation, RS could be able to decide the next hop to send the traffic. The criteria for such decision could be number of hops towards MMR-BS, overall delay, etc, which is not within the scope of this contribution.
- If the traffic is over downlink and the error occurs in the RS, the RS should send management message to MMR-BS to report the error.

After receiving the error report or if the error occurs in the MMR-BS, the MMR-BS should use the most up-to-date topology information and regenerate the path as described in the previous sections.

3. CHANGES TO THE SPECIFICATION

Add new subclause 6.3.10.4

6.3.10.4 Relaying support for Combined Ranging and Initial Topology Discovery

A combined initial ranging and initial topology discovery procedure can be conducted as defined below.

- When a MS or RS (termed as RSi in this section) conducts its initial ranging, it sends an initial RNG-REQ (i.e., with the CID = Initial ranging CID).
- When an access station (termed as RSj in this section) receives an initial RNG-REQ (i.e., with the CID = Initial ranging CID), it includes the complete RNG-REQ message into an Encapsulated-RNG-REQ TLV and its RSID into an Attached_RS_ID TLV, generates an Encapsulated-RNG-REQ message and sends it to the upstream neighbour (MMR-BS or RS) with its basic CID.
- When a MMR-BS receives an initial RNG-REQ from a MS or RSi, it determines that the MS or RSi sending the RNG-REQ directly attaches to itself and is just one hop away.
- When an intermediate RS receives an Encapsulated-RNG-REQ message, it simply forwards it to the next hop.
- When a MMR-BS receives an Encapsulated-RNG-REQ message, it retrieves the original RNG-REQ sent from the MS or RSi from the Encapsulated-RNG-REQ TLV and the RSID of the RS (i.e., RSj) from the Attached_RS_ID TLV. The MMR_BS then determines that the MS or RSi attaches to the system via the RSj identified by the RS-ID. Since MMR-BS is already aware of the topology between RSj and itself using the mechanism as defined before, it derives the topology between the MS or RSi and itself.
- After processing the Encapsulated-RNG-REQ from RSj and the RNG-REQ from the MS or RSi, the MMR-BS replies the MS or RSi with a RNG-RSP, encapsulates it into an Encapsulated-RNG-RSP and sends it to RSj.
- When a RS receives an Encapsulated-RNG-RSP message targeting to itself, it retrieves the original RNG-RSP from the Encapsulated-RNG-RSP TLV and sends it to the correspondent MS; otherwise, the RS just simply forward it to the next hop.

Add new subclause 6.3.25

6.3.25 Relay Station Topology and Path Management

After MMR-BS discovers the topology between a newly attached MS or RS and itself, or detects a topology update due to events such as mobility, MMR-BS may cancel an old path, calculate a new path and then advertise the new path information to all the RSs on the path. The topology update and path management procedure are specified below.

6.3.25.1 Topology Update

The topology established during initial network entry of the MS or RS could be changed due to events such as mobility including handover, network re-entry or location update. These mobility related procedure should be able to provide update to the MMR-BS with the new topology information. MMR-BS is aware of the RS mobility, it can detect topology update (MRS handover, active set update etc) and may delete, modify and establish new path and advertise them to all the affected RSs on the path with the messages described in following sections. Therefore separate procedure for topology update is not required.

6.3.25.2 Path Calculation

Based on the topology information obtained from topology discovery or update process as specified in section 6.3.10.4 and 6.3.25.1, MMR-BS makes centralized calculation for the path between MMR-BS and MS for both uplink and downlink direction.

6.3.25.3 Path Advertisement

When a new path is discovered and calculated as specified in section 6.3.25.2, MMR-BS advertises the complete path information to all the RSs on that path by sending a PATH-ADV-REQ message (with the Action-Type field set to ESTABLISH) with a uniquely assigned path id. The complete path information and the path id are carried in the Path-Information TLV and Path-Id TLV respectively.

If the MMR-BS decides to cancel an existing path, it sends PATH-ADV-REQ message (with the Action-Type field set to CANCEL) with a Path-Id TLV. The RSs receiving the PATH-ADV-REQ message with the Action-Type field set to CANCEL should remove the associated record for the path specified by the path id and replies with a PATH-CAC-RSP message.

PATH-ADV-REQ message is sent by MMR-BS to all the RSs in the path. The transmission scheme used for PATH-ADV-REQ message could be End-to-end unicast or Hop-by-hop unicast with end-to-end response. MMR-BS decides on the type of transmission scheme and set the Transmission Type field in the PATH-ADV-REQ accordingly. In the case that the transmission scheme to be used is Hop-by-Hop unicast with end-to-end response and the Action-Type is ESTABLISH, a Basic-CID-Information TLV which contains the basic CID of each RS on the path should be included in the PATH-ADV-REQ message. An intermediate RS uses such information to obtain the basic CID used by the next hop on the path and sends the PATH-ADV-REQ message. The intermediate RS should also record such information, which will be used to send other MAC management messages that have the transmission scheme to be Hop-by-hop unicast with end-to-end response.

6.3.25.4 Path Selection

After calculating and advertising the paths as specified in section 6.3.25.2 and 6.3.25.3, MMR-BS maintains all the possible paths. When a new connection is established for an MS, the MMR-BS selects one or more path to carry the traffic for the new connection.

In order to inform all the RSs on the selected paths of the traffic information, the MMR-BS sends PATH-SEL-REQ message to all the RSs on the selected path. Such PATH-SEL-REQ message contains the CIDs of the connections that will be routed through the specified path, the path-id carried in the Path-ID TLV and optionally the SFID and the QoS requirement for each of the associated service flow. When a RS on the path receives the PATH-SEL-REQ message, it retrieves the CIDs and path id information, which will be used to route the traffic in the future for the specified CID using the path specified in the Path Advertisement process. If the SFID and the QoS requirement are also present for certain connection, the RS saves them for scheduling the traffic for the specified CID. Each RS then replies with the PATH-SEL-RSP message to the MMR-BS.

If the MMR-BS decides to cancel an existing mapping between a path and one or more CID, it sends a PATH-SEL-REQ message (with the Action-Type field set to CANCEL), which includes the Path-Id and the affected CIDs. The RSs receiving the PATH-SEL-REQ with the Action-Type field set to CANCEL should remove the record of the mapping between the Path-ID and the associated CIDs, and won't use such information to route the subsequent packets carried over the specified CIDs.

There could be multiple PATH-SEL-REQ message can be sent for same CID to establish multiple paths to MS. This can be utilized for dynamic switching of traffic among multiple paths based on traffic condition or in case of macro diversity handoff.

The transmission schemes of the PATH-SEL-REQ message could be End-to-end unicast or Hop-by-hop unicast with end-to-end response. MMR-BS decides on the type of transmission scheme and set the Transmission Type field in the PATH-ADV-REQ accordingly.

Change subclause 6.3.2.3.5 as indicated

TLV message elements shall only be included in RNG-REQ message of adequate UL bandwidth. In OFDMA, when the MS transmits the handover CDMA ranging code, the BS shall provide for initial UL bandwidth allocation of size at least sufficient for transmission of RNG-REQ message with MS MAC address TLV and Grant Management subheader.

In multi-hop relay system, when the MS transmits initial Ranging Request, the MMR-BS/RS shall provide for extra UL bandwidth allocation of size at least sufficient for the RS, to which the MS directly attaches, to encapsulate the original RNG-REQ to an Encapsulated_RNG-REQ message. Such extra bandwidth allocation only applies to the Encapsulated_RNG-REQ generated by RS and other intermediate RSs in between, but not to the MS.

Change Table 14 (MAC Management Messages) as indicated

Type	Message Name	Message Description	Connection
67	PATH-ADV-REQ	Path Advertisement Request	Basic
68	PATH-ADV-RSP	Path Advertisement Response	Basic
69	PATH-SEL-REQ	Path Selection Request	Basic
70	PATH-SEL-RSP	Path Selection Response	Basic
71	Encapsulated-RNG-REQ	Encapsulated Ranging Request	Basic
72	Encapsulated-RNG-RSP	Encapsulated Ranging Response	Basic

Insert new subclause 6.3.2.3.66

6.3.2.3.66 Encapsulated Ranging Request (Encapsulated-RNG-REQ) message

In multi-hop relay system, upon receiving a RNG-REQ with the CID equal to Initial ranging CID from an MS, the RS retrieves the complete RNG-REQ message and generates an Encapsulated-RNG-REQ in the form shown in Table T1.

Table T1 – Encapsulated-RNG-REQ message format

Syntax	Size	Notes
Encapsulated-RNG-REQ() {		
Management Message Type = TBD	8 bits	
TLV Encoded Information	Variable	TLV specific
}	-	-

The following TLV parameters shall be included:

Original Ranging Request

The original RNG-REQ received from the MS.

Attached-RS-ID

The RSID of the first RS that receives the original RNG-REQ.

CMAC/HMAC Tuple (see 11.1.2)

The CMAC/HMAC Tuple attribute contains a keyed message digest (to authenticate the sender). The CMAC/HMAC Tuple attribute shall be the final attribute in the Encapsulated-RNG-REQ message's attribute list.

Insert new subclause 6.3.2.3.67

6.3.2.3.67 Encapsulated Ranging Response (Encapsulated-RNG-RSP) message

In multi-hop relay system, upon receiving an Encapsulated-RNG-REQ, the MMR-BS retrieves the original RNG-REQ, generates a RNG-RSP, and then encapsulates it into an Encapsulated-RNG-RSP in the form shown in Table T2.

Table T2 – Encapsulated-RNG-RSP message format

Syntax	Size	Notes
Encapsulated-RNG-RSP() {		
Management Message Type = TBD	8 bits	
Confirmation Code	8 bits	
TLV Encoded Information	variable	TLV specific
}	-	-

Parameters shall be as follows:

Confirmation Code (see 11.13)

The appropriate Confirmation Code (CC) for the entire corresponding Encapsulated-RNG-REQ

The following TLV parameters shall be included:

Original Ranging Response

The original RNG-RSP sent to the MS.

CMAC/HMAC Tuple (see 11.1.2)

The CMAC/HMAC Tuple attribute contains a keyed message digest (to authenticate the sender). The CMAC/HMAC Tuple attribute shall be the final attribute in the Encapsulated-RNG-RSP message's attribute list.

Insert new subclause 6.3.2.3.68

6.3.2.3.68 Path-Advertisement Request (PATH-ADV-REQ) message

An MMR-BS shall send a PATH-ADV-REQ message when it intends to advertises the complete path information to all the RSs on the path. An MMR-BS shall generate PATH-ADV-REQs in the form shown in Table T3. When a RS receives a PATH-ADV-REQ with Transmission Type equal to Hop-by-hop unicast with end-to-end response, and it is not the last hop on the relay path, it shall also generate PATH-ADV-REQ in the form shown in Table T3.

Table T3 – PATH-ADV-REQ message format

Syntax	Size	Notes
PATH-ADV-REQ() {		
Management Message Type = TBD	8 bits	
Transaction ID	16 bits	
Transmission Type	2 bits	Type of Transmission Scheme as defined in Nokia's contribution x.y.z
Action Type	3 bits	
TLV Encoded Information	*Variable*	TLV specific
}		

The PATH-ADV-REQs shall include the following parameters:

Transaction ID
Unique identifier for this transaction assigned by the sender
Transmission Type (see section 11.1.S2)
The type of transmission scheme for MAC management messages targeting to all the RSs on a relay path
Action Type (see section 11.1.S1)
The type of actions for the path advertisement, including ESTABLISH and CANCEL

All other parameters are coded as TLV tuples.

The PATH-ADV-REQ shall contain the following TLVs:

Path-ID ()
Unique identifier for the path assigned by the sender (i.e., MMR-BS)
Path-Information ()
The complete path information for the path identified by the Path-ID

CMAC/HMAC Tuple (see 11.1.2)
The CMAC/HMAC Tuple attribute contains a keyed message digest (to authenticate the sender). The CMAC/HMAC Tuple attribute shall be the final attribute in the PATH-ADV-REQ message's attribute list.

The PATH-ADV-REQ shall contain the following TLVs if Transmission Type equal to Hop-by-hop unicast with end-to-end response:

Basic-CID-information()
A list of basic CID for each RS on the path.

Insert new subclause 6.3.2.3.69

6.3.2.3.69 Path-Advertisement Response (PATH-ADV-RSP) message

Upon receiving a PATH-ADV-REQ message, a RS replies with a PATH-ADV-RSP in the form shown in Table T4.

Table T4 – PATH-ADV-RSP message format

Syntax	Size	Notes
PATH-ADV-RSP() {		
Management Message Type = TBD	8 bits	
Transaction ID	16bits	
Confirmation Code	8 bits	
TLV Encoded Information	*Variable*	TLV specific
}		

Parameters shall be as follows:

Transaction ID
Transaction ID from corresponding PATH-ADV-REQ
Confirmation Code (see 11.13)
The appropriate Confirmation Code (CC) for the entire corresponding PATH-ADV-REQ

The PATH-ADV-RSP should contain the following TLVs:

CMAC/HMAC Tuple (see 11.1.2)
The CMAC/HMAC Tuple attribute contains a keyed message digest (to authenticate the sender). The CMAC/HMAC Tuple attribute shall be the final attribute in the PATH-ADV-RSP message's attribute list.

Insert new subclause 6.3.2.3.70

6.3.2.3.70 Path-Selection-Request (PATH-SEL-REQ) message

After selecting one or more path to carry the traffic for a new connection, an MMR-BS shall send a PATH-SEL-REQ message in the form shown in Table T5 to the multicast group to which all the RSs on the selected path belong. When a RS receives a PATH-SEL-REQ with Transmission Type equal to Hop-by-hop unicast with end-to-end response, and it is not the last hop on the relay path, it shall also forward PATH-SEL-REQ in the form shown in Table T5.

Table T5 – PATH-SEL-REQ message format

Syntax	Size	Notes
PATH-SEL-REQ() {		
Management Message Type = TBD	8 bits	
Transaction ID	16 bits	
Transmission Type	2 bits	Type of Transmission Scheme as defined in Nokia's contribution x.y.z
Action Type	8 bits	
TLV Encoded Information	Variable	TLV specific
}		

The PATH-SEL-REQ shall include the following parameters:

Transaction ID
Unique identifier for this transaction assigned by the sender
Transmission Type (see section 11.1.S2)
The type of transmission scheme for MAC management messages targeting to all the RSs on a relay path
Action Type (see section 11.1.S1)
The type of actions for the path selection, including ESTABLISH and CANCELL.

All other parameters are coded as TLV tuples.

The PATH-SEL-REQ shall contain the following TLVs:

Path-ID
Unique identifier for the path selected
CID
The CID for the connection to be routed through the path identified by the Path-ID. More than one CID can be included in the message.
CMAC/HMAC Tuple (see 11.1.2)
The CMAC/HMAC Tuple attribute contains a keyed message digest (to authenticate the sender). The CMAC/HMAC Tuple attribute shall be the final attribute in the PATH-SEL-REQ message's attribute list.

The PATH-SEL-REQ may contain the following TLV when the Action-Type field = ESTABLISH.

Service Flow Parameters
Specification of the service flow's traffic characteristics and scheduling requirements. Each set of Service Flow parameter corresponds to one CID listed in the same message.

Insert new subclause 6.3.2.3.71

6.3.2.3.71 Path-Selection-Response (PATH-SEL-RSP) message

Upon receiving a PATH-SEL-REQ message, a RS retrieves and records the relative information and replies with a PATH-SEL-RSP in the form shown in Table T6.

Table T4 – PATH-SEL-RSP message format

Syntax	Size	Notes
PATH-SEL-RSP() {		
Management Message Type = TBD	8 bits	
Transaction ID	16bits	
Confirmation Code	8 bits	
TLV Encoded Information	Variable	TLV specific
}		

Parameters shall be as follows:

Transaction ID
Transaction ID from corresponding PATH-SEL-REQ
Confirmation Code (see 11.13)
The appropriate Confirmation Code (CC) for the entire corresponding PATH-SEL-REQ.

The PATH-SEL-RSP should contain the following TLVs:

CMAC/HMAC Tuple (see 11.1.2)
The CMAC/HMAC Tuple attribute contains a keyed message digest (to authenticate the sender). The CMAC/HMAC Tuple attribute shall be the final attribute in the PATH-SEL-RSP message's attribute list.

Insert new subclause 11.20

11.20 Topology Discovery message encodings

The TLV encodings defined in this section are specific to the Encapsulated-RNG-REQ MAC Management message.

11.20.1 Original Ranging Request

This field contains the original RNG-REQ sent from an MS.

Type	Length	Value	Scope
TBD	variable	RNG-REQ	Encapsulated-RNG-REQ

11.20.2 Original Ranging Response

This field contains the original RNG-RSP sent from a MMR-BS to an MS.

Type	Length	Value	Scope
TBD	variable	RNG-RSP	Encapsulated-RNG-RSP

11.20.3 Attached-RS-ID

This field contains the ID of the RS that encapsulate the original RNG-REQ sent from a MS into an Encapsulated-RNG-REQ and sends to the MMR-BS.

Type	Length	Value	Scope
TBD	6	ID of the RS	Encapsulated-RNG-REQ

Insert new subclause 11.21

11.21 Path Management message encodings

The TLV encoding defined in this section are specific to the path management related MAC Management messages including PATH-ADV-REQ/RSP and PATH-SEL-REQ/RSP.

11.21.1 Path-ID TLV

This filed contains the ID of a path between MMR-BS and a RS.

Type	Length	Value	Scope
TBD	4	ID of path	PATH-ADV-REQ PATH-SEL-REQ

11.21.2 Path-Information TLV

This field contains a compound attribute containing Path ID, the direction of the path, the number of RSs on the path and an ordered list of RSs on the path as listed in Table S3.

Type	Length	Value	Scope
TBD	Variable	Compound	PATH-ADV-REQ

Table S3 – Path Information Subattributes

Attribute	Content
Path ID	The ID of the path
Path Direction	The direction of the path
Number of RS	The number of RSs on the path
Ordered list of RSs	An ordered list of RSs that identifies the path

11.21.3 Path-Direction TLV

This field specifies the direction of the path, which could be uplink only, downlink only or both uplink and downlink.

Type	Length	Value	Scope
TBD	1	0 – uplink 1- downlink 2 – both uplink and downlink	PATH-ADV-REQ

11.21.4 Number-of-RS TLV

This field specifies the number of intermediate RSs on the path.

Type	Length	Value	Scope
TBD	1	Number of RSs on the path	PATH-ADV-REQ

11.21.5 Ordered-List-of-RS TLV

This field contains an ordered list of intermediate RSs on the path. Note that if the Path Direction indicates for both uplink and downlink, then the ordered list of RS is for the downlink direction. The ordered list of RS for the uplink can be obtained by reverse the ordered list.

Type	Length	Value	Scope
TBD	Length of RSID x Number of RS	An ordered list of RSs on a path; if Path Direction == 2, then the ordered list of RS on the path is for the downlink direction	PATH-ADV-REQ

11.21.6 Basic-CID-Information TLV

This field contains an ordered list of basic CIDs, each of which corresponds to each RS in the ordered list of RS TLV.

Type	Length	Value	Scope
TBD	2 bytes x Number of RS	An ordered list of basic CID, each of which corresponds to each RS in the ordered list of RS TLV	PATH-ADV-REQ

Changes to subclause 11.13.2 as indicated

The value of this field specifies the CID assigned by the BS to a service flow with a non-null AdmittedQoSParamSet or ActiveQoSParamSet. The 16-bit value of this field is used in bandwidth requests, path selection requests and in MAC PDU headers. This field shall be present in a BS-initiated DSA-REQ or DSC-REQ message related to establishing an admitted or active service flow. This field shall also be present in DSA-RSP and DSC-RSP message related to successful establishment of an admitted or active service flow. In addition, in multi-hop relay system, this field shall be present in a PATH-SEL-REQ message in order to establish a mapping between the CID and the ID of a path at a RS.

Insert new subclause 11.1.8

11.1.8 Action Type

This parameter specifies the type of the action to be performed for the associated messages.

Type	Length	Value	Scope
Action Type	1	0 – Indicates the action is ESTABLISH 1 – Indicates the action is CANCEL	PATH-ADV-REQ PATH-SEL-REQ

Insert new subclause 11.1.9

11.1.9 Transmission Type

This parameter specifies the type of the transmission scheme for MAC management message targeting to all the RSs on the same relay path.

Type	Length	Value	Scope
Transmission Type	2	00 – End-to-end Unicast 01 – Hop-by-hop unicast with end-to-end response 10/11 - Reserved	PATH-ADV-REQ PATH-SEL-REQ AC-REQ AF-REQ

4. SUMMARY

This contribution proposes a light-weight topology discovery and path management scheme for multi-hop relay system. The topology discovery procedure is combined together with initial ranging process, which produces less overhead on bandwidth requirement and less delay. The MMR-BS makes centralized decision on path management across the multi-hop relay system under its coverage area based on feedback information from the RSs and MSs, and then informs RSs of the routing information. This contribution specifies the new additions of the MAC procedures as well as the modified MAC procedures. The changes to the existing specification are also included.

5. REFERENCES

[1] C802.16j-06_196.pdf **Transmission Scheme of MAC Management Message towards a RS Group in multi-hop relay System**