Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>
Title	MMR Network end-to-end routing and connection management
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)
Notice	
Release	
Patent Policy and Procedures	

MMR Network End-to-End Routing and Connection Management

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Nortel

1 Introduction

In IEEE 802.16j-06/014r1 it has defined the concepts of access link, relay link (R-link) and relay path to describe MMR network topology. These terminologies are used to support end-to-end connection management and data forwarding schema over MMR relay topology. To enable backward compatibility and efficient multi-hop relay operations, this harmonized contribution describes the general specification for Section 6.1.1 (IEEE 802.16j-06/017-r2), “Relaying extension to MAC Common part sublayer”. The contribution covers the following text descriptions:

- Relay path interfaces associated with various routing schema (i.e., centralized routing vs. distributed routing)
- Routing path management related to MR-RS to RS connection, RS to RS connection, and RS to MS connection
- Various type of relay connections and CID semantic
- CID/Path binding operation and its application to relay data forwarding
- Relay QoS schema
- Security issue related to path-oriented operations

This contribution proposes a suit of common relay MAC sub-layer (R-MAC) functions for relay operations.

Overview

Relay network discovery and route creation

MMR network topology is constituted by BS and set of RS and their access relationship over air links. Within a MMR cell, the topology-related operations include topology discovery, routing path creation/optimization, route population and routing maintenance caused by the topology updates (e.g., node mobility or node failure). MMR network topology provides two interfaces: the relay interface over R-link and the access interface over access link (Figure 1). A routing path is created by the radio resource manager and routing controller which either reside on BS (centralized routing) or some RS (distributed routing). A path is consists of an array of relay node identifier, and it is determined in a MMR cell subject to the constraints of available radio resource within a spectrum usage domain.

MMR connectivity consists of R-link connectivity and access link connectivity, where R-link connectivity is defined as transport connections (a.k.a, R-link CID) over multiple R-links, and access link connectivity is defined as transport connections (access link CID) over access link. R-link CID can be thought as a “tunnel” connection to support data burst aggregation, with a coarser QoS processing for relaying data upstream and downstream. While access link CID, as defined for MS transport CID in 802.16-2005, represents a per-flow connection with finer QoS parameters. Both R-link CID and access link CID are bounded to a given routing path. Based on the different data forwarding schema, this CID/path binding information may be stored at different relay nodes along the path. Working together, R-link connections and access link connections provide an end-to-end connectivity to support end-to-end service flow between BS and MS.

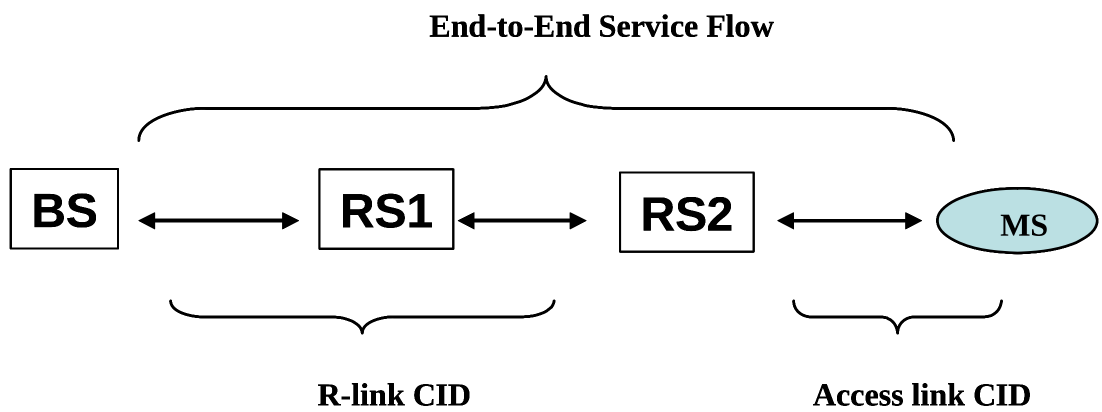

Figure 1 Relay interface over R-link and the access interface over access link

Relay Data Forwarding Schemes

There exist various approaches for severing data forwarding schema in MMR network, depending on whether distributed routing or centralized routing to be used. For example, in centralized routing schema, only BS will store MMR topology and path information. In this case, BS could use source-routing mechanism to embedded relay path information in the data burst, and each RS just navigates the relay by following the given path from the received data burst. While in distributed routing schema, every RS would store a routing table with established mapping relationship between path and CID/RS-ID. In this case, for the received data burst, each RS would check the routing table to navigate the forwarding operation and relay the data to the destination.

Relay forwarding can be implemented in two types: per-connection-based and per-packet-based.

In per-connection-based forwarding, access link transport CID (a.k.a, MS’s CID) or R-link transport CID is used in MAC PDU to navigate the data forwarding, and every RS has a pre-built CID/path binding relationship in the routing table. When RS received a data burst, it would check the CID against the routing table, and determine which air link is the next interface to forwarding the data to. The difference between using MS CID and R-link CID is the granularity of connection management. The former needs BS populate all MS CID data to a RS in which the MS directly attached to the RS or attached to RS's subordinate tree. While in the latter case it only needs BS populate R-link CID data to the intermediate RS and MS CID data to the access RS.

In per-packet-based forwarding, the destination RS-ID or the basic CID of the destination RS can be used in MAC PDU to navigate the data forwarding. There are two scenarios for packet-based forwarding. In distributed routing schema, every RS should have a pre-built routing table. When RS received a packet, it would check the destination RS-ID or basic CID against the routing table to determine where the packet should go. While in a centralized routing schema, BS would embed a routing path list in MAC PDU header/sub-header, and for the received data, RS just follows what has been specified in the routing path to determine where the next air link the packet should go.

Overall Relay Routing and Forwarding

The overall MMR relay behavior related to distributed routing and connection management can be described as following:

- MMR Network topology discovery via RS/MS initial entry process. For example, BS collects RS/MS attachment information from initial ranging process
- BS creates the routing paths and populate the newly created route to all the RS along the path
- BS allocates CIDs to the attached nodes and create a binding relationship between CID(RS-ID) and the path (Path-ID)
- BS populates the CID(RS-ID)/path binding information to all the RSs along the path
- Each RS would store the CID(RS-ID)/path binding data into routing table and derive a forwarding table
- For the received management data and payload data, each RS would check the CID(RS-ID) associated with the burst (or MAC PDU), and determine should they process, further forwarding or simply discard the data
- When topology changes, for example, an RS moves from the severing BS to the target BS, a new path may be created and CID(RS-ID)/path binding data needs to be re-populated, and the old path will be removed from the original route.

QoS control

Based on various connection management and data forwarding schemes, relay network may adopt two QoS schemes: per-connection-based and per-packet-based.

For per-connection-based QoS, the QoS profile is populated to each RS during CID/path binding process (e.g., using DSx signaling messages). In MS-CID case, per-flow QoS profile is populated to each RS; while in R-link CID case, per-tunnel QoS profile is populated to each RS. For the received data packet, RS would check the CID against associated QoS profile to prioritize and to schedule the transmission queue.

For per-packet-based QoS, each MACPDU header would carry QoS bits information for the relay. Before transmitting data downstream/upstream, BS and access RS would map per-flow QoS profile into QoS bits. For the received data packet, RS would check the QoS bits carried in the MAC PDU header to prioritize and to schedule the transmission queue.

The difference between per-connection-based QoS and per-packet-based QoS is that in the latter case, it does not need BS populate QoS profile to all RS. It is beneficiary for scalability and it also reduces the overhead for QoS re-population during mobility management.

2. Proposed text changes

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[Insert the followings after the end of section 6.1:]

6.1.1 Relaying extension

MMR relay functions introduce the concepts of access link, relay link (R-link) and relay path to describe MMR network topology. These terminologies are used to support end-to-end routing, connection management and data forwarding schema over MMR relay topology.

The general relay MAC sub-layer (R-MAC) functions to support routing, connection management and data forwarding should cover:

- Relay path interfaces associated with various routing schema (i.e., centralized routing vs. distributed routing)
- Routing path management related to MR-RS to RS connection, RS to RS connection, and RS to MS connection
- Various type of relay connections and CID semantic
- CID/Path binding operation and its application to relay data forwarding
- Relay QoS schema
- Security issue related to path-oriented operations

MMR network topology is constituted by BS and set of RS and their access relationship over air links. Within a MMR cell, the topology-related operations include topology discovery, routing path creation/optimization, route population and routing maintenance caused by the topology updates (e.g., node mobility or node failure). MMR network topology provides two interfaces: the relay interface over R-link and the access interface over access link (Figure 1). A routing path is created by the radio resource manager and routing controller which either reside on BS (centralized routing) or some RS (distributed routing). A path is consists of an array of relay node identifier, and is determined in a MMR cell subject to the constraints of available radio resource within a spectrum usage domain.

MMR connectivity consists of R-link connectivity and access link connectivity, where R-link connectivity is defined as transport connections (i.e. R-link CID) over multiple R-links, and access link connectivity is defined as transport connections (access link CID) over access link. R-link CID can be thought as a “tunnel” connection to support data burst aggregation, with a coarser QoS processing for relaying data upstream and downstream. While access link CID, as defined for MS transport CID in 802.16-2005, represents a per-flow connection with finer QoS parameters. Both R-link CID and access link CID are bounded to a given routing path. Based on the different data forwarding schema, this CID/path binding information may be stored at different relay nodes along the path. Working together, R-link connections and access link connections provide an end-to-end connectivity to support end-to-end service flow between BS and MS.

There exist various approaches for severing data forwarding schema in MMR network, depending on whether distributed routing or centralized routing to be used. For example, in centralized routing schema, only BS would store MMR topology and path information. In this case, BS could use source-routing mechanism to embed relay path information in the data burst, and each RS just navigates the relay by following the given path from the received data burst. But in distributed routing schema, every RS would store a routing table with established mapping relationship between path and CID. In this case, for the received data burst, each RS would check the routing table to navigate the forwarding operation and relay the data to the destination.

Relay forwarding can be implemented in two types: per-connection-based and per-packet-based.

In per-connection-based forwarding, access link transport CID (i.e. MS's CID) or R-link transport CID is used in MAC header/sub-header to navigate the data forwarding, and every RS has a pre-built CID/path binding relationship in the routing table. When RS received a data burst, it would check the CID against the routing table, and determine which air link is the next interface to forwarding the data to. The difference between using MS CID and R-link CID is the granularity of connection management. The former needs BS populate all MS CID data to a RS in which the MS directly attached to the RS or attached to RS's subordinate tree. While in the latter case it only needs BS populate R-link CID data to the intermediate RS and MS CID data to the access RS

In per-packet-based forwarding, the destination RS-ID or the basic CID of the destination RS can be used in MAC PDU to navigate the data forwarding. There are two scenarios for packet-based forwarding. In distributed routing schema, every RS should have a pre-built routing table. When RS received a packet, it would check the destination RS-ID or basic CID against the routing table to determine where the packet should go. While in a centralized routing schema, BS would embed a routing path list in MAC PDU, and for the received data, RS just follows what has been specified in the routing path to determine the next air link the packet should go.

The overall MMR relay behavior related to distributed routing and connection management can be described as Figure xxxxx

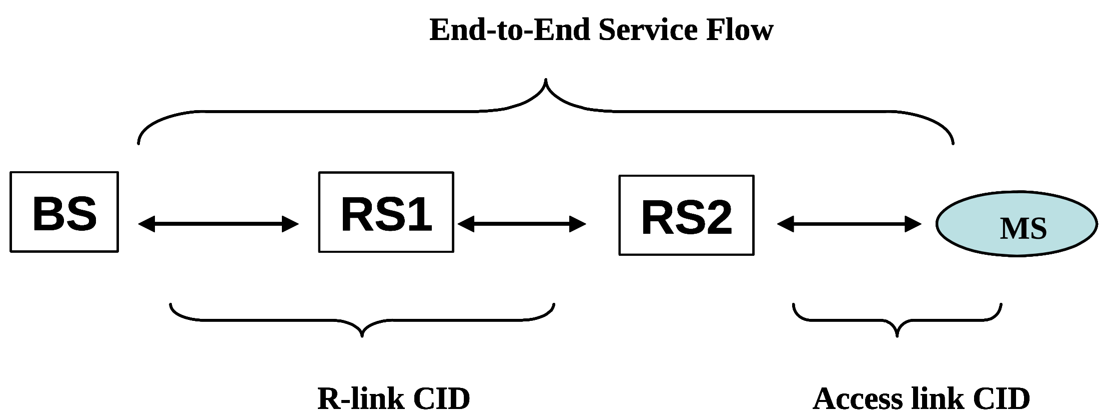

Figure. xxxxx

- MMR Network topology discovery via RS/MS initial entry process. For example, BS collects RS/MS attachment information from initial ranging process
- BS creates the routing paths and populate the newly created route to all the RS along the path
- BS allocates CIDs to the nodes and create a binding relationship between CID(RS-ID) and the path
- BS populates the CID(RS-ID)/path binding information to all the RS(s) along the path
- Each RS would store the CID(RS-ID)/path binding data into routing table and derive a forwarding table
- For the received management data and payload data, each RS would check the CID(RS-ID) associated with the burst (or MAC PDU), and determine should they process, further forwarding or simply discard the data
- When topology changes, for example, an RS moves from the severing BS to the target BS, a new path may be created and CID(RS-ID)/path binding data needs to be re-populated, and the old path will be removed from the original route.

[Insert the followings after the end of section 6.3.1]

6.3.1.3 Addressing and connections for relay support

Similar to MS, each air interface in RS shall have a 48-bit universal MAC address. This address is used for RS initial ranging process for network entry operation; as well it is used as part of authentication process to build up peer-peer security association between BS and RS.

In additional to MAC address, each RS shall have a x-bit RS identifier (RS-ID). RS-ID uniquely identifies a RS within a MMR cell scope and is used for routing purpose.

In relay network, it defines two types of air interfaces: R-link interface between BS and RS, or between RS and RS; and access link interface between access RS and MS. The connections created over R-link enable data burst relay between BS and the designated access RS, the connections over access link facilitate data burst transmission/receiving between access RS and MS.

MMR network can support two types of data forwarding schema: connection-based and packet-based. The connection-based data forwarding uses transport CID to manage connections and to relay the data bursts to the designated RS; while packer-based data forwarding uses RS-ID or basic CID to relay the data bursts to the designated access RS. In distributed routing, both connection-based relay and packet-based relay would need routing table to navigate the data forwarding.

After the initial network ranging process, BS allocates management CIDs to the designated RS for management/control purposes. Similar to MS connection management, in connection-based relay schema, BS may also allocate transport CIDs to the designated RS for relaying data traffic. The allocation of transport CID to the RS (i.e., R-link CID) may be pre-configured or be triggered by service provisioning operations. In general, the transport CID allocation to the RS is to create an end-to-end connectivity from BS to the RS. These CIDs will be used to relay the data traffic between BS and the designated RS. BS may allocate several transport CIDs to the designated RS, which may facilitate special-purpose data relay functions. For example, the CID can be used for QoS-based relay operations, or data aggregation relay operation, downstream and upstream.

In MMR network, to relay the data traffic (both management data and service flow date) to the designed RS, the CIDs (management CID and transport CID) have to be bounded to a given path. The process to establish this binding relationship and to populate the binding data to a path is called CID(RS-ID)/path binding. The binding relationship between CID(RS-ID) and a path is determined by BS, and this information is populated (via signaling messages) to all the RSs along the selected path. After RS has received this binding data and stored it in the routing table, the RSs along the path could use it to navigate the relay of data burst hop by hop by checking the CID(RS-ID) (carried either in DL-MAP_IE, or in MAC PDU header/sub-header) against the routing table.

In the case of connection-based forwarding, where BS does not allocate transport CID to any RS, the CID/path binding process has to be applied to the transport CID allocated to each MS. In this case, the RS has to store all the biding data associated with the MS either directly attached to its self or attached to its subordinate tree.

Whether or not BS allocate R-link CID to RS, the BS should populate the transport CID of MS to the access RS the MS attached to. These CIDs are used over access link to deliver/receive the data to/from MS, and integrated with relay connection over R-link to fulfill the end-to-end data relay between BS and MS.

DSx management messages, with the extension of path-ID TLV, could be used to support end-to-end CID(RS-ID)/path binding functions.

[Insert the followings after the end of section 6.3.24:]

6.3.25 Relay path management and routing

Relay path is a topological object which was defined as the concatenation of K consecutive relay links (K.>= 1) between BS and the designated access RS. Relay path is created by the radio resource routing controller which reside either in BS (centralized routing domain), or in some RS (distributed routing domain). Before a path to be created, the routing controllers need collect the topology information (e.g., nodes, links and associated parameters/status).

In general, MMR routing will adopt constraint-based routing approach to determine an explicit route. Constraint-based routing is a process of determining the most suitable route in a MMR cell topology subject to constraints of available radio resource over the route. Many criterions can be used to optimize the selection of the path, but how to apply optimization algorithms to generate an optimal path is out of the scope.

An explicit route/path is consist of an array of relay node ID, and a path can be assigned a uniquely path ID. In distributed routing schema, the explicit route is used in signaling messages to populate the routing information to every RS; while in source-routing schema, the explicit route is embedded in data burst to navigate the relay operation. In distributed routing, path ID is used for path-related operations such as path creation, updates and maintenance.

To support data forwarding in multi-hop relay topology, the BS or RS needs a path to guide the hop-by-hop data forwarding. In distributed routing, the path needs to be populated to every RS, and CID/path binding relationship has to be established before the relay operation starts.

Relay Path management includes path creation/deletion/updates, path population and CID/path binding.

DSx management messages, with the extension of explicit route TLV and path-ID TLV, can be used to support end-to-end path management functions.

[Insert the followings after the end of section 6.3.14:]

Relay QoS control

Based on various connection management and data forwarding schemes, relay network may adopt two QoS schemes: per-connection-based and per-packet-based.

For per-connection-based QoS, the QoS profile is populated to each RS during CID/path binding process (e.g., using DSx signaling messages). In MS-CID case, per-flow QoS profile is populated to each RS; while in R-link case, per-tunnel QoS profile is populated to each RS. For the received data packet, RS would check the CID against associated QoS profile to prioritize and schedule the transmission queue.

For per-packet-based QoS, each MAC header/sub-header would carry QoS bits information for the relay. Before transmitting data downstream/upstream, BS and access RS would map per-flow-based MS QoS profile into QoS bits. For the received data packet, RS would check the QoS bits carried in the MAC header/sub-header to prioritize and schedule the transmission queue.

The difference between per-connection-based QoS and per-packet-based QoS is that in the latter case, it does not need BS populate QoS profile to the RS. It is beneficiary for scalability and it also reduces the overhead for QoS re-population during mobility management.

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