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Re:	IEEE 802.16j-06_034: “Call for Technical Proposals regarding IEEE Project P802.16j”	
Abstract	Define path management framework	
Purpose	For text changes in emerging amendment of IEEE 802.16e-2005 to support MMR functionality.	
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Multi-hop Path Management Framework in MMR Networks

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1 Introduction

This document is to describe path management framework as an input for call for contribution of 802.16j task group. The terminologies defined in IEEE 802.16j-06/014r1 are used to support path management in MMR relay topology.

In this document, we propose a flexible framework together with corresponding messages and procedures to support the path management (path setup/change/delete). The framework facilitates QoS provision, multi-path routing and data/control plane separation in MMR networks and be fully compatible with 802.16 on the access link.

The contribution covers the following text descriptions:

- Connection path management related to MS to RS connection, RS to RS connection and RS to MR-BS connection
- CID and Relay path binding
- Relay operations involving the modification of CIDs via CID mapping

2 Path Management

Refer to figure 1, along a relay path <RS(1), RS(2), …, RS(n), MR-BS>, a RS may transparently relay or tunnel the message between MS and MR-BS. When using tunneling, connection switching path (CSP) for a particular MAC PDU that is sent via CID C(0) on the logical access link is defined as the sequence of CIDs <C(1), C(2), …, C(n)>:

1. For all i, 1<=i<=n, C(i) is the CID allocated to identify a transport connection between MR-BS and RS(i).

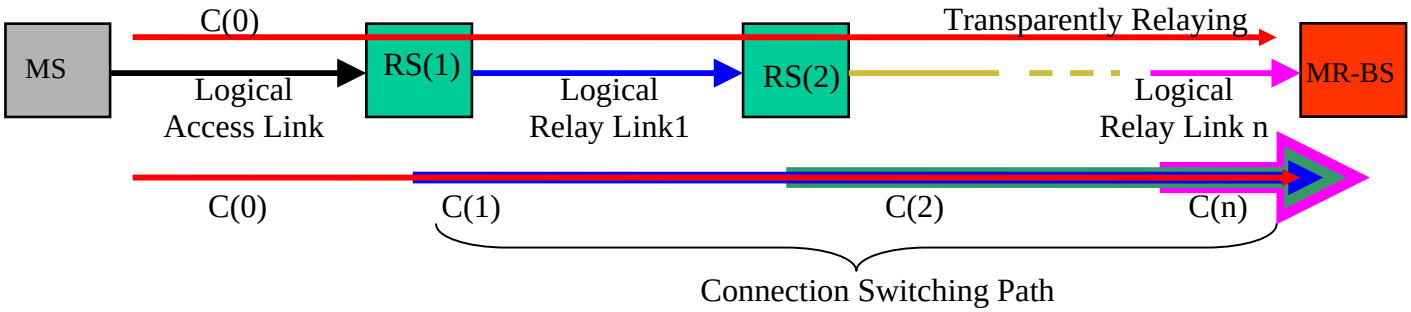

Fig.1 Connection Switching Path, Logical Relay Link and Connection

The main purpose of introducing CSP in MMR is to enhance QoS provision and facilitate advanced features such as load balancing and multi-path routing in such network.

CSP may be managed via DSx message (or optionally, additional new messages) exchange between MMR-BS and access RS. RS may choose transparently relaying for the message exchange in CSP management. After a CSP is setup for a service flow, RS can then tunnel the service flow in the CSP.

2.1 Path Management via DSx messages

In MMR, after initial ranging and network entry procedures, Both MS and RS shall get a primary CID. MS can then request via DSA-REQ message for a service connection for the service communication between it and MR-BS. A connection switching path (CSP) may be setup during the service flow creation procedure. Similarly, CSP change and deletion may be initiated by the service flow change and deletion procedure, respectively.

The overall operation related to a new CSP setup can be described as following:

1. MS requests a service connection for a service flow via DSA-REQ message
2. Access RS relays the message to MR-BS.
   a) Due to the requirement of security sub-layer in 802.16e, the change on a message such as modification on the MAC PDU header/sub-header may not always be possible. In such cases, RS may relay the message transparently.
      - When relaying transparently, RS shall keep the DSA-REQ message in its original form when relaying to MR-BS. The message is carried on the MS's primary CID. This CID is in the CID space allocated for the access RS.
3. Intermediate RS relays the message to MR-BS.
   a) Due to the requirement of security sub-layer in 802.16e, the change on a message such as modification on the MAC PDU header/sub-header may not always be possible. In such cases, RS may relay the message transparently.
      - When relaying transparently, RS shall keep the received DSA-REQ message in its original form when relaying to MR-BS. The message is carried on the MS's primary CID. This CID is in the CID space allocated for the intermediate RS.
4. MR-BS gets the DSA-REQ message relayed by RS. After that, MR-BS shall allocate a service CID A for the MS to carry the service flow and also determine a connection switching path (CSP) for it.
   a) MR-BS determines a CSP for the service flow. Refer to figure 2, if it can not find a suitable CSP, MR-BS may initiate CSP setup by sending DSA-REQ message to corresponding RSs in the relay path to request for transport connections. MR-BS shall also bind the CSP with the relay path that is stored in the routing table

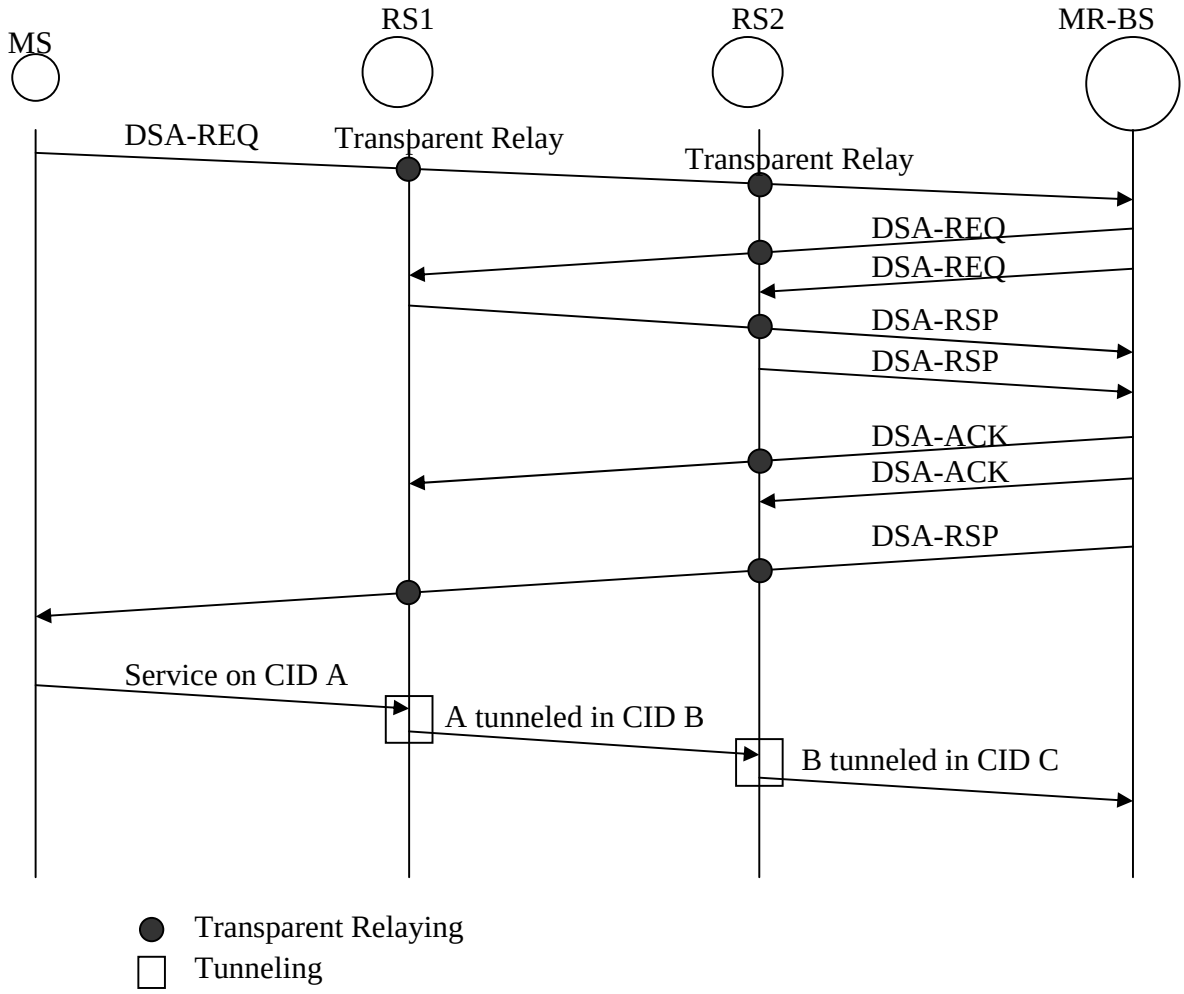

Fig.2. MR-BS initiated CSP setup triggered by MS initiated DSA-REQ

1) MS sends DSA-REQ to MR-BS to request a service connection for a service flow *SF*, access RS (RS1) and intermediate RS (RS2) transparently relay the DSA-REQ message until it reaches MR-BS.

2) MR-BS allocates a service CID A for the *SF*, and chooses a connection switch path (CSP) for it. If such CSP does not exist, MR-BS will create a new CSP for it. The CSP may be identified by a Path-ID and reflect the CID mapping information, for example, on a relay path <RS1, RS2>, a CSP <B, C> for service connection A means the traffic on A shall be mapped onto B in RS1 and the traffic on B shall be mapped onto C.

3) MR-BS shall notify the RSs on the relay path of the CSP and corresponding action for the service CID A. The CSP path information and related action may be carried in the DSA-REQ message initiated by MR-BS. In such case, 802.16 standard DSA-REQ message shall be extended. Optionally, MR-BS may use new defined messages to notify the CSP information and action. When MR-BS uses extended DSx message to notify such information, after the 3-way handshake, the RSs on the relay path shall know how to forward MAC PDU, for example, for a CSP <CID B, CID C>,

a) MR-BS sends extended DSA-REQ to RS1 to request for a transport CID B to tunnel CID A, also, MR-BS sends extended DSA-REQ to RS2 to request for a transport CID C to tunnel CID B

b) After standard DSA-RSP and DSA-ACK exchange, RS1 shall update its CID forwarding table such that service on CID A shall be tunneled in CID B and RS2 shall update its CID forwarding table such that service on CID B shall be tunneled in CID C. The CID forwarding table stores the CID mapping information between ingress and outgress CID. Table 1 depicts an example of the CID forwarding table. When a RS get a MAC PDU on a ingress CID, it will look against the ingress CID in the CID forwarding table and take corresponding action to forward the MAC PDU. The CID forwarding table may support various actions. Encapsulation means tunneling the MAC PDU on a outgress CID, de-capsulation means de-tunneling the MAC PDU and no action means directly relaying it. Multiple different ingress CID can be encapsulated in same outgress CID.

Tab.1. CID forwarding table

Ingress CID	Outgress CID	Action	Next Hop (Optional)
20	50	Encapsulation	XX
30	50	Encapsulation	XX
100	105	Encapsulation	XX
105	---	De-capsulation	XX
500	Same	Transparent relay	XX

5. MR-BS responds to MS with DSA-RSP message which is carried on the MS's primary CID
6. After getting the DSA-RSP, MS can then use the CID A to carry the service flow.
7. Access RS gets the MAC PDU sent by MS on the service connection CID A, processes it according to its CID forwarding table
   a) If using encapsulation action, access RS encapsulates the MAC PDU and carries it on a transport CID
   b) If using no action, access RS directly relay the MAC PDU in its received form.
8. Intermediate RS gets the MAC PDU sent by RS on the connection CID B, processes it according to its CID forwarding table.
   a) If using encapsulation action, intermediate RS encapsulates the MAC PDU and carries it on a transport CID
   b) If using no action, intermediate RS directly relay the MAC PDU in its received form.
9. MR-BS gets the MAC PDU sent by intermediate RS on the connection CID C, parses to get the original MAC PDU sent by MS on the connection CID A.

3 Text to be inserted into standard

----------Beginning of Text Changes----------

6.3.26 Connection Path Management

Relay path is defined as a series of consecutive relay links between MR-BS and the access RS. Traffic between a MS and MR-BS is routed along the relay path. Along the relay path, a MAC PDU on a connection CID A may be transparently relayed by RSs in its original form, or processed by RSs before relaying it. For the latter case, due to the requirement of security sub-layer in 802.16e, the change on a MAC PDU such as modification on the CID in the MAC PDU header/sub-header may not always be possible, in such case, RS may encapsulate the MAC PDU in its own MAC PDU which is carried on RS's CID B before relaying to MS-BS in uplink direction and de-capsulate to get the MAC PDU before relaying it in downlink direction, otherwise, RS could swap the CID in the MAC PDU header/sub-header avoiding the encapsulation/de-capsulation overhead when relaying it. As such, a MAC PDU may undergo a series of connections along the relay path. Connection path for a particular MAC PDU that is sent via CID C(0) on the access link is identified by a Path-ID and defined as the sequence of CIDs <C(1), C(2), …, C(n)>, where for 1<=i<=n, C(i) is the CID allocated to identify a transport connection between MR-BS and RS(i). When RS(i) transparently relays an ingress connection C(i), C(i) and outgress connection C(i+1) are same CID. Here ingress connection is the connection on which the MAC PDU is received, outgress connection is the connection on which the MAC PDU is transmitted. It is possible that some RSs on a connection path transparently relay ingress connection.

In MMR networks, as a RS may be allocated one or more transport connections, there may be several connection paths for a given relay path. These connection paths could be provided differentiated QoS. As connection path provide finer granularity than relay path, it helps better load balancing capability in a MMR network and QoS provision for a service flow. Connection path management in MMR includes connection path setup, connection path change and connection path delete which can be initiated by MR-BS, MS or RS, and triggered by service creation, service change, service deletion or MS/RS handover. MMR network could use DSx messages and 3-way handshake processes to mange connection path. The 802.16 standard DSx management messages shall be extended with relay path TLV and connection path TLV for the purpose. Optionally, MMR network could define new management messages and processes to mange connection path.

RS shall use the connection path information to relay a connection. The connection path information could be retrieved from the CID forwarding table in the RS, or retrieved directly from the header/sub-header of the received MAC PDU.

- In the former case, after a service connection C(0) is created for a service flow and a connection path <C(1), C(2), …, C(n)> is created for C(0), RS(i) (1<=i<=n) on the relay path shall be notified of corresponding CID mapping information. MMR could use extended DSx management messages or new management message for this purpose. The CID mapping information tells RS(i) to take what actions to relay ingress connection(s) to outgress connection(s). RS shall support encapsulation, de-capsulation and transparent relay action. Multiple ingress connections could be mapped onto one outgress connections. One ingress connection could be mapped onto one or multiple outgress connections.
- In the latter case, after a service connection C(0) is created for a service flow and a connection path <C(1), C(2), …, C(n)> is created for C(0), access RS on the relay path shall be notified to add connection path information to the header/sub-header of the MAC PDU it sends to MR-BS. Intermediate RS could directly relay the received MAC PDU using the connection path information in the header/sub-header. MMR could use extended DSx management messages or new management message for this purpose.

MR-BS shall also bind the connection path with the corresponding relay path. When a relay path is deleted or changed, the connection paths on the relay path shall be deleted or changed too.