Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>
Title	DSx message extension for Constraint-Based routing and CID/path binding
Date Submitted	2007-01-08
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Re:	A response to a Call for Technical Proposal, http://wirelessman.org/relay/docs/80216j-06_034.pdf
Abstract	This document provides text descriptions for end-to-end routing and connection management sections defined in ToC of IEEE 802.16j-06/017r2
Purpose	To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r1)
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DSx message extension for Constraint-Based routing and CID/path binding

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1 Introduction

Constraint-Based routing is defined as a process of determining the most suitable routes in a MR-cell subject to constraints of available radio resource over the route. In constraint-based routing, the path is determined by MR-BS or cluster RS, where the global topology information and link status are stored. In connection-based forwarding, the path is specified as explicit route in the signaling messages to populate the CID/path binding information to all RSs along the selected path; while in the source-routing case, the explicit route can be embedded in data burst for navigating the relay hop-by-hop.

DSx (x represents Add, Change and Deletion) messages were defined in 802.16-2005 to support data service provisioning and to allocate/binding transport CID with service flow ID. In this contribution, we suggest add two new TLVs: Explicit-Route TLV and Path-ID TLV in DSx messages to support constraint-based routing path population and CID/path binding operations.

In 802.16-2005, DSx messages were used for peer-to-peer operations between BS and MS. The transport CID (assigned to MS) is provisioned as per-flow based connection. While in MMR network, DSx would involve multiple RS's operations end-to-end along the selected path. The transport CID (assigned to RS) is per-tunnel based connection.

We introduce Explicit-Route TLV to represent the selected route, and Path-ID TLV assigned to each such route.

Routing creation and population

After a new RS was attached to MMR cell, BS would create a new path for the designated RS and assign a Path-ID to the path. BS will initiate DSA-REQ message including Explicit-Route TLV and Path-ID TLV. The call flow for path population is as follows:

- In MAC header, the CID is the primary CID of the destination RS
- Explicit-Route TLV is an array of node ID, starting from BS and ending at the destination RS
- Path-ID is an integer assigned to the path
- Optionally, DSA-REQ may include a set of transport CIDs allocated to the designated RS, and the associated SF-ID and QoS parameters. These CID are used as tunnel CID.
- For the received DSA-REQ, the RS would check whether its RS-ID is in the Explicit-Route or not. If it is in the list, the RS will create a new entry in the routing table, and store the Explicit-Route, Path-ID, the primary CID and allocated transport CID (a.k.a., tunnel CID) in to the routing table, and establish the binding relationship between Path-ID and CID in forwarding table. If RS is not the last node in Explicit-Route, RS would further forward the DSA-REQ downstream. If the RS is the last RS in the Explicit Route, RS would send DSA-RSP upstream with the received Path-ID.
- For the received DSA-REQ, if the RS is not in the Explicit-Route, RS would simply discard the message.

- After BS received DSA-REQ, the routing path is established in all the RSs along the path, and it is ready to relay the data burst to the designated RS (the data could be both service flow data and management data).

CID/path binding and population

Once a path has been created between BS and a designated RS, BS can dynamically add more CID/path bindings and populate them to the RS(s) along the selected path. This happens due to the new tunnel CID to be provisioned, or the new MS and the associated service flows to be provisioned. In this case, only Path-ID is needed in DSA to navigate the population. Based on the different connection mode, CID/path bindings are classified as end-to-end and peer-to-peer.

End-to-End: In this connection mode, CID/path binding is populated to every RS, no matter the CID is R-link based (a.k.a, per-tunnel CID), or the CID is access-link based (a.k.a, per-flow CID). Every RS along the path should process this message and store the CID/path binding data.

The call flow for end-to-end CID/path binding population is as follows:

- In MAC header, the CID is the primary CID of the destination RS
- Path-ID TLV is included in DSx messages
- For the received DSA-REQ, the RS would check the primary CID and inclusion of Path-ID TLV.
- If the primary CID is not in the routing table, discard the DSx message
- Based on Path-ID, the RS would process CID/path binding data and update routing/forwarding table, and further relay the DSx message downstream

Peer-to-Peer: In this connection mode, BS only populates CID/path binding to the access RS. In this scenario, the CID is access-link based (i.e., the per-flow CIDs allocated to MS).

In peer-to-peer case, DSx messages are encapsulated in destination tunnel CID (i.e., the transport CID was allocated to the designated access RS). All the intermediate RS would by-pass DSx messages and forward them to the designated RS.

The call flow for peer-to-peer CID/path binding population is as follows:

- In outer MAC header, the CID is the transport CID of the destination RS
- Based on the received tunnel CID, all the intermediate RS would check the routing table to determine should it continue to relay the messages, or simply drop them.
- For the received MAC PDU, the destination RS would check the primary CID and inclusion of Path-ID TLV from inner MAC header.
- If the primary CID is RS's CID, process CID/path binding data
- Otherwise, the MAC PDU is targeting to the MS attached to this access RS. RS would further relay the messages downstream

Routing path deletion and CID/path unbinding

DSD message with Path-ID can be used to dynamically delete the routing path and to unbinding CIDs from a given path. When a path no longer exists, the path is removed from the routing table. As well when a service flow is de-provisioned, CID/path binding relationship should be removed from all the BSs. DSD message would include Path-ID and related CIDs to support deletion operation.

- If DSD only includes Path-CID TLV, it is to remove the path (and all the related CID/path binding data);
- Otherwise, the DSD is to remove CID/path binding data

The rest operational semantic is similar to DSA

Routing path maintenance

DSC message with Path-ID can be used to dynamically update some attributes of an established routing path. The operational semantic is similar to DSA.

2. Proposed text changes

++++++++++++ start text proposal ++++++++++++++++++++++++++++++++++

[Insert the followings in sections of 6.3.2.3.10 ~ 6.3.2.3.17:]

Explicit-Route (see 11.1.xx)
The Explicit-Route attribute contains an array of node ID (BS-ID and RS-ID) which uniquely identifies a routing path from BS to the designated RS. In the Explicit Route, the starting node is BS, and the ending node is the designated access RS.

Path ID (see 11.1.yy)
The Path-ID attribute is integer which assigned and associated with a given Explicit-Route.

[Insert the followings after the end of section 11.1.xx]
Explicit route is a variable size list TLV with Node_ID as list entities. Explicit route represents a routing path which is determined by the MMR radio resource routing controller. Explicit route is used in path-oriented signaling messages to support CID/path binding operations.

Name	Type	Length	Value
Explicit Route	xxx	Variable	Compound

Syntax	Size	Notes
N_entry	8 bits	The number of entries in the list
For(j=0;j<N-entry;j++) {		
Node_ID	8 bits	Node_ID assigned to each RS
}		

[Insert the followings after the end of section 11.1.yy]
Path-ID is an integer which is uniquely assigned to each explicit route. Path-ID is used to identify a routing path and to support path-oriented operations such as path population, path updates and path deletion.

Name	Type	Length	Value
Path-ID	xxx	1 byte	8-bit Integer

Syntax	Size	Notes
Path-ID	32 bits	Routing path identifier to uniquely represent an explicit route. The first 24-bit is the BS-ID and the rest 8-bit is the local integer assigned to the path

[Insert the followings after the end of section 6.3.24:]
6.3.25 Relay path management and routing

[After overview text]

6.3.25.1 Relay path-oriented Operations

DSx (x represents Add, Change and Deletion) messages (defined in 6.3.2.3.10 ~ 6.3.2.3.17), with two extended TLVs: Explicit-Route TLV and Path-ID TLV (defined in 11.1.xx/yy), are defined in this section to support constraint-based routing path population and CID/path binding operations.

Routing creation and population

After a new RS was attached to MMR cell, BS would create a new path for the designated RS and assign a Path-ID to the path. BS will initiate DSA-REQ message including Explicit-Route TLV and Path-ID TLV. The call flow for path population is as follows:

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- For the received DSA-REQ, if the RS is not in the Explicit-Route, RS would simply discard the message.
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++++++++++++++++++++ *End of text proposal* ++++++++++++++++++++++