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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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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.

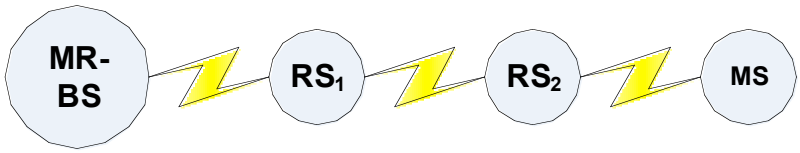

Figure 1: Example Topology in multi-hop relay System

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 proposed mechanism is in line with the network entry procedure defined in the baseline document for multi-hop relay. 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. The initial ranging process is in line with the procedure defined in the baseline document.

- 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 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 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 RSi, it determines that the MS or RSi 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 RSj, it first verifies the message using the security association shared between RSj and itself. If the message is valid, The MR-BS determines that the MS or RSi attaches to the system via RSj. Since MR-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 original RNG-REQ from MS or RSi, the MR-BS replies a RNG-RSP. Instead of using the Initial ranging CID, it uses the basic CID of RSj, and then protects the message with HMAC/CMAC tuple using the security association shared between RSj and itself, and sends to RSj.
- When an intermediate 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, the RS regenerates the original RNG-RSP by removing the HMAC/CMAC tuple and replacing the RSj'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 RS1 attempts to conduct initial ranging, it sends regular initial RNG-REQ. After receiving a regular initial RNG-REQ, the MR-BS determines that RS1 directly attaches to it. MR-BS then sends the RNG-RSP to RS1. The other initial network entry procedures remain the same as legacy MS. Such procedure may trigger routing table update and path update for RS1 [1].
- When RS2 attempts to conduct initial ranging, it sends regular initial RNG-REQ. After receiving an initial RNG-REQ, RS1 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 RS1's basic CID, the MR-BS verifies the message and determines that RS2 attaches to RS1 directly if the message is valid. MR-BS restores the original RNG-REQ sent by RS2 by removing the HMAC/CMAC tuple and replacing RS1's basic CID with the Initial ranging CID, and processes it. The MR-BS then generates a RNG-RSP for RS2. MR-BS replaces the Initial ranging CID with the basic CID of RS1, inserts the HMAC/CMAC tuple, and then sends it to RS1. Upon receiving the RNG-RSP, RS1 verifies the message and restores the original RNG-RSP by removing the HMAC/CMAC tuple and replacing the RS1's basic CID with the Initial ranging CID. RS1 then sends the RNG-RSP to RS2. The other initial network entry procedures remain the same as legacy MS. Such procedure may trigger routing table update and path update for RS2 [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 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, 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 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.

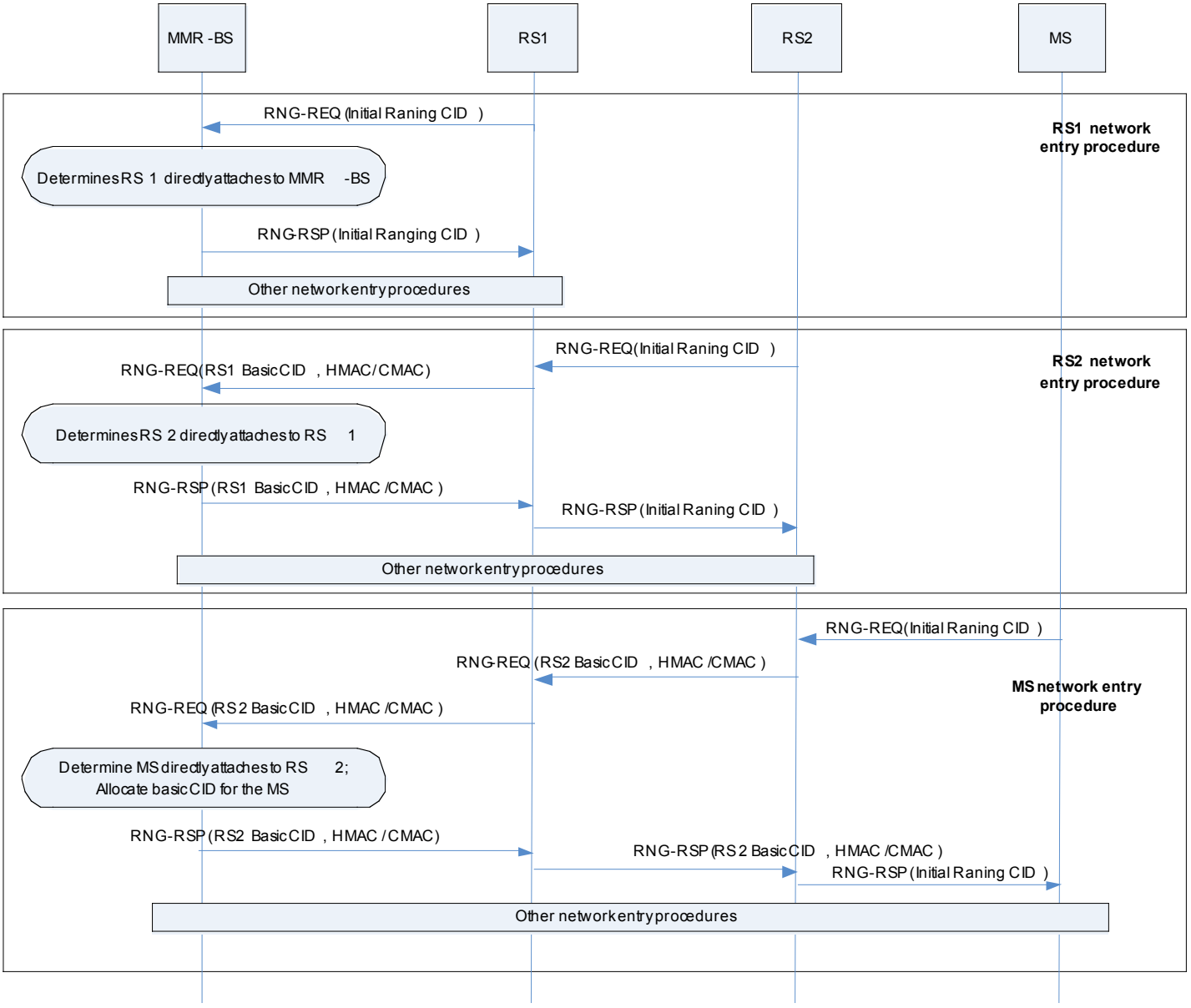

Figure 2: Illustration of Topology Discovery and Path Management Procedures During Network Entry

3. CHANGES TO THE SPECIFICATION

Add new subclause 6.3.25.1

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 RSi in this section) conducts its initial ranging, it sends an initial RNG-REQ
- When a RS (termed as RSj 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 RSi, it determines that the MS or RSi 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 RSj, MMR-BS determines that the MS or RSi attaches to the system via RSj. Since MR-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 original RNG-REQ from MS or RSi, the MR-BS replies a RNG-RSP. Instead of the Initial ranging CID, it uses the basic CID of RSj, protects the message with HMAC/CMAC tuple using the security association shared between RSj and itself, and sends to RSj.
- 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 with its RS basic CID, it regenerates the original RNG-RSP by removing the HMAC/CMAC tuple and replacing the RSj's basic CID with the Initial ranging CID. It then sends the new RNG-RSP to the MS.

4. REFERENCES

[1] C802.16j-07_031r2.pdf, Path Management in Multi-hop Relay System, Haihong Zheng et. al., Nokia and Huawei