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Re:	This is a response to Call for Technical Proposals issued by IEEE 802.16j.	
Abstract	We suggest the procedure of tunnel establishment.	
Purpose	The objective of this contribution is to propose the procedure of tunnel establishment in MMR system.	
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## Tunnel Establishment

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### Introduction

In MMR system as depicted in figure 1, there exists multiple and multi-hop path between an MMR-BS and an MS [1].

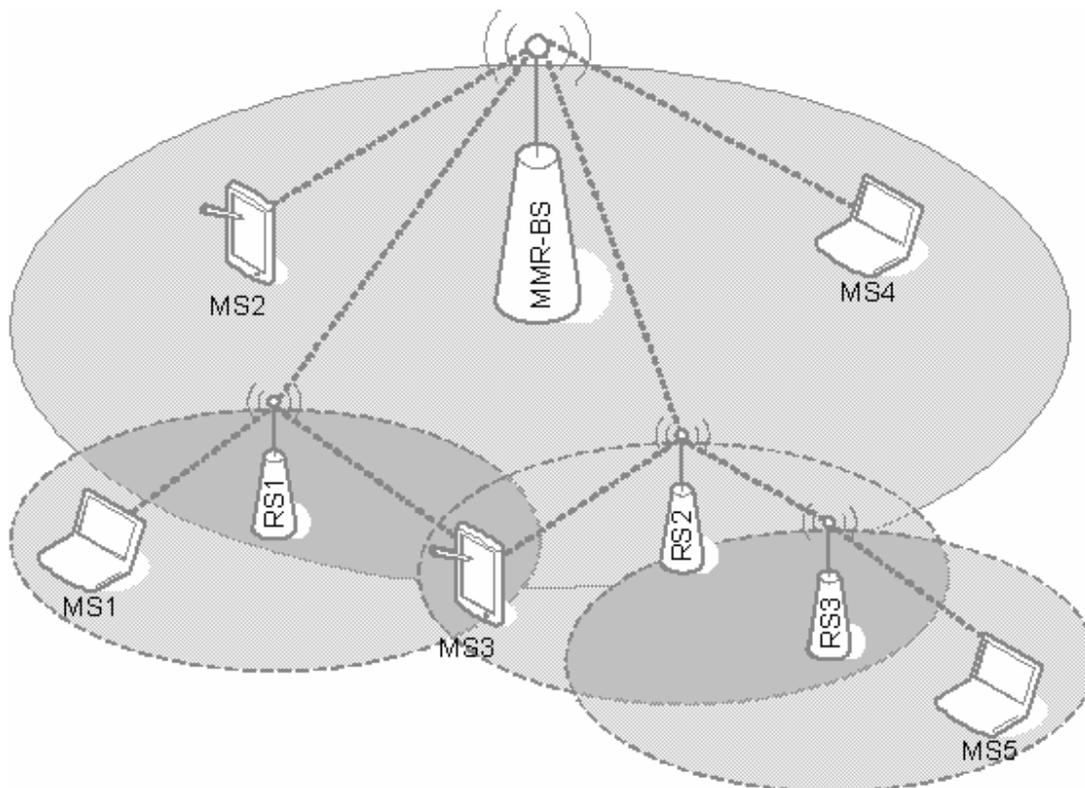


Figure 1 MMR System

So it is important to decide the suitable path from the MMR-BS to the MS. For this purpose, the MMR-BS and RSs have to maintain and manage the path information.

There exist several path management methods, but tunneling is more efficient method than others.

In general path management, when the MS moves from one RS to another, the MMR-BS, intermediate RS(s) and access RS have to update the path information related to the MS.

In the tunneling, intermediate and access RSs would not change any path information, but the only MMR-BS selects other tunnel toward access RS connected with moved MS.

For tunneling, we propose the way to establish tunnels by using encapsulation.

### The procedures

Herein we define the tunnel as the direct path between the MMR-BS and the access RS, and the basic CID of the access RS is used to identify the specific tunnel.

In our method, the encapsulated RNG, DSx and DREG messages is used to establish a tunnel, and all traffic between the MMR-BS and the MS is encapsulated with the basic CID of the access RS.

This method is suitable only to a fixed RS. But, after declaring the procedure of RS movement detection, our method would be extended to support moving RS.

We are not interested in how intermediate RS(s) relay a ranging code and its response (first RNG-RSP). But, we are just interested in how intermediate RS(s) relay an RNG-REQ and its response (second RNG-RSP) and establishes a tunnel and a look-up table.

The first case is 1-hop RS initial ranging.

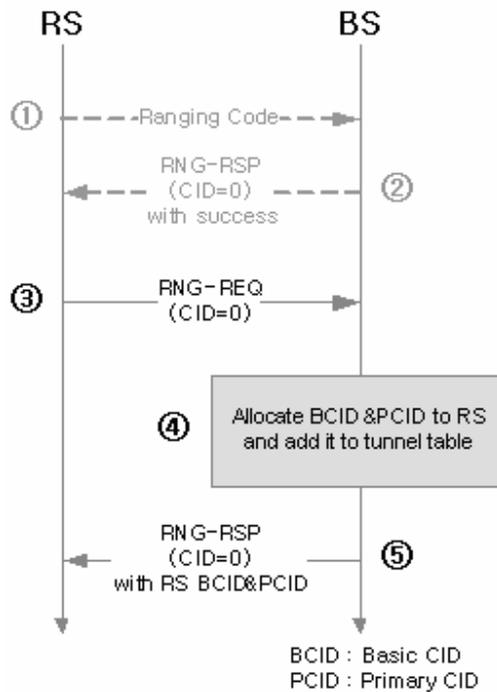


Figure 2 The procedure of 1-hop RS initial ranging

The RS transmits an initial ranging code.

The BS sends an RNG-RSP (CID=0) with status=success.

The RS sends an RNG-REQ (CID=0).

The BS allocates a basic and a primary CID to an RS and adds it to tunnel table.

The BS sends an RNG-RSP with an RS basic and primary CID.

Table 1 MMR-BS tunnel table (The case of 1-hop RS)

Destination (CID)	Tunnel (CID)
RS BCID	-

RS PCID	-
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After the initial ranging of 1-hop RS is finished, Table 1 is made by the MMR-BS

The second case is multi-hop RS initial ranging.

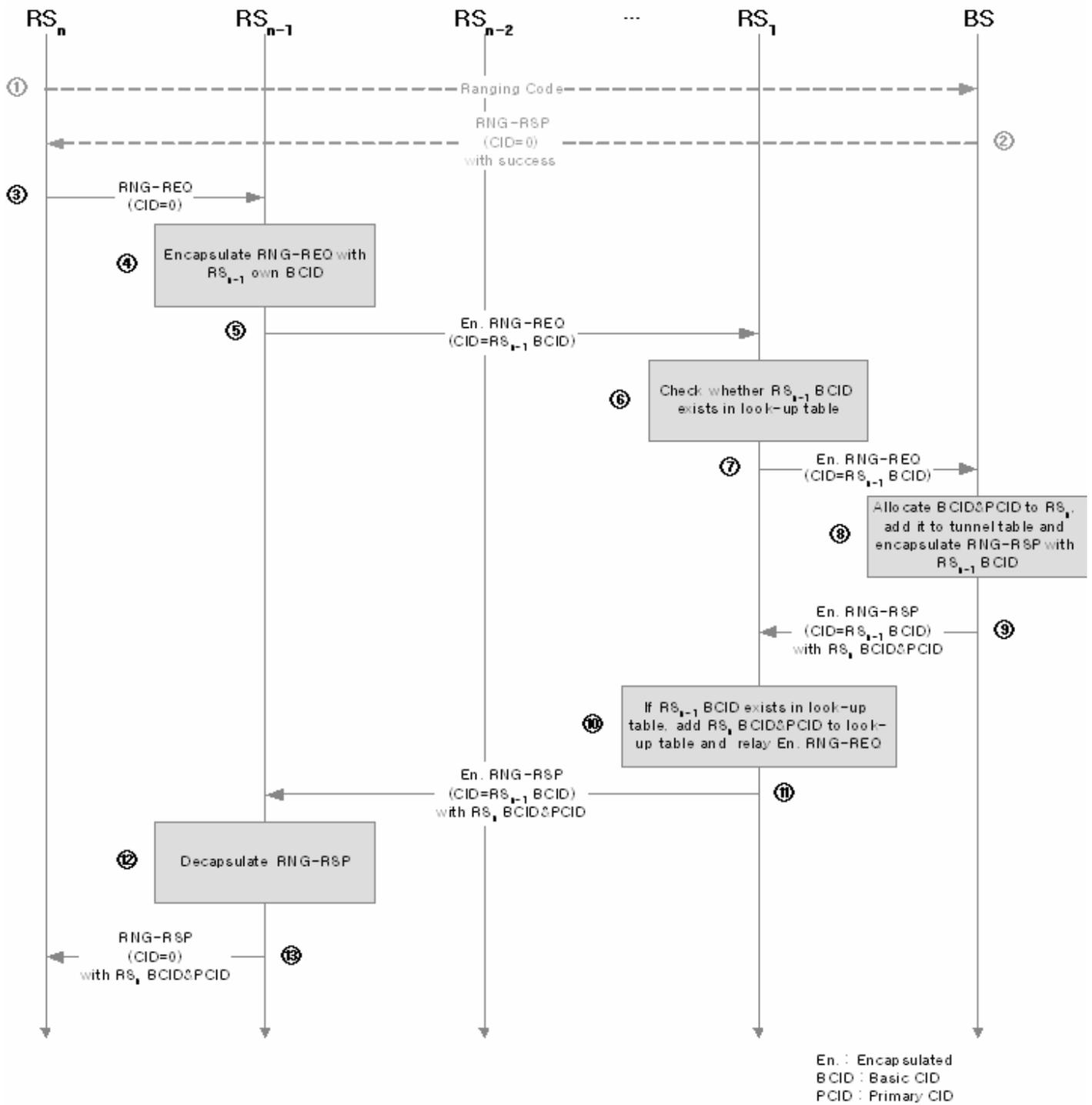


Figure 3 The procedure of multi-hop MS/RS initial ranging

- The  $RS_n$  transmits an initial ranging code.
- The BS sends an RNG-RSP (CID=0) with status=success.
- The  $RS_n$  sends an RNG-REQ (CID=0).
- The  $RS_{n-1}$  encapsulates an RNG-REQ with its own basic CID.
- The  $RS_{n-1}$  sends an encapsulated RNG-REQ (CID=  $RS_{n-1}$  BCID).

Intermediate RSs check whether an  $RS_{n-1}$  BCID exists in a look-up table.

Intermediate RSs relay an encapsulated RNG-REQ (CID=  $RS_{n-1}$  BCID).

The BS allocates a basic and a primary CID to MS/ $RS_n$ , adds it to tunnel table and encapsulates an RNG-RSP with an  $RS_{n-1}$  BCID.

The BS sends an encapsulated RNG-RSP (CID= $RS_{n-1}$  BCID) with an  $RS_n$  basic and primary CID.

If  $RS_{n-1}$  BCID exists in a look-up table, intermediate RSs add an  $RS_n$  basic and primary CID to look-up table.

Intermediate RSs send an encapsulated RNG-RSP (CID= $RS_{n-1}$  BCID) to next node.

The  $RS_{n-1}$  decapsulates an encapsulated RNG-RSP (CID= $RS_{n-1}$  BCID).

The  $RS_{n-1}$  sends an RNG-RSP (CID=0) to the  $RS_n$ .

Table 2 MMR-BS tunnel table (The case of multi-hop RS)

Destination (CID)	Tunnel (CID)
$RS_1$ BCID	-
$RS_1$ PCID	-
$RS_2$ BCID	$RS_1$ BCID
$RS_2$ PCID	$RS_1$ BCID
...	...
$RS_n$ BCID	$RS_{n-1}$ BCID
$RS_n$ PCID	$RS_{n-1}$ BCID

Table 3  $RS_1$  tunnel table (The case of multi-hop RS)

Destination (CID)	Tunnel (CID)
$RS_2$ BCID	-
$RS_2$ PCID	-
...	...
$RS_n$ BCID	$RS_{n-1}$ BCID
$RS_n$ PCID	$RS_{n-1}$ BCID

Table 4  $RS_{n-1}$  tunnel table (The case of multi-hop RS)

Destination (CID)	Tunnel (CID)
$RS_n$ BCID	-
$RS_n$ PCID	-

After the initial ranging of multi-hop RS, Table 2 is updated by the MMR-BS, the look-up table like Table 3 or Table 4 is updated by intermediate RSs.

The third case is the service flow addition.

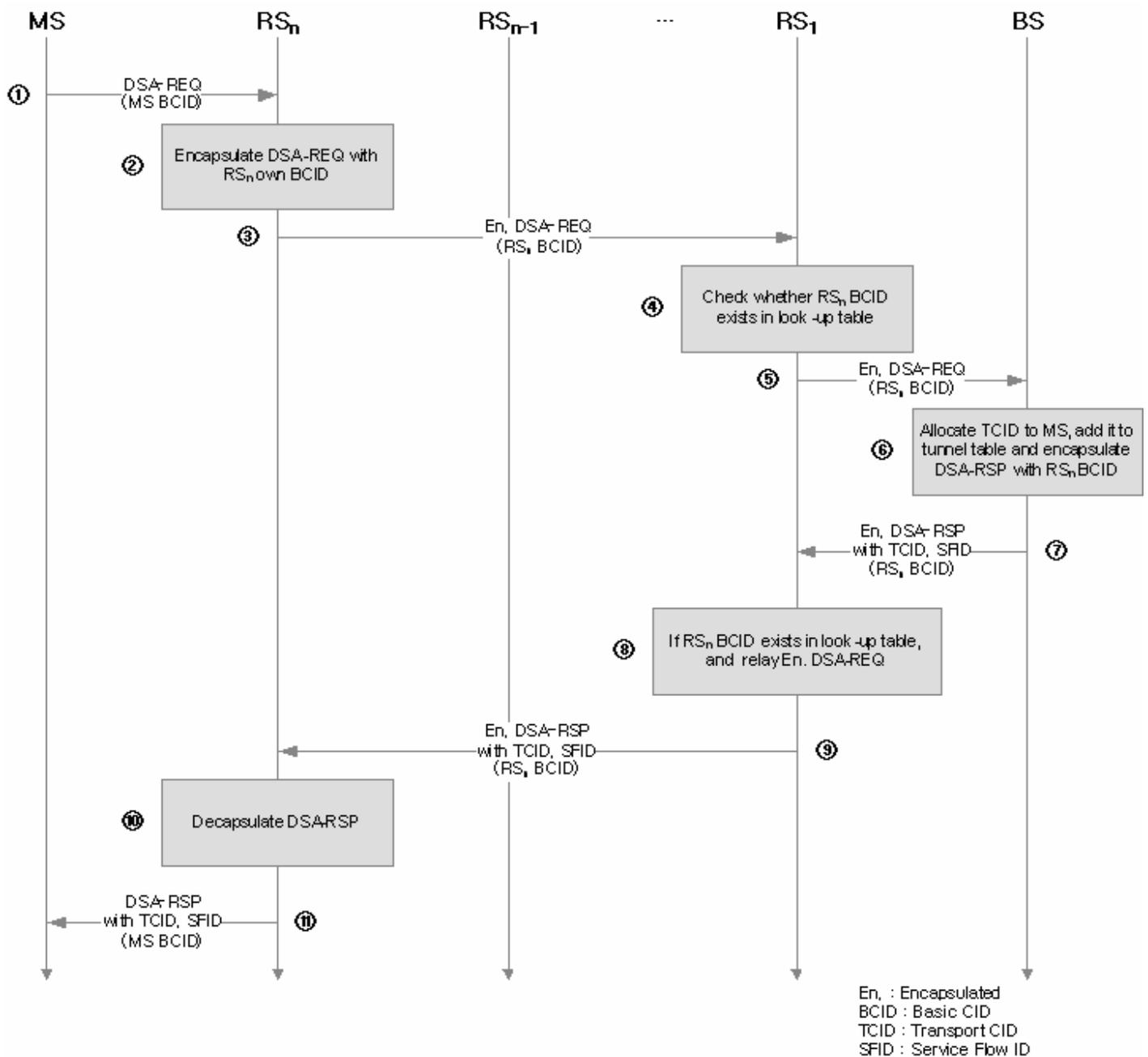


Figure 4 The procedure of multi-hop MS service flow addition

The MS sends a DSA-REQ (CID=MS BCID).

The RS<sub>n</sub> encapsulates a DSA-REQ with its own basic CID.

The RS<sub>n</sub> sends an encapsulated DSA-REQ (CID= RS<sub>n</sub> BCID).

Intermediate RSs check whether an RS<sub>n</sub> BCID exists in a look-up table.

Intermediate RSs relay an encapsulated DSA-REQ (CID= RS<sub>n</sub> BCID).

The BS allocates a transport CID to MS, adds it to tunnel table and encapsulates a DSA-RSP with an RS<sub>n</sub> BCID.

The BS sends an encapsulated DSA-RSP (CID=RS<sub>n</sub> BCID) with an MS transport CID.

Intermediate RSs check whether RS<sub>n</sub> BCID exists in a look-up table.

Intermediate RSs send an encapsulated DSA-RSP (CID=RS<sub>n</sub> BCID) to next node.

The RS<sub>n</sub> decapsulates an encapsulated DSA-RSP (CID=MS BCID).

The RS<sub>n</sub> sends a DSA-RSP (CID=MS BCID) to the MS.

Table 5 MMR-BS tunnel table (The case of multi-hop MS)

Destination (CID)	Tunnel (CID)
RS <sub>1</sub> BCID	-
RS <sub>1</sub> PCID	-
RS <sub>2</sub> BCID	RS <sub>1</sub> BCID
RS <sub>2</sub> PCID	RS <sub>1</sub> BCID
...	...
MS BCID	RS <sub>n</sub> BCID
MS PCID	RS <sub>n</sub> BCID
MS TCID	RS <sub>n</sub> BCID

After the service flow addition of MS is finished, Table 5 is updated by the MMR-BS.

The fourth case is the service flow deletion.

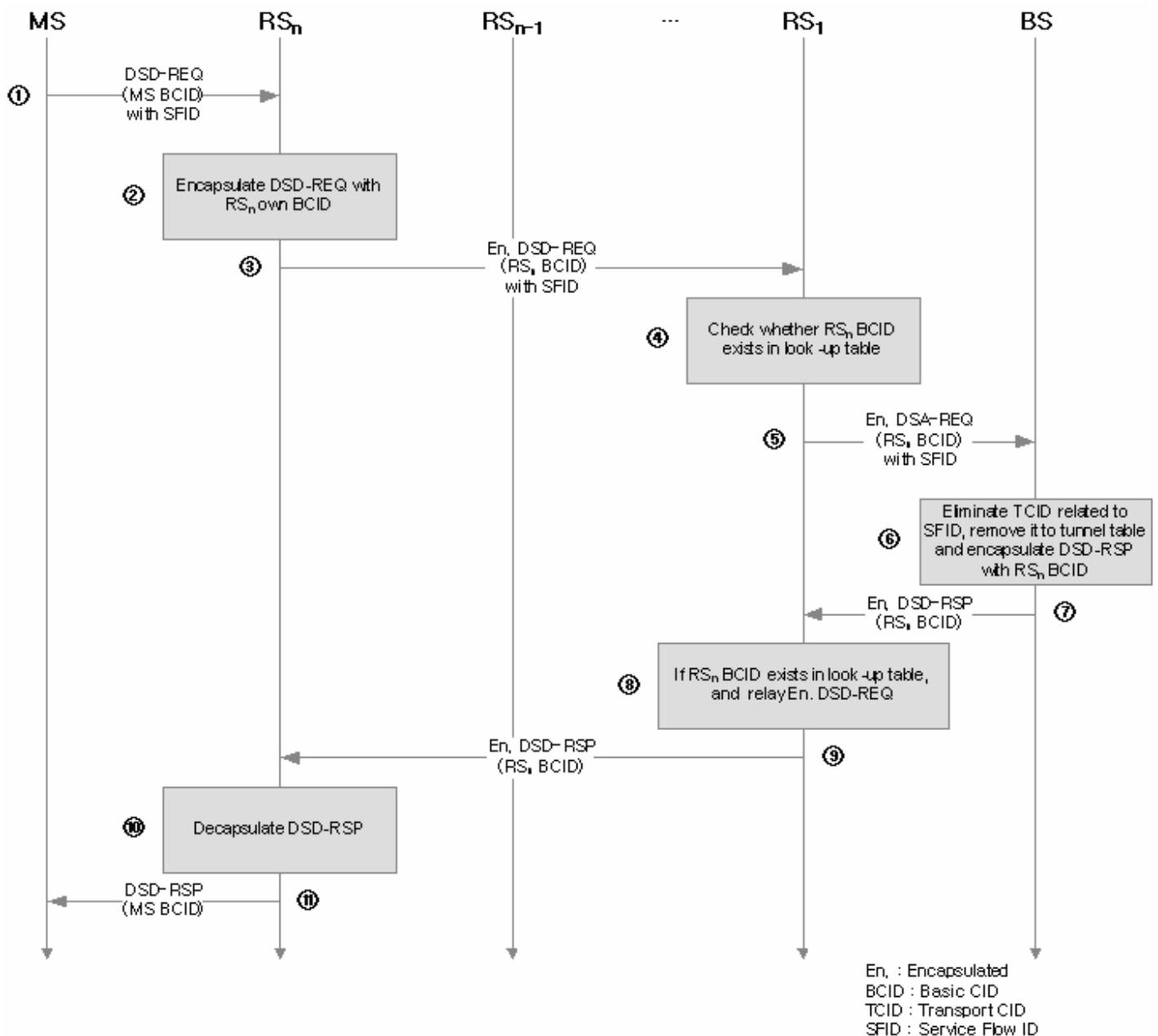


Figure 5 The procedure of multi-hop MS service flow deletion

- The MS sends a DSD-REQ (CID=MS BCID) with an SFID.
- The RS<sub>n</sub> encapsulates a DSD-REQ with its own basic CID.
- The RS<sub>n</sub> sends an encapsulated DSD-REQ (CID= RS<sub>n</sub> BCID).
- Intermediate RSs check whether an RS<sub>n</sub> BCID exists in a look-up table.
- Intermediate RSs relay an encapsulated DSD-REQ (CID= RS<sub>n</sub> BCID).
- The BS eliminates a transport CID related to SFID, removes it from tunnel table and encapsulates a DSD-RSP with an RS<sub>n</sub> BCID.
- The BS sends an encapsulated DSD-RSP (CID=RS<sub>n</sub> BCID).
- Intermediate RSs check whether RS<sub>n</sub> BCID exists in a look-up table.
- Intermediate RSs send an encapsulated DSD-RSP (CID=RS<sub>n</sub> BCID) to next node.

The  $RS_n$  decapsulates an encapsulated DSD-RSP (CID=MS BCID).  
 The  $RS_n$  sends a DSD-RSP (CID=MS BCID) to the MS.

Table 6 MMR-BS tunnel table (The case of multi-hop MS)

Destination (CID)	Tunnel (CID)
$RS_1$ BCID	-
$RS_1$ PCID	-
$RS_2$ BCID	$RS_1$ BCID
$RS_2$ PCID	$RS_1$ BCID
...	...
MS BCID	$RS_n$ BCID
MS PCID	$RS_n$ BCID
MS TCID	$RS_n$ BCID

After the service flow deletion of MS is finished, Table 6 is updated by the MMR-BS.

The fifth case is the RS deregistration.

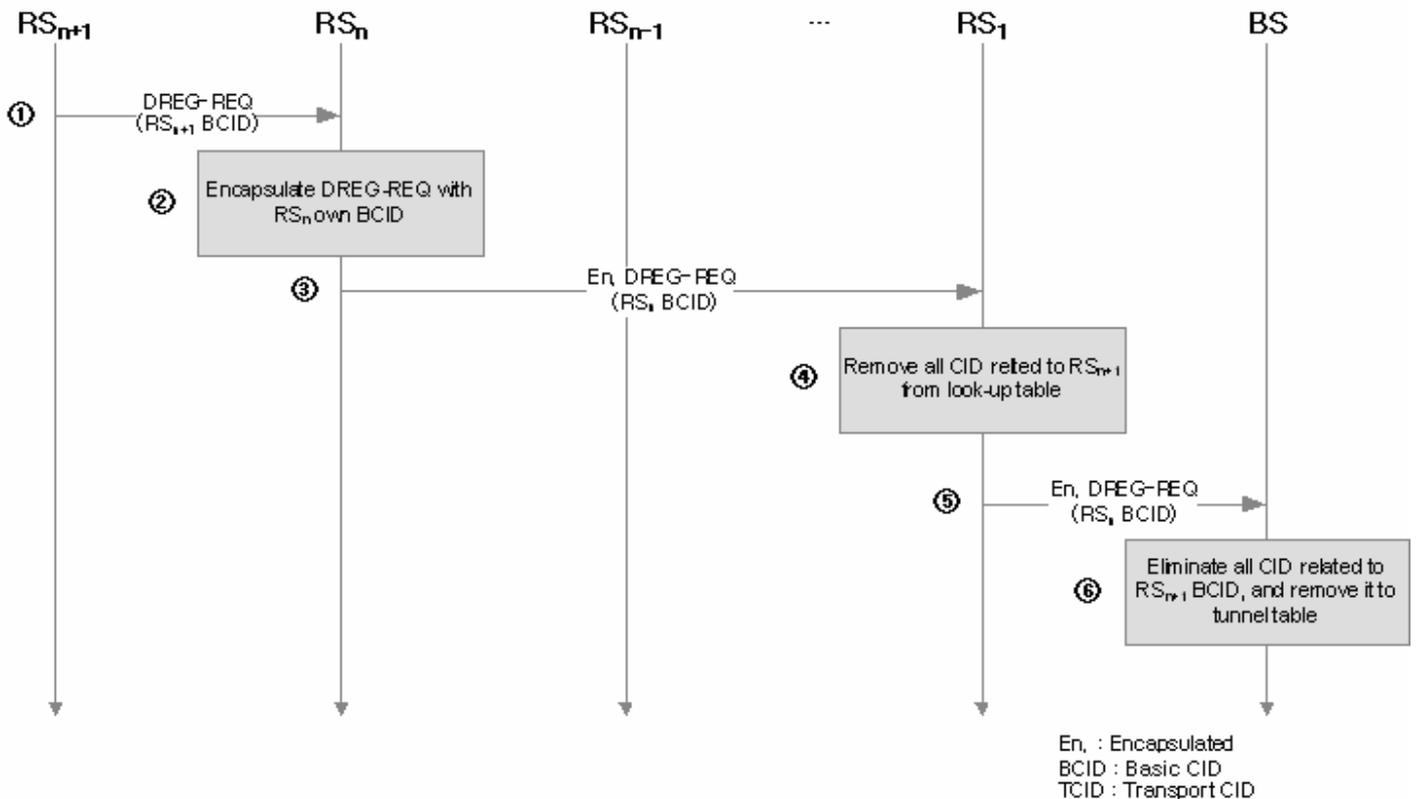


Figure 6 The procedure of multi-hop RS deregistration

The  $RS_{n+1}$  sends a DREG-REQ (CID=  $RS_{n+1}$  BCID).  
 The  $RS_n$  encapsulates a DREG-REQ with its own basic CID.  
 The  $RS_n$  sends an encapsulated DREG-REQ (CID=  $RS_n$  BCID).

Intermediate RSs remove all CID related to  $RS_{n+1}$  from the look-up table  
 Intermediate RSs relay an encapsulated DREG-REQ (CID=  $RS_n$  BCID).  
 The BS eliminates all CID related to  $RS_{n+1}$ , and removes it from tunnel table.

Table 7 MMR-BS tunnel table (The case of multi-hop MS)

Destination (CID)	Tunnel (CID)
$RS_1$ BCID	-
$RS_1$ PCID	-
$RS_2$ BCID	$RS_1$ BCID
$RS_2$ PCID	$RS_1$ BCID
...	...
$RS_{n+1}$ BCID	$RS_n$ BCID
$RS_{n+1}$ PCID	$RS_n$ BCID
MS BCID	$RS_{n+1}$ BCID
MS PCID	$RS_{n+1}$ BCID

Table 8  $RS_1$  tunnel table (The case of multi-hop MS)

Destination (CID)	Tunnel (CID)
$RS_2$ BCID	-
$RS_2$ PCID	-
...	...
$RS_{n+1}$ BCID	$RS_n$ BCID
$RS_{n+1}$ PCID	$RS_n$ BCID

Table 9  $RS_n$  tunnel table (The case of multi-hop MS)

Destination (CID)	Tunnel (CID)
$RS_{n+1}$ BCID	-
$RS_{n+1}$ PCID	-

After the deregistration of RS, Table 7 is updated by the MMR-BS, and the look-up table like Table 8 or Table 9 is updated by intermediate RSs.

After tunnels are established, all the traffic to the multi-hop MS is relayed through tunnel. In this case, the traffic is encapsulated with the extended subheader

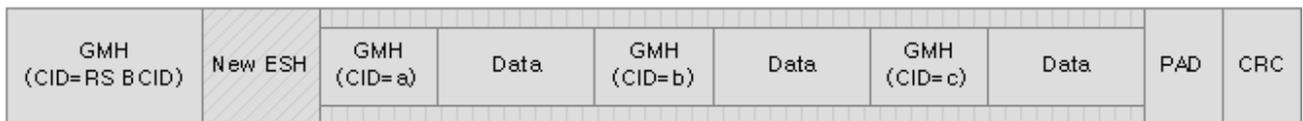


Figure 7 the example of encapsulation [2]

## Proposed Text

### 3 Definitions

*Insert new terminology as followed:*

3.x tunnel : A logically direct path from the MMR-BS to the access RS

#### 6.3.2.2.7 Extended subheader format

*Change Table 13b as indicated:*

Table 13b—Description of extended subheaders types (DL)

ES type	Name	ES body size	Description
6-127	<del>Reserved</del> Encapsulation Extended Subheader	—1 byte	—See 6.3.2.2.7.9
7-127	Reserved	—	—

#### 6.3.2.2.7 Extended subheader format

*Insert new subclause 6.3.2.2.7.9 at the end of 6.3.2.2.7:*

##### 6.3.2.2.7.9 Encapsulation Extended Subheader

Encapsulation extended subheader is used to establish a tunnel and is added to all traffic through tunnel. This extended subheader is solely used, so other extended subheader and subheader shall be not followed. The format of the encapsulation extended subheader is as described in Table 13m.

Table 13m—Encapsulation Extended Subheader

<u>Name</u>	<u>Size</u>	<u>Description</u>
<u>Message Type</u>	<u>1 byte</u>	<u>Specify the type of message</u> <u>0-3 : Reserved</u> <u>4 : RNG-REQ</u> <u>5 : RNG-RSP</u> <u>6-10 : Reserved</u> <u>11 : DSA-REQ</u> <u>12 : DSA-RSP</u> <u>13 : DSA-ACK</u> <u>14 : DSC-REQ</u> <u>15 : DSC-RSP</u> <u>16 : DSC-ACK</u> <u>17 : DSD-REQ</u> <u>18 : DSD-RSP</u> <u>19-28 : Reserved</u> <u>29 : DREG-CMD</u> <u>30-48 : Reserved</u> <u>49 : DREG-REQ</u> <u>50-254 : Reserved</u> <u>255 : Traffic</u>

### 6.3.25 Relay path management and routing

*Insert the following at the end of 6.3.25:*

#### 6.3.25.1 Tunnel Establishment

Tunnel is defined as a logically direct path between the MMR-BS and the access RS. All traffic to the multi-hop MS passes via tunnel. In the tunnel, all MPDU is encapsulated with the encapsulation extended subheader.

Tunnel is established in the procedure of RS initial ranging and MS service flow addition, and is eliminated in the procedure of RS deregistration and MS service flow deletion.

In the procedure of RS initial ranging, the MMR-BS and RSs act as followed:

- New RS transmits an initial ranging code.
- The access RS and intermediate RS(s) relay the code to the MMR-BS.
- The MMR-BS sends an RNG-RSP with status=success
- Intermediate RS(s) and access RS relay the RNG-RSP to the RS.
- The RS sends an RNG-REQ.
- The access RS encapsulates an RNG-REQ with its own basic CID and sends it to the next node.
- Intermediate RS(s) relays the encapsulated RNG-REQ to the MMR-BS.
- The MMR-BS allocates a new basic and primary CID to the RS, adds new entry related to the RS to the tunnel table, and sends an encapsulated RNG-RSP with the basic CID of the access RS to the RS.
- Intermediate RS(s) updates its own look-up table and relays the encapsulated RNG-RSP to the access RS.
- Access RS updates its own look-up table, decapsulates the encapsulated RNG-RSP, and sends it to the RS.

In the procedure of RS deregistration, the MMR-BS and RSs act as followed:

- The RS sends a DREG-REQ with its own basic CID.
- The access RS eliminates the entry related to the RS from its own look-up table, encapsulates a DREG-REQ with its own basic CID and sends it to the MMR-BS.
- Intermediate RS(s) eliminate the entry related to the RS from its own look-up table, and relay the encapsulated DREG-REQ to the MMR-BS.
- The BS eliminates entries related to the RS from the tunnel table.

In the procedure of MS service flow addition, the node act as followed:

- The MS sends a DSA-REQ with its own basic CID.
- The access RS encapsulates a DSA-REQ with its own basic CID and sends it to the next node.
- Intermediate RS(s) relay the encapsulated DSA-REQ to the MMR-BS.

- The BS allocates a new transport CID to the MS, adds new entry related to the MS to the tunnel table and sends an encapsulated DSA-RSP with the basic CID of the access RS to the MS.
- Intermediate RS(s) relay the encapsulated DSA-RSP to the access RS.
- The access RS decapsulates an encapsulated DSA-RSP and sends it to the MS.

In the procedure of MS service flow deletion, nodes act as followed:

- The MS sends a DSD-REQ with its own basic CID and an SFID.
- The access RS encapsulates a DSD-REQ with its own basic CID and sends it to the next node.
- Intermediate RS(s) relays an encapsulated DSD-REQ to the MMR-BS.
- The BS eliminates a transport CID related to SFID, removes entries related to the transport CID from tunnel table and sends an encapsulated DSD RSP with the basic CID of the access RS to the MS.
- Intermediate RS(s) relay the encapsulated DSD-RSP to the access RS.
- The access RS decapsulates an encapsulated DSD-RSP and sends it to the MS.

#### 10.4 Well-known addresses and identifiers

*Change Table 345 as indicated:*

Table 345—CIDs

CID	Value	Description
Initial Ranging <u>for MS</u>	0x0000	Used by MS and BS during initial ranging process.
<u>Initial Ranging for RS</u>	<u>0x0001</u>	<u>Used by RS and BS during initial ranging process.</u>
Basic CID	0x000 <u>1</u> 2 - m	The same value is assigned to both the DL and UL connection.

#### References

- [1] C. K. Kim, et. Al, "Simple Path Management by Encapsulation in MMR System", IEEE C802.16j-07/168, IEEE 802.16 meeting #47, London, January 2007
- [2] J. Z. Tao, et. Al, "Relay Tunnel Connection for 802.16j", IEEE X802.16j-07/115r3, IEEE 802.16 meeting #47, London, January 2007