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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 initial topology discover procedure in multi-hop relay system. The relevant changes to the specification are also defined.	
Purpose	Add proposed spec changes.	
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# Topology Discovery in Multi-hop Relay System

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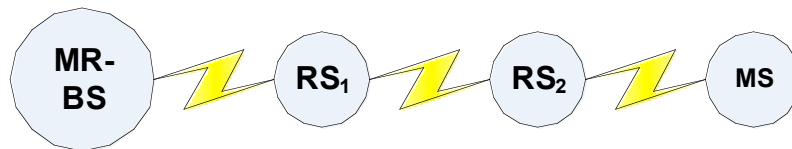
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## 1. INTRODUCTION

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



**Figure 1: Example Topology in multi-hop relay System**

The knowledge of the topology by MR-BS is required to support different features, such as scheduling, path establishment and selection, etc. However, maintaining the topology could produce significant system overhead, especially if it is designed as a separate procedure with its own signaling. This contribution proposes a simple and light-weight topology discovery scheme for multi-hop relay system by enhancing the existing ranging procedures, instead of adding a new procedure. The relevant changes to the standard to support such scheme are also proposed.

## 2. TOPOLOGY DISCOVERY AND UPDATE

### 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 MR-BS with the CID field in the MAC header set to Initial ranging CID (0x0000). With slight enhancement to the initial ranging procedure, the MR-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 RS<sub>i</sub> 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 RS<sub>j</sub> in this section) receives an initial RNG-REQ (i.e., with the CID = Initial ranging CID), it replaces the Initial ranging CID in the RNG-REQ with its basic CID, adds a MS Ranging Indication TLV, protects the message with HMAC/CMAC tuple using the security association shared between MR-BS and itself, and then sends it to the MR-BS.
- When a RS receives RNG-REQ message with the CID value not equal to the Initial ranging CID, it simply forwards it to the next hop.

- When a MR-BS receives an initial RNG-REQ from a MS or RS<sub>i</sub>, it determines that the MS or RS<sub>i</sub> sending the RNG-REQ directly attaches to itself and is just one hop away.
- When a MR-BS receives a RNG-REQ message with the CID set to the basic CID of RS<sub>j</sub>, it first verifies the message using the security association shared between RS<sub>j</sub> and itself. If the message is valid, it checks the presence of MS Ranging Indication TLV. If it is present, the MR-BS regenerates the original RNG-REQ sent from MS or RS<sub>i</sub> by removing the HMAC/CMAC tuple and the MS Ranging Indication TLV and replacing the RS<sub>j</sub>'s basic CID with the Initial ranging CID in the received RNG-REQ message. MR-BS then processes the initial ranging request. The MR-BS also determines that the MS or RS<sub>i</sub> attaches to the system via RS<sub>j</sub>. Since MR-BS is already aware of the topology between RS<sub>j</sub> and itself using the same mechanism as defined in this section, it establishes the topology between the MS or RS<sub>i</sub> and itself.
- After processing the original RNG-REQ from MS or RS<sub>i</sub>, the MR-BS replies a RNG-RSP. Instead of using the Initial ranging CID, it uses the basic CID of RS<sub>j</sub>, add the MS Ranging Indication TLV and then protects the message with HMAC/CMAC tuple using the security association shared between RS<sub>j</sub> and itself, and sends to RS<sub>j</sub>.
- When a RS receives RNG-RSP message with the CID value not equal to the Initial ranging CID, it simply forwards it to targeting station.
- When a RS receives a RNG-RSP message targeting to itself, it first verifies the message based on the HMAC/CMAC tuple. If the message is valid, it checks the presence of MS Ranging Indication TLV. If it is present, the RS regenerates the original RNG-RSP by removing the HMAC/CMAC tuple and MS Ranging Indication TLV and replacing the RS<sub>j</sub>'s basic CID with the Initial ranging CID in the received RNG-RSP message. It then sends the new RNG-RSP to the correspondent MS.

## 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 MR-BS with the new topology information. Separate procedure for topology update procedure is not required.

## 2.3 Illustration of Topology Discovery

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

- When RS<sub>1</sub> attempts to conduct initial ranging, it sends regular initial RNG-REQ. After receiving a regular initial RNG-REQ, the MR-BS determines that RS<sub>1</sub> directly attaches to it. MR-BS then sends the RNG-RSP to RS<sub>1</sub>. The other initial network entry procedures remain the same as legacy MS. Such procedure may trigger routing table update and path update for RS<sub>1</sub> [1].
- When RS<sub>2</sub> attempts to conduct initial ranging, it sends regular initial RNG-REQ. After receiving an initial RNG-REQ, RS<sub>1</sub> modifies the RNG-REQ by replacing the Initial ranging CID with its basic CID and inserting HMAC/CMAC tuple, and sends to MR-BS. Upon receiving a RNG-REQ with RS<sub>1</sub>'s basic CID and the MS Ranging Indication TLV, the MR-BS verifies the message and determines that RS<sub>2</sub> attaches to RS<sub>1</sub> directly if the message is valid. MR-BS restores the original RNG-REQ sent by RS<sub>2</sub> by removing the HMAC/CMAC tuple and replacing RS<sub>1</sub>'s basic CID with the Initial ranging CID, and processes it. The MR-BS then generates a RNG-RSP for RS<sub>2</sub>. MR-BS replaces the Initial ranging CID with the basic CID of RS<sub>1</sub>, inserts the MS Ranging Indication TLV and HMAC/CMAC tuple, and then sends it to RS<sub>1</sub>. Upon receiving the RNG-RSP, RS<sub>1</sub> verifies the message and restores the original RNG-RSP by removing the HMAC/CMAC tuple and replacing the RS<sub>1</sub>'s basic CID with the Initial ranging CID. RS<sub>1</sub> then sends the RNG-RSP to RS<sub>2</sub>. The other initial network entry procedures remain the same as legacy MS. Such procedure may trigger routing table update and path update for RS<sub>2</sub> [1].

- When MS attempts to conduct initial network entry, it sends a regular initial RNG-REQ to RS2. RS2 modifies the RNG-REQ by replacing the Initial ranging CID with its basic CID and inserting the MS Ranging Indication TLV and HMAC/CMAC tuple, and sends to MR-BS. RS1 will just simply forward it to the MR-BS. Upon receiving the RNG-REQ with RS2 basic CID and MS Ranging Indication TLV, MR-BS verifies the message and determines that MS attaches to RS2 directly. MR-BS restores the original RNG-REQ sent by MS by removing the HMAC/CMAC tuple and replacing RS2's basic CID with the Initial ranging CID, and processes it. Such procedure may trigger routing table update and path update for the MS [1]. The MR-BS then generates a RNG-RSP for MS. MR-BS replaces the Initial ranging CID with the basic CID of RS2, inserts the MS Indication TLV and HMAC/CMAC tuple, and then sends it to RS2. Upon receiving the RNG-RSP, RS2 verifies the message and restores the original RNG-RSP by removing the HMAC/CMAC tuple and replacing the RS2's basic CID with the Initial ranging CID. RS2 then sends the RNG-RSP to MS. The other initial network entry procedures remain the same.

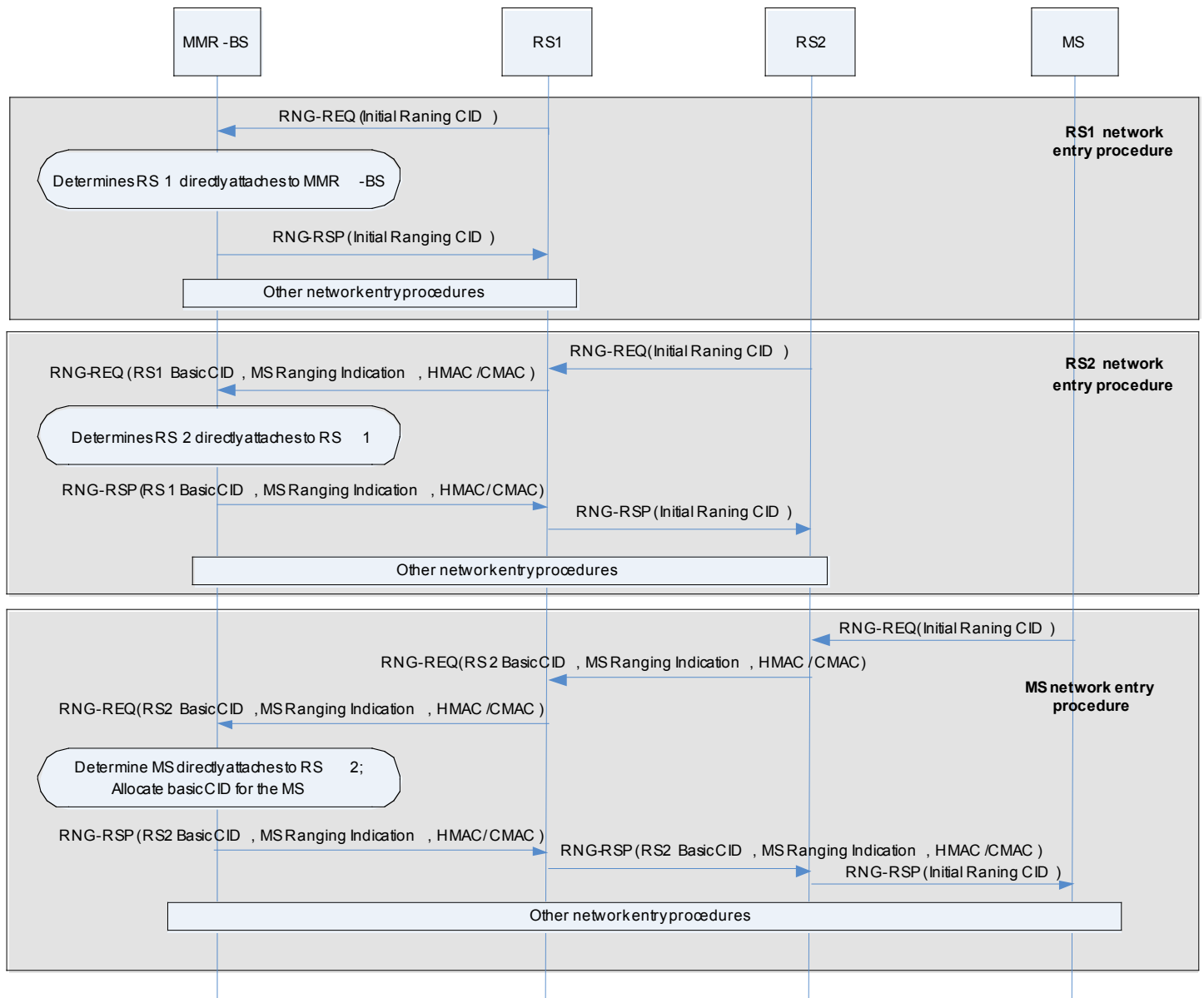


Figure 2: Illustration of Topology Discovery and Path Management Procedures During Network Entry

**3. CHANGES TO THE SPECIFICATION**

**Add new subclause 6.3.25**

**6.3.25 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 RS<sub>i</sub> 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 RS<sub>j</sub> in this section) receives an initial RNG-REQ, it replaces the Initial ranging CID in the RNG-REQ with its basic CID, protects the message with HMAC/CMAC tuple using the security association shared between MR-BS and itself, and then sends it to the MR-BS.
- When a RS receives a RNG-REQ message with the CID value not equal to the Initial ranging CID, it simply forwards it to the MR-BS.
- When a MR-BS receives an initial RNG-REQ from a MS or RS<sub>i</sub>, it determines that the MS or RS<sub>i</sub> sending the RNG-REQ directly attaches to MR-BS and is just one hop away.
- When a MR-BS receives a RNG-REQ message with the CID set to the basic CID of RS<sub>j</sub>, it first verifies the message using the security association shared between RS<sub>j</sub> and itself. If the message is valid, MR-BS determines that the MS or RS<sub>i</sub> attaches to the system via RS<sub>j</sub>. Since MR-BS is already aware of the topology between RS<sub>j</sub> and itself using the same mechanism as defined in this section, it establishes the topology between the MS or RS<sub>i</sub> and itself. MR-BS also restores the original RNG-REQ sent from MS or RS<sub>i</sub> by removing the HMAC/CMAC tuple and replacing the RS<sub>j</sub>'s basic CID with the Initial ranging CID in the received RNG-REQ message, and process the initial ranging request.
- After processing the original RNG-REQ from MS or RS<sub>i</sub>, the MR-BS replies a RNG-RSP. Instead of the Initial ranging CID, it uses the basic CID of RS<sub>j</sub>, protects the message with HMAC/CMAC tuple using the security association shared between RS<sub>j</sub> and itself, and sends to RS<sub>j</sub>.
- When a RS receives RNG-RSP message with the CID value not equal to the Initial ranging CID, it simply forwards it to target station.
- When a RS receives a RNG-RSP message targeting to itself, it first verifies the message using the included HMAC/CMAC tuple. If the message is valid, it regenerates the original RNG-RSP by removing the HMAC/CMAC tuple and replacing the RS<sub>j</sub>'s basic CID with the Initial ranging CID in the received RNG-RSP message. It then sends the new RNG-RSP to the correspondent MS.

**Add new subclause 6.3.26**

**6.3.26 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 MR-BS with the new topology information. Since MR-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. Separate procedure for topology update is not required.

***Insert the following rows into Table 364 in subclause 11.5:***

Table 364—RNG-REQ message encodings

Name	Type (1 byte)	Length	Value (variable-length)
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<u>MS Ranging Indicator</u>	<u>TBD</u>	<u>1</u>	<u>0: reserved</u> <u>1: indicating this RNG-REQ is originated from MS or a RS that performs initial ranging</u> <u>2-255: reserved</u>
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***Insert the following rows into Table 367 in subclause 11.6:***

Table 367—RNG-RSP message encodings

Name	Type (1 byte)	Length	Value (variable-length)
<u>MS Ranging Indicator</u>	<u>TBD</u>	<u>1</u>	<u>0: reserved</u> <u>1: indicating this RNG-RSP is originated from MS or a RS that performs initial ranging</u> <u>2-255: reserved</u>

#### **4. SUMMARY**

This contribution proposes a light-weight topology discovery 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. This contribution specifies the modified MAC procedures as well as the changes to the existing specification.

#### **5. REFERENCES**

[1] C802.16j-07\_031.pdf, Path Management in Multi-hop Relay System, Haihong Zheng et. al., Nokia and Huawei