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Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**Topology Discovery in Multi-hop Relay System**	
Date Submitted	**2007-03-09**	
Source(s)	Haihong Zheng, Yousuf Saifullah, Shashikant Maheshwari Nokia 6000 Connection Drive, Irving, TX	Voice: +1 972 894 5000 Haihong.1.Zheng@nokia.com, Yousuf.Saifullah@nokia.com, Shashikant.Maheshwari@nokia.com
	David Comstock, John Lee, Shang Zheng, Aimin Zhang Huawei Technologies No.98, Lane91, Eshan Road, Shanghai, P.R.C	dcomstock@huawei.com Voice: +1 858 735 9382
	Masato Okuda Fujitsu Laboratories LTD. Kamikodanaka 4-1-1, Nakahara-ku Kawasaki, Japan. 211-8588	Voice: +81-44-754-2811 Fax: +81-44-754-2786 mailto:okuda@jp.fujitsu.com
	G.Q. Wang, Wen Tong, Peiying Zhu, Hang Zhang, David Steer, Gamini Senarath, Derek Yu, Mo-Han Fong Nortel 3500 Carling Avenue Ottawa, Ontario K2H 8E9	Voice: 1-613-763-1315 [mailto:wentong@nortel.com]
	Tzu-Ming Lin, Chie-Ming Chou, Fang-Ching Ren, I-Kang Fu, Jen-Shun Yang, Wern-Ho Sheen, NCTU / ITRI Industrial Technology Research Institute (ITRI)/ National Chiao Tung University (NCTU), Taiwan 195,Sec. 4, Chung Hsing Rd. Chutung, Hsinchu, Taiwan 310, R.O.C.	Voice: +886-3-5916020 Fax: +886-3-5820371 tmlin@itri.org.tw
	Yuan-Ying Hsu Telcordia Applied Research Center Taiwan Co., Taipei, Taiwan	Voice: +886-2-37895177#4558 Fax: +886-2-26552078 yyhsu@tarc-tw.research.telcordia.com

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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

Haihong Zheng, Yousuf Saifullah and Shashikant Maheshwari
Nokia

David Comstock, John Lee, Shang Zheng and Aimin Zhang
Huawei Technologies Co. Ltd

Masato Okuda
Fujitsu Laboratories LTD.

G.Q. Wang, Wen Tong, Peiying Zhu, Hang Zhang, Gamini Senarath,
David Steer, Derek Yu, Mo-Han Fong
Nortel

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.

Shashikant Maheshwari 3/13/07 1:22 AM
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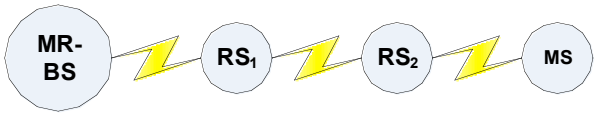

Figure 1: Example Topology in multi-hop relay System

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). The initial ranging process can be used by the MR-BS to derive the topology between the newly attached station and itself. The basic idea is

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that the identity of the selected access RS is added into the initial RNG-REQ, which is used by the MR-BS to determine the access RS to which the new station is attached. Depending on the forwarding mode (i.e., tunneling mode or non-tunneling mode), the access RS identity is carried in different manner. In the non-tunneling mode, the access RS is identified by its basic CID in the Generic MAC Header (GMH), while in the tunneling mode, it is identified by the tunnel CID in the GMH. The criteria for the selected access RS to decide the operational mode (i.e., tunnel or non-tunnel) is out of the scope of this contribution. The detailed procedure is described in the proposed spec change.

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

2.3.1 Topology discovery under non-tunnelling mode

Using the topology illustrated in Figure 1, the Figure shows an example of initial topology discovery procedure in a multi-hop relay system using non-tunnelling mode.

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- 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 replaces the initial rang CID with its basic CID in the MAC header 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. The MR-BS then generates a RNG-RSP with initial ranging CID for RS2. MR-BS creates RNG-RSP with the basic CID of RS1 in the MAC header and inserts the HMAC/CMAC tuple, and then sends it to RS1. Upon receiving the RNG-RSP, RS1 verifies the message. 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 follows the same procedure (as described above for RS1) to replacing the initial ranging CID with its own basic CID. The other initial network entry procedures remain the same.

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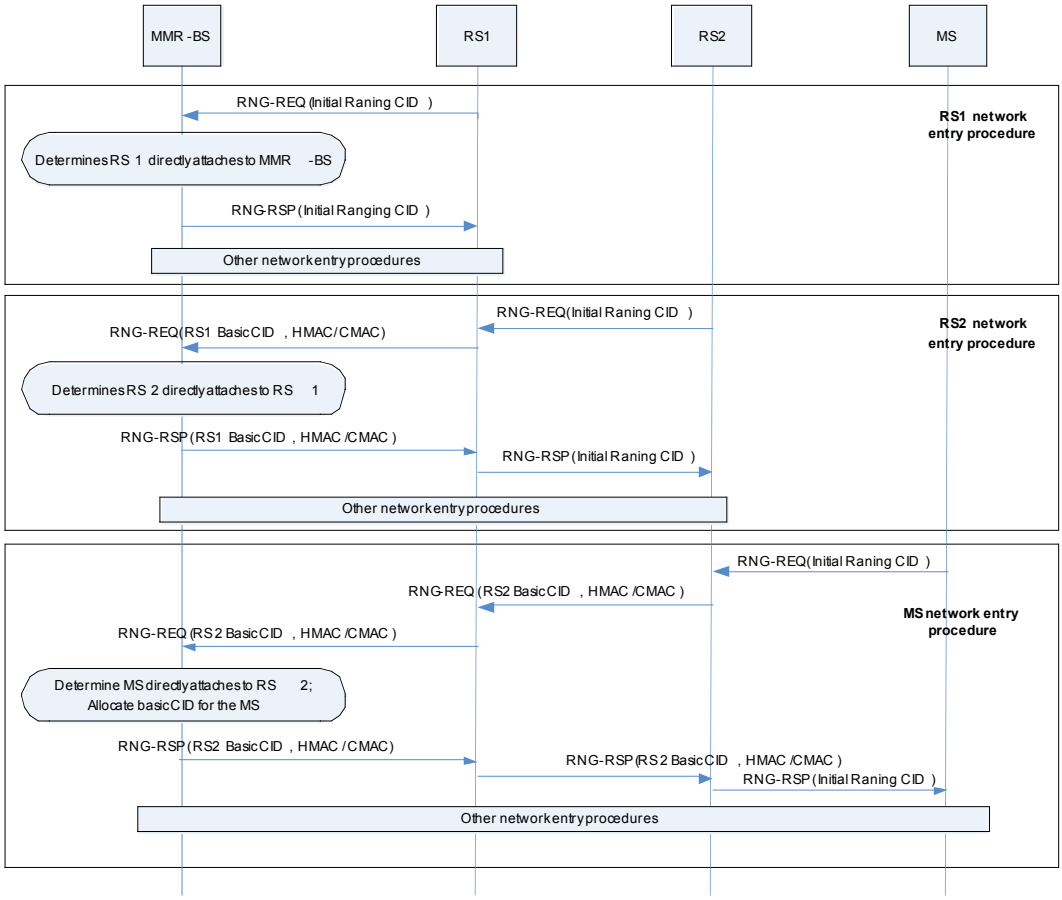

Figure 2: Topology Discovery and Path Management Procedures under non-tunnel mode

2.3.2 Topology discovery under tunnel mode

Figure 3 shows an example of initial topology discovery procedure in a multi-hop relay system using tunnel mode.

1. New node sends RNG-req with initial ranging CID, to the selected RS
2. The selected RS receives RNG-req and encapsulates it with other RNG-req messages (from other new node, if any) into tunneled data burst, and sends it upstream

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3. Upon received tunneled data, BS handles RNG-req following the standard entry procedure, and then tunnels all RNG-rsp into data burst and sends it back to the designated RS. From the received CID and new node information, BS can create a new path in its routing database
4. Using the same procedure described above, BS and the designated RS would tunnel all the messages back and forth for the rest operations associated with ranging, capacity negotiation, security and registration from the new node.
5. After the new node gets into normal operation mode, if it is a RS node, BS should create a new path and populate path/CID binding data to all the RS along this new path. This makes the new path and new CIDs available for the future topology discovery.

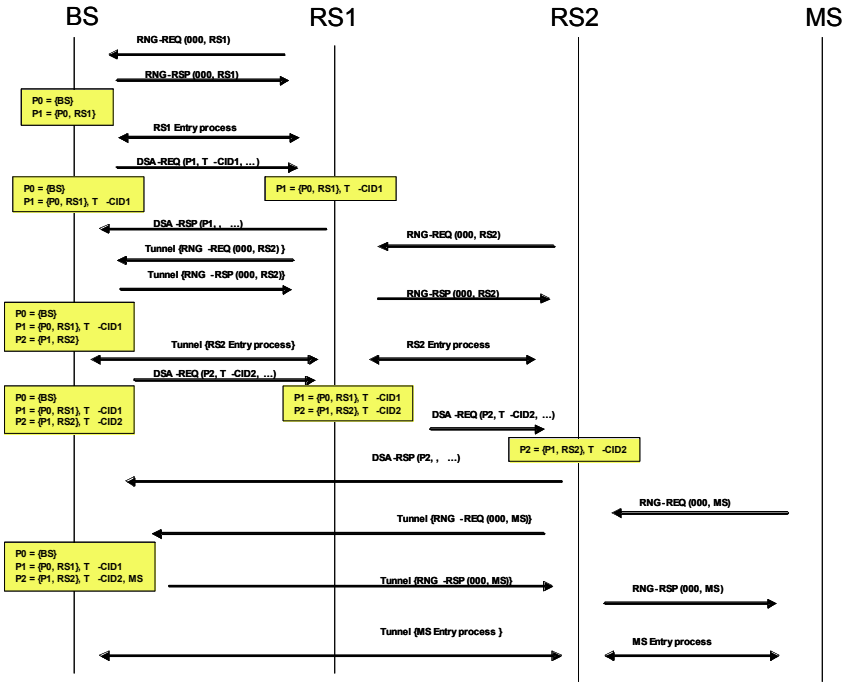

Figure 3: Discovery and Path Management Procedures under tunnel mode

3. CHANGES TO THE SPECIFICATION

Add new subclause 6.3.25.1

6.3.25.1 Relaying support for Combined Ranging and Initial Topology Discovery

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

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- When a MS or RS (termed as RSi in this section) conducts its initial ranging, it sends an initial RNG-REQ.
- When a selected RS (termed as RSj in this section) receives an initial RNG-REQ, depending on the operational mode (i.e., tunnel or non-tunnel) to be used, the follow procedures apply.
    - If the forwarding mode is non-tunnel, RSj puts its basic CID into MAC header, 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.
    - If the forwarding mode is tunnel, RSj puts a tunnel CID into MAC header, 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 an RS, it verifies its validity and replaces the basic CID with the initial ranging CID. When a MR-BS receives initial RNG-REQs from a tunnel, it de-caps the tunnel message and handles the initial RNG-REQ one-by-one. MR-BS then determines that the MS or RSi attached to the system via RSj. Since MR-BS is already aware of the topology between RSj and itself, by using the same mechanism as defined in this section, it establishes the topology between the MS or RSi and itself.
- After processing the initial RNG-REQ from MS or RSi, the MR-BS generates a RNG-RSP message. Depending on the forwarding scheme to be used, the follow procedures apply.
    - If the forwarding mode is non-tunnel, MR-BS uses the basic CID of RSj in the MAC header, protects the message with HMAC/CMAC tuple using the security association shared between RSj and itself, and sends RNG-RSP to RSj.
    - If the forwarding mode is tunnel, MR-BS uses tunnel CID of RSj in the tunnel header, then sends the response 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 basic CID, it replaces it with the initial ranging CID. When a RS receives initial RNG-REQs from a tunnel, it de-caps the tunnel and get all the individual RNG-RSP messages. It then further sends the individual RNG-RSP to the MS/RS accordingly.

4. REFERENCES

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[3] C802.16j-07_214, Incremental Approach for MMR Topology Discover, G.Q Wang et. Al.., Nortel