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Source(s)	G.Q. Wang, Wen Tong, Peiying Zhu Hang Zhang, David Steer, Gamini Senarath, Derek Yu, Mo-Han Fong Nortel 3500 Carling Avenue Ottawa, Ontario K2H 8E9 Voice: 1-613-763-1315 [mailto:wentong@nortel.com] [mailto:pyzhu@nortel.com] Erwu Liu, Dongyao Wang, Gang Shen, Kaibin Zhang, Jimin Liu, Shan Jin Alcatel Lucent, R&I Shanghai, No.388, Ningqiao Road, Shanghai, P.R.C. Voice: 86-21-50551240-8194 Fax: 96-21-50554554 {Erwu.liu, Dongyao.Wang, Gang.A.Shen, Kaibin.Zhang, Jimin.Liu, Shan.Jin}@alcatel-sbell.com.cn Torsten Fahldieck Alcatel-Lucent R&I Holderaeckerstr.35, Stuttgart, Germany Voice: +4971182132163 Fax: +4971182132453 torsten.fahldieck@alcatel-lucent.de
Re:	A response to a Call for Technical Proposal, http://www.wirelessman.org/relay/docs/80216j-07_007r2.pdf
Abstract	This document provides text descriptions for routing/forwarding schema and associated QoS sections defined in ToC of IEEE 802.16j-06/026r2
Purpose	To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r2)
Notice	

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MMR Network Data Forwarding and QoS Schema

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

David Steer, Derek Yu, Mo-Han Fong
Nortel
Erwu Liu, Torsten Fahldieck, Dongyao Wang, Shen Gang, Kaibin Zhang, Jimin Liu, Shan Jin
Alcatel-Lucent

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 link interface associated with various data forwarding schema (i.e., per-connection-based vs. per-hop-based)
- Routing path management related to data forwarding (i.e., distributed routing vs. source routing)
- Transport tunnel CID and destination basic CID application to data forwarding
- Relay QoS processing related to various data forwarding schema

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

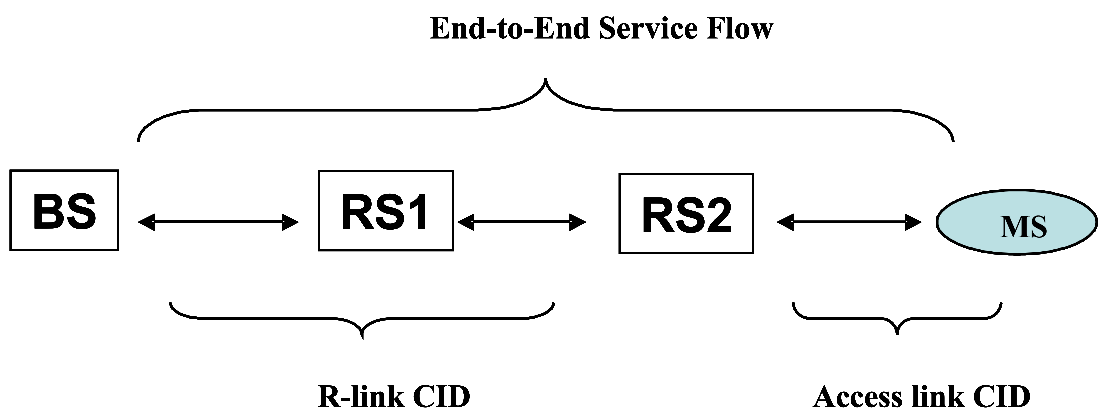
Overview

MMR network relay path and CIDs

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 includes either a Transport Tunnel CID (a.k.a., Tunnel CID), or a destination basic CID. R-link CIDs are allocated to each designated access RS. R-link CID is used to relay data upstream and downstream. While access link CID, as defined for MS transport CID in 802.16-2005, represents a per-service-flow connection between BS and MS.

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 either at BS (centralized routing), or at different relay nodes along the path (distributed routing). 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.



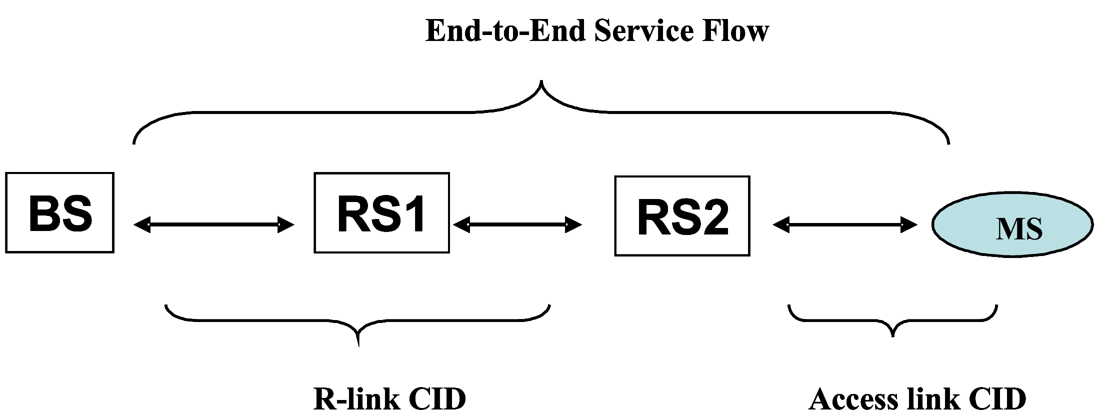


Figure 1 Relay interface over R-link and the access interface over access link

Relay Data Forwarding Schemes
Relay forwarding over R-link can be implemented in two types: per-connection-based and per-hop-based.

Per-connection-based forwarding
In per-connection-based forwarding, end-to-end connection should be created via signaling message prior to

data burst relay. Every RS has a pre-built CID/path binding relationship in the routing table, and R-link transport tunnel CID or MS's transport CID is used in MAC PDU to navigate the data forwarding. Upon received a data burst, the RS would check the CID against the routing table, and determine which air link is the next hop interface to forwarding the data to. If no entry can be found in routing table, the RS simply drops the data packet. The difference between using MS CID and R-link CID is the granularity of connection management. MS CID is associated with service flow provisioning; while R-link CID is the connection for data burst aggregation upstream and downstream transport. In an end-to-end relay operation, the former needs BS populate all MS CID and the tunnel CID to all intermediate RS along the given path; While in the latter case it only needs BS to populate tunnel CID to the intermediate RS and to populate MS CID to the access RS.

Per-hop-based forwarding

Different from connection-based forwarding, per-hop-based forwarding does not need to populate the transport CID to any intermediate RS. Instead, the basic CID of the destination RS is used in R-link MAC PDU to navigate the data forwarding hop-by-hop, and QoS subheader is used to indicate QoS constrains. In this case, basic CID is used as a logical destination address to determine the next hop. There are two scenarios for per-hop-based forwarding. In distributed routing schema, every RS should have a pre-built routing table and CID/Path binding relationship. When RS received a data burst, it should check the destination basic CID against the routing table to determine where is the next hop the burst should go. While in a centralized routing schema, BS would embed a routing path list in MAC PDU header/sub-header and send it to the next hop RS. Upon the received data burst, RS just follows what has been specified in the routing path to determine where the next air link the data burst should go. Two different mechanisms for per-hop-based forwarding are defined as follows:

Forwarding by path subheader processing

In this mode the path between the BS and the designated access RS is defined by the MAC PDU header and a subheader. The subheader contains a path list of basic CID, which represents the logical address of each RS. In downstream direction the MR-BS generates the MAC header with the destination basic CID and a subheader which contains the pre-selected path and QoS constrains. Upon the received message, if the RS is the first CID in the list, it would perform a CID wrap around and forward the burst to the next hop in the path list. The wrap around is done by moving first CID from list head to the list tail. If RS is not in the list, it simply drops the burst. The same procedure is repeated on the hop-by-hop until the burst reaches to the destination access RS. The destination RS then removes the subheader after wrap around and sends a 802.16e compliant MAC PDU to the MS. The destination RS may store the path information and reuse this information to generate a header/subheader for upstream communications. This may be feasible for connections which use the same CID's for downlink and uplink. In upstream direction, when an access RS receives a MAC PDU from MS, it performs a lookup in its path database and generate subheader containing the path. Access RS then adds a new MAC header, inserts the subheader and sends the MAC PDU to the next hop. If the next hop is an intermediate RS, it performs a CID wrap around which is opposite to the wrap around in downstream direction. The same procedure is repeated on the next hop until the burst reaches to the destination BS.

Forwarding by destination CID hop-by-hop

In this mode every RS stores the routing table and the MAC PDU header/subheader only carries the destination RS basic CID. Up received MAC PDU the intermediate RS would check the destination RS CID against the routing table to determine next hop and forward the MAC PDU accordingly. If the destination CID is not in the routing table, RS just simply drops the burst.

Relay QoS control

Based on various connection management and data forwarding schemes, relay network may adopt two QoS schemes: per-connection-based and per-hop-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 tunnel CID case, per-tunnel QoS profile is populated to each RS. For the received data packet, RS should check the CID against associated QoS profile to prioritize and to schedule the transmission queue. If the tunnel aggregates several flows connection the QoS constrains of the tunnel shall fulfill the QoS constraints of all connections.

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

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

Overall Relay Routing and Forwarding

The overall MMR relay behavior related to distributed/centralized 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

In distributed routing, BS creates the routing paths and populates the newly created route to all the RS along the path. In centralized routing, only BS stores the routing paths.

BS allocates CIDs to the attached nodes and create a binding relationship between CID and the path (Path-ID)

BS populates the CID/path binding information to all the RSs along the path

In distributed routing, each RS would store the CID/path binding data into routing table and derive a forwarding table for next hop relay. The routing table is for RS control plane to store routing path and CID binding information; while the forwarding table is for RS data plane to store CID/interface mapping to navigate the data burst forwarding from the ingress port to the egress port

For the received management data and payload data, each RS would check the CID 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/path binding data needs to be re-populated and the old path will be removed from the original route.

2. Proposed text changes

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

[Insert the followings after the end of section 6.1.1]

Overall Relay Routing and Forwarding

The overall MMR relay behavior related to distributed/centralized 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

In distributed routing, BS creates the routing paths and populates the newly created route to all the RS

along the path. In centralized routing, only BS stores the routing paths.
BS allocates CIDs to the attached nodes and create a binding relationship between CID and the path (Path-ID)
BS populates the CID/path binding information to all the RSs along the path
In distributed routing, each RS would store the CID/path binding data into routing table and derive a forwarding table for next hop relay. The routing table is for RS control plane to store routing path and CID binding information; while the forwarding table is for RS data plane to store CID/interface mapping to navigate the data burst forwarding from the ingress port to the egress port
For the received management data and payload data, each RS would check the CID 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/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 6.3.2.3:]

6.3.3.1 Relay link CID and Relay MAC PDU forwarding schema

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 includes either a Transport Tunnel CID (a.k.a., Tunnel CID), or a destination basic CID. R-link CIDs are allocated to each designated access RS. R-link CID is used to relay data upstream and downstream. While access link CID, as defined for MS transport CID in 802.16-2005, represents a per-service-flow connection between BS and MS.

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 either at BS (centralized routing), or at different relay nodes along the path (distributed routing). 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.

Relay forwarding over R-link can be implemented in two types: per-connection-based and per-hop-based.

Per-connection-based forwarding

In per-connection-based forwarding, end-to-end connection should be created via signaling message prior to data burst relay. Every RS has a pre-built CID/path binding relationship in the routing table, and R-link transport tunnel CID or MS's transport CID is used in MAC PDU to navigate the data forwarding. Upon received a data burst, the RS would check the CID against the routing table, and determine which air link is the next hop interface to forwarding the data to. If no entry can be found in routing table, the RS simply drops the data packet. The difference between using MS CID and R-link CID is the granularity of connection management. MS CID is associated with service flow provisioning; while R-link CID is the connection for data burst aggregation upstream and downstream transport. In an end-to-end relay operation, the former needs BS populate all MS CID and the tunnel CID to all intermediate RS along the given path; While in the latter case it only needs BS to populate tunnel CID to the intermediate RS and to populate MS CID to the access RS.

Per-hop-based forwarding

Different from connection-based forwarding, per-hop-based forwarding does not need to populate the transport CID to any intermediate RS. Instead, the basic CID of the destination RS is used in MAC PDU to navigate the data forwarding hop-by-hop, and QoS subheader is used to indicate QoS constrains. In this case, basic CID is used as a logical destination address to determine the next hop.. There are two scenarios for per-hop-based forwarding. In distributed routing schema, every RS should maintain routing table and CID/Path binding relationship. When RS received a data burst, it should check the destination basic CID against the routing table to determine where is the next hop the burst should go. While in a centralized routing schema, BS would embed a routing path list in MAC PDU header/sub-header and send it to the next hop RS. Upon the received data burst, RS just follows what has been specified in the routing path to determine where the next air link the data burst should go. Two different mechanisms for per-hop-based forwarding are defined as follows:

Forwarding by path subheader processing

In this mode the path between the BS and the designated access RS is defined by the MAC PDU header and a subheader. The subheader contains a path list of CID, which represents the logical address of each RS. In downstream direction the MR-BS generates the MAC header with the destination basic CID and a subheader which contains the pre-selected path and QoS constrains. Upon the received message, the RS would perform a CID list wrap around. The CID list wrap around in downlink direction is done by removing the CID from the header and append this CID at the tail of the CID list. The first CID of the list is than removed and inserted into the header. If the connection defined by this new CID doesn’t exist, the burst has to be drop; otherwise the bust is forwarded to the next hop. The same procedure is repeated on the hop-by-hop until the burst reaches to the destination access RS. The destination RS then removes the subheader after wrap around and sends a 802.16e compliant MAC PDU to the MS. The destination RS may store the path information and reuse this information to generate a header/subheader for upstream communications. This may be feasible for connections which use the same CID’s for downlink and uplink. In upstream direction, when an access RS receives a MAC PDU from MS, it performs a lookup in its path database and generate a header with the appropriate CID and a subheader containing the CID list. If the next hop is an intermediate RS, it performs a CID wrap around which is opposite to the wrap around in downstream direction. The same procedure is repeated on the next hop until the burst reaches to the destination BS.

Forwarding by destination CID hop-by-hop

In this mode every RS stores the routing table and the MAC PDU header/subheader only carries the destination RS basic CID. Up received MAC PDU the intermediate RS would check the destination RS CID against the routing table to determine next hop and forward the MAC PDU accordingly. If the destination CID is not in the routing table, RS just simply drops the burst.

[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-hop-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 tunnel CID case, per-tunnel QoS profile is populated to each RS. For the received data packet, RS should check the CID against associated QoS profile to prioritize and to schedule the transmission queue. If the tunnel aggregates several flows connection the QoS constrains of the tunnel shall fulfill the QoS constraints of all connections.

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

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

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