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	2007-03-05
Source(s)	G.Q. Wang, Wen Tong, Peiying Zhu, Hang Zhang, David Steer, Gamini Senarath, Derek Yu, Mo-Han Fong Voice: 1-613-763-1315 [mailto:wentong@nortel.com] Nortel 3500 Carling Avenue Ottawa, Ontario K2H 8E9
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	
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

DSx message extension for Constraint-Based routing and CID/path binding

G.Q. Wang, Wen Tong, Peiying Zhu, Hang Zhang, Gamini Senarath,

David Steer, Derek Yu, Mo-Han Fong

Nortel

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.

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 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. 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. These two TLV can be used in DSx management messages. For example, the path is specified as explicit route in DSA signaling to populate the CID/path binding information to all RSs along the selected path. The explicit route TLV consists of an array of station IDs along the given path. The transport CIDs allocated to each RS in DSA message body are called "tunnel transport CID". Upon received DSA message, every RS along the path should process DSA message to update their routing table for CID/Path biding operation.

As tunnel transport CID is per-tunnel based connection, it only carries two types of data packets: these data are either targeting to a designated RS (e.g., management messages to this RS), or targeting to all MSs (i.e.., aggregated traffic over access link), in which both the designated RS and MS are directly attached to the tunnel-end-point RS.

For non-tunnel operation, DSA is also used to populate MS's CID to every RS for per-flow relaying operation.

There are various downstream data forwarding schema in MMR network:

1) Connection-based forwarding: In this case, BS builds MAC pdu using tunnel transport CID and sends it to the next hop. Tunnel CID here has an end-to-end sense. Upon received MAC pdu, the RS would check tunnel CID against the routing table and decide where the data should go.

2) Per-hop-based forwarding: In this case, BS builds data burst using basic CID. Basic CID here represents a destination address. Upon received data burst, the RS would check basic CID against the routing table and decide where this data should go.

3) Source-routing: In this case, BS builds MAC pdu by embedding explicit route in the header. Upon received MAC pdu, the RS would check the explicit route to navigate where the data should go.

In (1) and (2), MMR system needs issue DSA to populate the path to all RS. While in (3), DSA is not used and the path information is only stored in BS. These data forwarding schema are also applicable to upstream relay operation.

The following sections describe end-to-end path population, CID/Path binding and data flow aggregation.

1. 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 in DSA message. The call flow for path population is as follows:

- Path-ID is an integer assigned to the path

- Explicit-Route TLV is an array of station ID, starting from BS and ending at the destination RS

- For the received DSA-REQ, the RS would check whether the path is new path or an existing path. If it is new, the RS will create a new entry and store the Explicit-Route and Path-ID in the routing 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.

- After BS received DSA-RSP, 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).

2. CID/path binding and population

Once a path has been determined between BS and a designated RS, BS can dynamically add more CID/path bindings and populate them to the RSs 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. Based on whether it is a new path or existing path, BS would include the explicit route or path-ID in DSA to navigate the population. CID/path bindings are classified as connection-based and Per-hop-based.

2.1 Connection-based: In this mode, CID/path binding is populated to every RS, whether the CID is R-link based (a.k.a, per-tunnel CID), or the CID is access-link based (a.k.a, per-flow MS CID). Every RS along the path should process this message and store the CID/path binding data.

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

- DSx messages include explicit route or path-ID, allocated CID and associated QoS profile

- For the received DSA-REQ, based on Path-ID, every RS would process CID/path binding data and update routing/forwarding table, and further relay the DSx message downstream (if it is not the last node in the route).

- After finished CID/path binding operation, the last RS should send DSA-RSP upstream.

2.2 Per-hop-based: In this mode, CID/path binding is populated with RS's basic CID. DSA message body contains explicit route TLV, path ID TLV and the basic CID. Each RS along the path should store this path information into routing table for data forwarding navigation.

3. Data flow aggregation

3.1 Connection-based: In tunnel connection mode, BS only populates MS's service flow parameters and associated CID to the access RS. Accordingly, based on QoS requirement, for upstream relay, the access RS will aggregate each received individual CID MAC PDU into appropriate tunnels; for downstream relay, the RS de-aggregate tunneled data burst into each individual MS CID for scheduling. In this case, DSx messages, together with other data, are encapsulated in destination RS tunnel CID. All the intermediate RS would by-pass DSx messages and forward them to the designated RS.

In non-tunnel connection, BS populates MS's service flow parameters and associated CID to every RS along the selected path.

The call flow for this type of CID/path binding population is as follows:

- DSx messages include the tunnel CID of the destination RS, MS CID and associated QoS profile

- The destination access RS processes the binding between tunnel CID, MS CID and QoS profile, and updates routing/forwarding table accordingly.

3.2 Per-hop-based: In this mode, BS only populates basic CID of access RS to every RS along the path. For the upstream relay, the access RS would aggregate the received MS MAC PDU into R-link MAC PDU with appreciate QoS setting; For the downstream relay, the access RS would de-aggregate the R-link MAC PDU and map the data burst into individual MS CID for scheduling.

4. 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.

4.1 Path deletion

In this case, DSD only includes Path-ID TLV, it is to remove the path (and all the related CID/path binding data);

4.2 CID/path unbinding

In this case, DSD includes both path ID and the removed CID

The rest operational semantic is similar to DSA

5. Routing path maintenance

DSC message with Path-ID can be used to dynamically update some attributes of an established routing path. For example, BS can issue DSC to change some QoS parameters associated with CID/path binding. In this case, DSC message may include path ID, CID and updated attributes. The operational semantic of DSC is similar to DSD.

6. 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	16 bits	The number of entries in the list
For(j=0;j<N-entry;j++) {		
Station_ID	48 bits	Station 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 were defined in 802.16-2005 to support data service provisioning and to allocate/binding transport CID with service flow ID. 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. 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. These two TLV can be used in DSx management messages. For example, the path is specified as explicit route in DSA signaling to populate the CID/path binding information to all RSs along the selected path. The explicit route TLV consists of an array of station IDs along the given path. The transport CIDs allocated to each RS in DSA message body are called "tunnel transport CID". Upon received DSA message, every RS along the path should process DSA message to update their routing table for CID/Path biding operation.

As tunnel transport CID is per-tunnel based connection, it only carries two types of data packets: these data are either targeting to a designated RS (e.g., management messages to this RS), or targeting to all MSs (i.e.., aggregated traffic over access link), in which both the designated RS and MS are directly attached to the tunnel-end-point RS.

For non-tunnel operation, DSA is also used to populate MS's CID to every RS for per-flow relaying operation.

There are various downstream data forwarding schema in MMR network:

1) Connection-based forwarding: In this case, BS builds MAC pdu using tunnel transport CID and sends it to the next hop. Tunnel CID here has an end-to-end sense. Upon received MAC pdu, the RS would check tunnel CID against the routing table and decide where the data should go.

2) Per-hop-based forwarding: In this case, BS builds data burst using basic CID. Basic CID here represents a destination address. Upon received data burst, the RS would check basic CID against the routing table and decide where this data should go.

3) Source-routing: In this case, BS builds MAC pdu by embedding explicit route in the header. Upon received MAC pdu, the RS would check the explicit route to navigate where the data should go.

In (1) and (2), MMR system needs issue DSA to populate the path to all RS. While in (3), DSA is not used and the path information is only stored in BS. These data forwarding schema are also applicable to upstream relay operation.

The following sections describe end-to-end path population, CID/Path binding and data flow aggregation.

1. 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 in DSA message. The call flow for path population is as follows:

- Path-ID is an integer assigned to the path

- Explicit-Route TLV is an array of station ID, starting from BS and ending at the destination RS

- For the received DSA-REQ, the RS would check whether the path is new path or an existing path. If it is new, the RS will create a new entry and store the Explicit-Route and Path-ID in the routing 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.

- After BS received DSA-RSP, 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).

2. CID/path binding and population

Once a path has been determined between BS and a designated RS, BS can dynamically add more CID/path bindings and populate them to the RSs 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. Based on whether it is a new path or existing path, BS would include the explicit route or path-ID in DSA to navigate the population. CID/path bindings are classified as connection-based and Per-hop-based.

2.1 Connection-based: In this mode, CID/path binding is populated to every RS, whether the CID is R-link based (a.k.a, per-tunnel CID), or the CID is access-link based (a.k.a, per-flow MS CID). Every RS along the path should process this message and store the CID/path binding data.

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

- DSx messages include explicit route or path-ID, allocated CID and associated QoS profile

- For the received DSA-REQ, based on Path-ID, every RS would process CID/path binding data and update routing/forwarding table, and further relay the DSx message downstream (if it is not the last node in the route).

- After finished CID/path binding operation, the last RS should send DSA-RSP upstream.

2.2 Per-hop-based: In this mode, CID/path binding is populated with RS's basic CID. DSA message body contains explicit route TLV, path ID TLV and the basic CID. Each RS along the path should store this path information into routing table for data forwarding navigation.

3. Data flow aggregation

3.1 Connection-based: In tunnel connection mode, BS only populates MS's service flow parameters and associated CID to the access RS. Accordingly, based on QoS requirement, for upstream relay, the access RS will aggregate each received individual CID MAC PDU into appropriate tunnels; for downstream relay, the RS de-aggregate tunneled data burst into each individual MS CID for

scheduling. In this case, DSx messages, together with other data, are encapsulated in destination RS tunnel CID. All the intermediate RS would by-pass DSx messages and forward them to the designated RS.

In non-tunnel connection, BS populates MS's service flow parameters and associated CID to every RS along the selected path.

The call flow for this type of CID/path binding population is as follows:

- DSx messages include the tunnel CID of the destination RS, MS CID and associated QoS profile
- The destination access RS processes the binding between tunnel CID, MS CID and QoS profile, and updates routing/forwarding table accordingly.

3.2 Per-hop-based: In this mode, BS only populates basic CID of access RS to every RS along the path. For the upstream relay, the access RS would aggregate the received MS MAC PDU into R-link MAC PDU with appreciate QoS setting; For the downstream relay, the access RS would de-aggregate the R-link MAC PDU and map the data burst into individual MS CID for scheduling.

4. 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.

4.1 Path deletion

In this case, DSD only includes Path-ID TLV, it is to remove the path (and all the related CID/path binding data);

4.2 CID/path unbinding

In this case, DSD includes both path ID and the removed CID

The rest operational semantic is similar to DSA

5. Routing path maintenance

DSC message with Path-ID can be used to dynamically update some attributes of an established routing path. For example, BS can issue DSC to change some QoS parameters associated with CID/path binding. In this case, DSC message may include path ID, CID and updated attributes. The operational semantic of DSC is similar to DSD.

+++++++++++++++++++++ *End of text proposal* +++++++++++++++++++++