Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	MAC PDU Design for Supporting Data Forwarding Schemes in 802.16j	
Date Submitted	**2007-01-08**	
Source(s)	Hang Zhang, Peiying Zhu, Mo-Han Fong, Wen Tong, David Steer, Gamini Senarath, Derek Yu, Mark Naden, G.Q. Wang Nortel 3500 Carling Avenue Ottawa, Ontario K2H 8E9	Voice: +1 613 7631315 [mailto:wentong@nortel.com] [mailto:pyzhu@nortel.com]
Re:	A response to a Call for Technical Proposal, http://wirelessman.org/relay/docs/80216j-06_034.pdf	
Abstract	This contribution propose MAC PDU design to support data forwarding	
Purpose	To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r1)	
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>.	

MAC PDU Design for Supporting Data Forwarding Schemes in 802.16j

Hang Zhang, Peiying Zhu, Mo-Han Fong, Wen Tong, David Steer, Gamini Senarath, Derek Yu, Mark Naden, G.Q. Wang

Nortel

1 Introduction

From session #46 of 802.16j, a lot of contributions proposed variety of data forwarding schemes.
In this contribution, we try to categorize those schemes and propose a MAC PDU design to enable main data forwarding schemes. Regarding the overview of routing control and QoS control, please refer to XX.

The design principles include:

- Enable flexible routing control
- Enable flexible QoS control
- Enable efficient resource utilization (low overhead)
- Enable extensibility for future development

We assume that each RS is assigned a RSID (8 bits) at initial network entry; RSID is described in a separate contribution [1].

2 Data forwarding schemes

In this section, we list some of data forwarding schemes and for each scheme the information, such as routing information and QoS information, required for governing further data forwarding is highlighted.

2.1 Routing control

2.1.1 Distributed routing control

2.1.1.1 MS CID based routing

- Each RS needs to maintain a routing table to include all CIDs for which data need to be relayed, as entries. Each CID is associated with a 'next hop RSID'
- For each received DL MAC PDU, the RS checks CID through the header of MAC PDU and then delivers the MAC PDU to the next hop RS corresponding to this CID in the routing table
- No modification of existing 802.16e MAC is required

2.1.1.2 Destination RSID or destination CID based

- The destination RSID is the ID of a RS who is the destination of a forward path. The destination CID is the basic CID of a RS who is the destination of a forward path
- The destination RSID/CID needs to be carried together along with a MAC PDU. Thus destination RSID/CID subheader needs to be introduced
- Each RS keeps a routing table to include a RSID/CID (destination RSID/CID) as entries. Each destination RSID/CID is associated with a 'next hop RSID'
- For each received DL MAC PDU, a RS needs to check the destination RSID/CID subheader and then deliver the MAC PDU to the next hop RS corresponding to this destination RSID/CID in the routing table

2.1.1.3 T-CID based

- T-CID is defined for a tunnel connection between MMR-BS and a RS for carrying 802.16e MAC PDU. Each T-CID is associated with a particular route and a set of QoS parameters
- The T-CID information needs to be carried along with a MAC PDU. Thus T-CID subheader needs to be introduced
- Each RS needs to keep a routing table with T-CID as entries. Each T-CID is associated with a 'next hop RS' field
- After a RS receives a MAC PDU, the RS checks the T-CID information and forwards this MPDU to the next hop RS corresponding to this T-CID in the routing table

2.1.2 Centralized routing control

2.1.2.1 Source routing based

- The source routing information includes one or multiple RSIDs of RSs in the forwarding path
- The source routing information needs to be carried along with a MAC PDU. Thus source routing subheader needs to be introduced. This subheader includes RSID(s) of all RS(s) in the forwarding path
- Each RS doesn't keep any routing table
- For each received MAC PDU, a RS simply removes its own RSID in the source routing subheader and forward this MAC PDU to the next RS corresponding to the next RSID in the source routing subheader

2.2 QoS control

2.2.1 Centralized control

2.2.1.1 Source QoS based

- For DL, MMR-BS sends the QoS information along with a DL MAC PDU to instruct RSs in the downstream forwarding path regarding relaying this MAC PDU. For UL, an access RS (a

RS receives MAC PDU from MSs) sends the QoS information along with a UL MAC PDU to instruct RSs in the upstream forwarding path (to MMR-BS) regarding relaying of this MAC PDU. Thus a QoS subheader needs to be introduced

- Each RS doesn't need to keep any QoS related information
- After a RS receives a MAC PDU, the RS checks the QoS information received along with this MAC PDU and schedules further transmission of this MAC PDU

2.2.2 Distributed control

2.2.2.1 MS CID based

- Each RS keeps a QoS table with CIDs as entries. Each CID is associated with a set of QoS parameters
- After a RS receives a MAC PDU, the RS checks the CID field and schedules the further transmission based on QoS parameters corresponding to this CID
- No modification is required

2.2.2.2 T-CID based

- T-CID information is transmitted along with a MAC PDU
- Each RS keeps a QoS table with T-CIDs as entries. Each T-CID is associated with a set of QoS parameters
- After a RS receives a MAC PDU, the RS checks the T-CID field and schedules further transmission based on QoS parameters corresponding to this T-CID

2.3 Data concatenation

In 802.16j, two types of links are defined. The relay link and access link. The packet transmission on relay link can be classified into two schemes. One is to transmit individual 802.16e MAC PDU on relay link. The other is to concatenate multiple 802.16j MAC PDUs sharing certain same property (e.g., to the same destination RS or have the same QoS requirement) and encapsulate those MAC PDUs into a new type PDU (e.g., R-MAC PDU). The MAC PDU concatenation method will reduce MAC overhead for most of routing and QoS control schemes discussed in section 2.1 and 2.2.

In data protocol stack, this new sub-layer can be called as R-MAC sub-layer. The R-MAC sub-layer locates between physical layer and MAC layer in a link between MMR-BS and RS as shown in Figure 1. Data plane of R-MAC is responsible for R-MAC PDU assembly and reassembly. The control plane of R-MAC sub-layer is responsible for routing and QoS control functions.

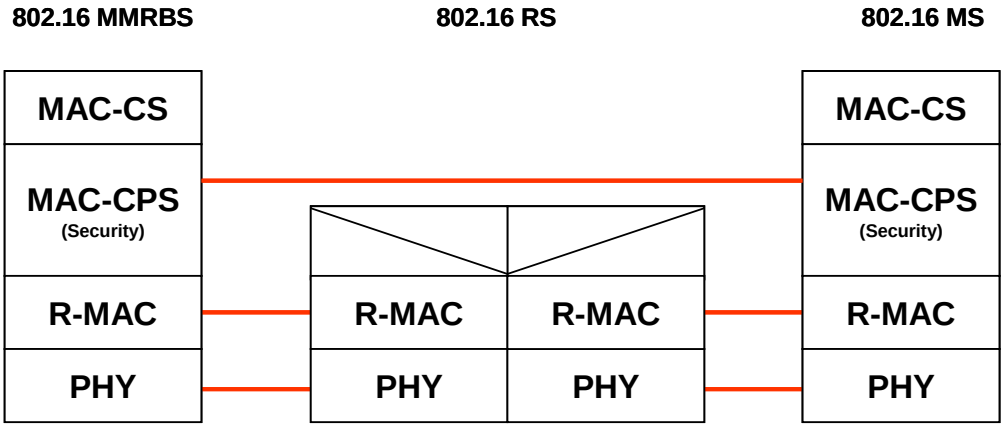

Figure 1. Protocol stack

The R-MAC header shall be designed to include the following fields to enable variety of data forwarding schemes:

- Routing control method field
  - Indicate T-CID based or destination RSID/CID based or source routing based or other routing method
- QoS control method
  - Indicate source QoS based or CID based or T-CID based or other QoS control method

Following figures illustrate the data concatenation and variety routing/QoS control scheme implementations.

Figure 2. System example.

Figure 2 shows the system example where MS1 and MS2 are attached with RS 2. MS1 has three connections (CID 11, CID 12 and CID 13) are established and MS2 has three connections established (CID21, CID22 and CID23). All of these 6 connections have the same QoS requirement.

Figure 3 shows a R-MAC PDU example of T-CID based (distributed QoS and routing control) scheme.

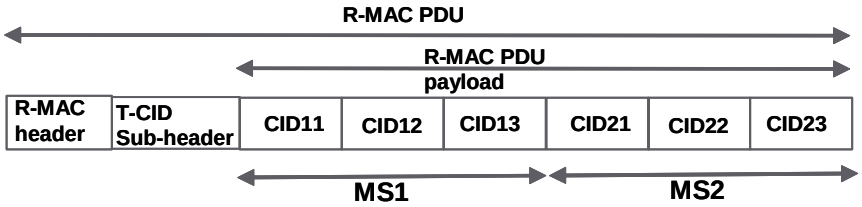

Figure 3. R-MAP PDU for T-CID based data forwarding scheme.

Figure 4 shows a R-MAC PDU example of QoS sub-header (centralized QoS control) and destination RS (distributed routing control) based scheme.

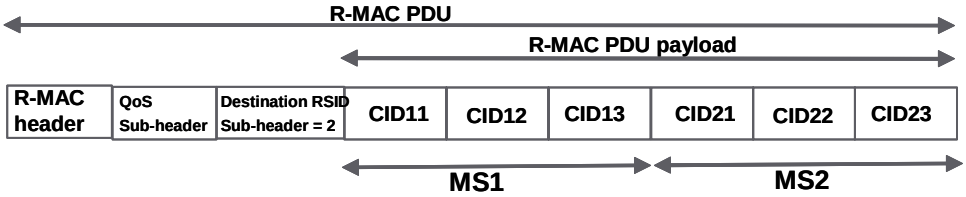

Figure 4. R-MAC PDU for centralized Qos control and distributed (destination RSID) based data forwarding scheme.

Figure 5 shows a R-MAC PDU example of source QoS and source routing control based (centralized QoS and routing control) scheme.

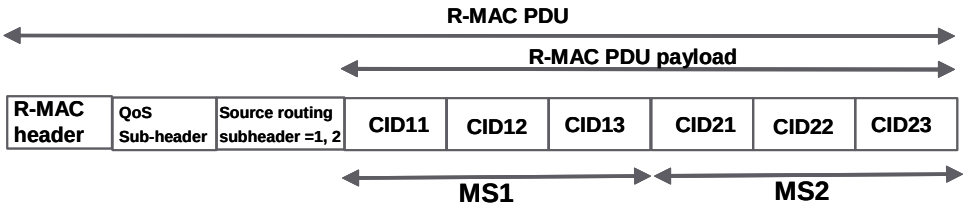

Figure 5. R-MAC PDU for centralized QoS and routing control data forwarding scheme.

3 Proposed text modification

In section 3.1, we propose the following text modifications to the 802.16e standard to include the R-MAC header and subheader format.

For the 802.16j data protocol stack and data forwarding schemes negotiation between MR-BS and RS during RS initial network entry are proposed in separate contributions [2][3].

3.1 R-MAC PDU format

++++++++++++++++++ Start Text ++++++++++++++++++++++++++++++++++

[Insert the following text after the section 6.3.2.1.2]

6.3.2.1.3 DL R-MAC header format

Two types of R-MAC headers are defined. Type 1 R-MAC header is used for data forwarding. A R-MAC PDU with payload contains type 1 R-MAC header, may include one or more subheader(s) and payload. Type 2 R-MAC header is a control header and a corresponding R-MAC PDU only contains a header, may include one or more subheader(s) and no payload.

6.3.2.1.3.1 Type 1 R-MAC header format

The format of type 1 R-MAC header is shown in Figure xxx.

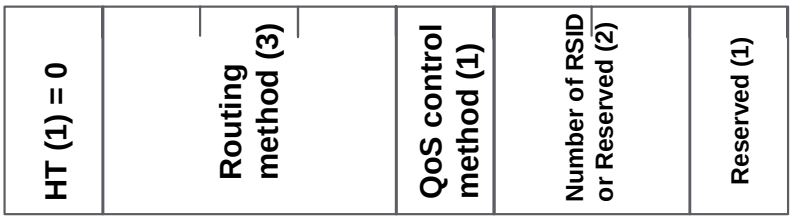

Figure xxx. Type 1 R-MAC header format

The fields of type 1 R-MAC header are described in Table xx.

Table xx. Type 1 R-MAC header fields.

Name	Length (bits)	Description
HC	1	R-MAC header control 0= Type 1 header (header with payload)
Routing control method	3	Routing control method indicator 000: T-CID based 001: destination RSID based 010: destination CID based 011: source routing based 100-111: reserved
QoS control method	1	QoS control method indicator 1: source QoS control based 0: reserved
Number of RSID	2	If the routing control method indicator = 011, this field is used to indicate the number of RSID in the source routing subheader Otherwise this field is reserved for future use
Reserved	1	Reserved

6.3.2.1.3.2 Type 2 R-MAC header format

The type 2 R-MAC header is used for variety RS related control functions.

The format of type 2 R-MAC header is shown in Figure xxx.

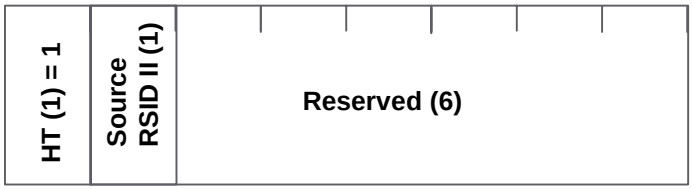

Figure xxx Type 2 R-MAC header format

The fields of type 2 R-MAC header are described in Table xx.

Table xx. Type 2 R-MAC header fields.

Name	Length (bits)	Description
HC	1	R-MAC header control 1 = Type 2 header (control header)
Source RSID II	1	Sourece RSID Inclusion Indicator 1: Source RSID subheader is included in this R-MAC PDU 0: Rserved
Reserved	6	Reserved

6.3.2.1.4 R-MAC subheader format

6.3.2.1.4.1 T-CID subheader

If the routing control method field in the R-MAC header is set to 000, the T-CID subheader shall present and immediately follow the R-MAC header.

T-CID subheader format is shown in Table xxx. The T-CID is a 16-bit tunneling connection ID assigned between MMR-BS and a RS.

Table xxx. T-CID subheader format.

Syntax	Size	Notes
T-CID	16	

6.3.2.1.4.2 Destination RSID subheader

If the routing control method field in the R-MAC header is set to 001, the destination RSID subheader shall present and immediately follow the R-MAC header. This subheader indicates the ID of the RS to which the payload of this R-MAC PUD is destinated (last node in data forward path). The Destination RSID subheader is shown in Table xxx.

Table xxx. Destination RSID sub-header format.

Syntax	Size	Notes
Destination RSID	8	RS ID assigned at RS initial network entry and re-entry

6.3.2.1.4.3 Destination CID subheader

If the routing control method field in the R-MAC header is set to 010, the destination CID subheader shall present and immediately follow the R-MAC header. This subheader indicates basic CID of the RS to which the payload of this R-MAC PUD is destinated (last node in data forward path). The Destination CID subheader is shown in Table xxx.

Table xxx. Destination CID sub-header format.

Syntax	Size	Notes
Destination CID	16	Basic CID of destination RS assigned at RS initial network entry and re-entry

6.3.2.1.4.4 Source routing subheader

If the routing control method field in the R-MAC header is set to 011, the Number of RSID in the source subheader is also indicated in the field of ‘Number of RSID’ in the R-MAC header. The Source routing subheader includes one or multiple RSID(s). The order of those RSID(s) shall be arranged as that the first one is corresponding to the RSID of the next hop RS in the path and the last one is corresponding to the RSID of the destination RS. The Source routing subheader is shown in Table xxx.

Table xxx. Source routing subheader format.

Syntax	Size	Notes
RSIDs	8 x Number of RSID defined in the Number of RSID field in R-MAC header	This field includes one or multiple RSID(s). The order of those RSID(s) shall be arranged as that the first one is corresponding to the RSID of the next hop RS in the path and the last one is corresponding to the RSID of the destination RS.

6.3.2.1.4.5 QoS subheader

If the QoS control method field in type 1 R-MAC header is set to 1, a QoS subheader presents in the R-MAC PDU and shall be the last subheader in the R-MAC PDU. This subheader is used for source QoS control and is inserted by the station which creates a R-MAC PDU. Such a station can be a MMR-BS for DL data transmission or an access relay station for UL data relay. The QoS subheader is shown in Table XXX.

Table xxx. QoS subheader format.

Syntax	Size	Notes
QoS subheader	8	Deadline for delivery to MS (DL) or MMRBS (UL) in terms of frame number (8 LSB)

6.3.2.1.4.5 Source RSID subheader

The Source RSID subheader, if presents, shall follow the type 2 R-MAC header (control header). This subheader is used for a sender station (RS/MMR-BS) to indicate the source of this R-MAP PDU. The source RSID subheader is shown in Table XXX.

Table xxx. Source RSID subheader format.

Syntax	Size	Notes
Source RSID	8	RS ID assigned at RS initial network entry and re-entry

++++++++++++++++++++++ End Text ++

4 Reference

[1] Hang Zhang et al “Introduction of RS ID”, IEEE C802.16j-07/095
[2] Hang Zhang et al “RS Initial Network Entry”, IEEE C802.16j-07/097
[3] Hang Zhang et al “ MMR Protocol Stack and Definition of RS Types ”, IEEE C802.16j-07/096