Project	IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>
Title	An efficient relay path management scheme for IEEE 802.16j
Date Submitted	2006-11-07
Source(s)	David Comstock, John Lee, Shang Zheng, Aimin Zhang Huawei Technologies No.98, Lane91, Eshan Road, Shanghai, P.R.C dcomstock@huawei.com Voice: +1 858 735 9382
Re:	IEEE 802.16j-06/027: “Call for Technical Proposals regarding IEEE Project P802.16j”
Abstract	This document proposes a relay path management scheme to support multi-hop relaying.
Purpose	This contribution is submitted for discussion and adoption in 802.16j.
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>.

An efficient relay path management scheme for IEEE 802.16j

David Comstock, John Lee, Shang Zheng, Aimin Zhang
Huawei Technologies Co. Ltd

1 Introduction

A tree-like system topology is considered in this contribution. Figure 1 shows the topological constructs from the 802.16j Usage Models document [1] .

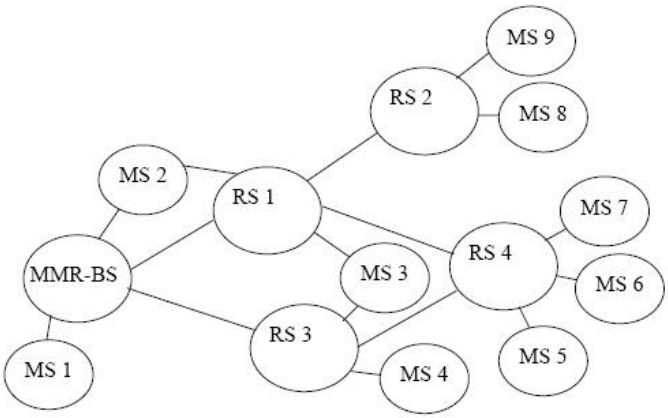

Figure 1: Multi-hop relay topological constructs

According to the 802.16j terminology document [2], a relay path is a

“Concatenation of k consecutive relay links (k >= 1) between the MMR-BS and the designated access RS”.

In the uplink transmission an intermediate RS simply delivers the MAC PDU (MPDU) to its access station. In the downlink, an RS delivers an MPDU to the next-hop RS in the associated relay path. For the downlink transmission, therefore, the next-hop RS selection should be based on a routing database and the relay path setup and management procedure amounts to a routing database management procedure.

The basic requirements on relay paths are as follows:

(a) Data belonging to different transport connections can travel along the same relay path since there are many MSs associated with the same RS.

(b) Data belonging to the same transport connection can simultaneously travel along different relay paths. The IEEE 802.16j technical requirement document [3] specifies that “The specification shall define a mechanism to select, set up and maintain one or more multi-hop paths between an MMR-BS and MS”.

(c) Data belonging to different connections but destined to the same MS can travel along different paths for load balancing or other purposes.

This system topology might be very complex and dynamic due to the mobility and the powering-on and off of the RSs. Therefore, a high efficient and effective path management scheme is proposed.

2 Path Management Scheme

Figure 2 shows an illustration of multiple relay paths.

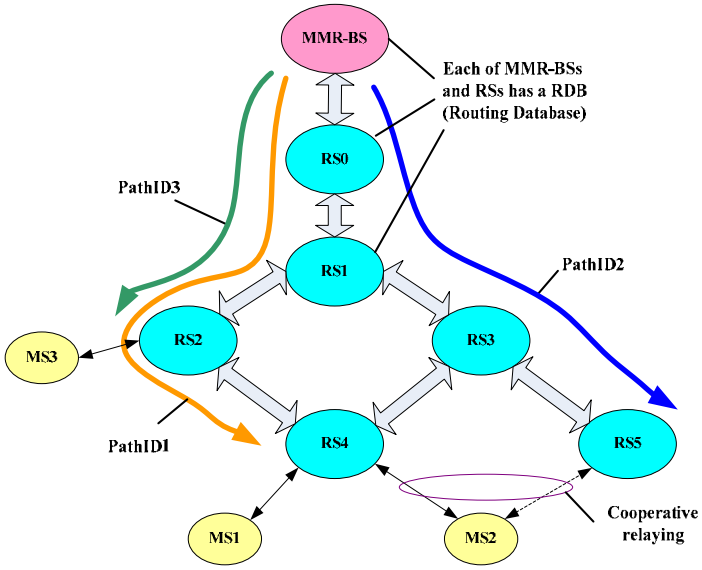

Figure 2: Multi-hop relay paths

Relay path ID (RPID) is used to identify a relay path within an MMR-cell. Once a relay path is setup, it is assigned a relay path ID and all changes on that relay path (such as path selection, path adding, path deletion etc.) can be based on the relay path ID instead of using a list of explicit RS IDs which has too much overhead.

Each MMR-BS and RS has a RDB (Routing Database). The RDB provides the mapping between CIDs, relay path IDs, and the next-hop RS ID. The RDB structure is shown in Figure 3.

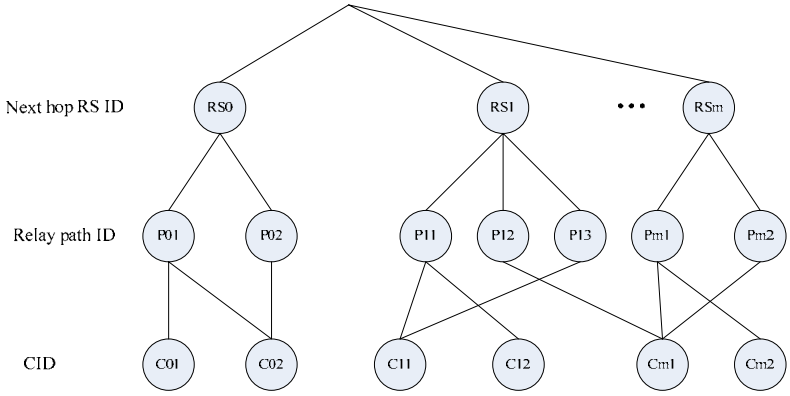

Figure 3: Structure of routing database

In the RDB, one CID may be associated with one or several relay path IDs. One relay path ID is associated with one next-hop RS ID and one next-hop RS ID may be associated with several relay path IDs. The set of relay path IDs associated with different next-hop RS ID cannot intersect. The next-hop RS ID with a null value means that the corresponding relay path IDs terminate at current RS, no RS is needed in the next hop.

When a RS receive a MAC PDU, it should compare the CID in a MAC PDU with the CID in its own RDB to determine

whether the PDU should be relayed or not and where be relayed.

The relay path setup and management procedure is a routing database update procedure. Updating RSs' routing databases is triggered by events in the network.

2.1 Triggering conditions for routing database update

Since the MPDU routing is based on the CID field in the MPDU header, the routing database update should be triggered when one of the following events occurs:

(a) MS/RS network entry;

(b) Establishment of secondary management connection;

(c) MS handover;

(d) MS de-registration;

(e) DSA (Dynamic Service Addition)

(f) DSD (Dynamic Service Deletion)

(g) BS detection of MS connection lost;

(h) BS decision to change the relay path of certain CID for load balancing or other purposes.

2.2 RDB (Routing Database) update procedure

When a triggering condition occurs, the MMR-BS should initiate the routing database update procedure, which is comprised of the following steps:

(a) MMR-BS generates a relay path update command according to the triggering condition to update each affected RS's RDB;

(b) MMR-BS transmits the relay path update command in a relay path update message to the first-hop RS such that each affected RS is reached;

(c) When an RS receives a relay path update command, it performs the following:

(d) Updates its RDB according to the command,

1) Modifies the command by removing the information that is only relevant for itself in order to reduce the bandwidth of the command,

2) Transmits the command to the appropriate next-hop RS.

This procedure continues until the relay path update command reaches the final RS, i.e., the RS at the end of the relay path.

(e) The final RS updates its RDB accordingly, then generates a relay path update feedback message and transmits it to the MMR-BS.

(f) The relay path update procedure is successful when the MMR-BS receives a relay path update feedback message with a positive acknowledgement.

The MMR-BS can aggregate multiple relay path update commands with overlapping relay paths in a relay path update message to save bandwidth. When the paths of different relay path update commands in the same message divaricates in an RS, the RS separates the relay path update commands into different messages and transmits them to the appropriate next-hop RSs.

2.3 MAC management messages

The MAC management messages for path management are as followings:

The PATH-Update-REQ message can perform the following functions in one message

- Add associated CIDs to an already existing path.
- Add a new relay path (from scratch or based on an existing path) including CID associations
- Delete an existing path.
- Delete CIDs associated with a path.

The PATH-Update-Feedback message can provide the following information in one message

- Which paths were successfully added, deleted, or modified.
- For paths that were not successfully added, deleted, or modified, an error code is provided for each CID that was the source of a problem.

3 Text to be inserted into standard

----------Beginning of Text Changes----------

6.3.2.3 MAC management messages

6.3.2.3.xx Path Update Request (PATH-Update-REQ) message

Temporary Table 1 PATH-Update-REQ Message Format

Syntax	Size (bits)	Notes
Management Message Type= PathUpdate	8	
Transaction ID	16	
Path_Update_Indicator	2	Bit#0=1: including new path to be added Bit#1=1: including paths to be deleted
if(Path_Update_Indicator[0] = 1)		
{		
Add_Path_Num	4	Number of paths need to be added
for i = 1 to Add_Path_Num		
{		
Add_Path_Indicator	2	Bit#0=1: the added path is a new path and utilized an existing path Bit#1=1: the added path is a new path and including detail path info Bit#0=0, Bit#1=0: Add CIDs to a existing path or added path is a new

		path which does not utilize existing path info and include detail path info (This case is happened when the next hop of the path update message is the target node)
Add_PathIDi	8	Added Path ID
Add_CID_Num	4	
for j = 1 to Add_CID_Num		CID list with same path
{		
Add_CIDj	16	
}		
if (Add_Path_Indicator[0] = 1)		
{		
Overlapped_PathID	8	The overlapped parts between new path and existing path
}		
if (Add_Path_Indicator[1] = 1)		Detail path info
{		
Add_RSID_Num	4	The number of RSID in the RSID list for the relay path
for j = 1 to Add_RSID_Num		
{		Detail RSID list
Add_RSIDj	6	
}		
}		
}		
}		
if(Path_Update_Indicator[1] = 1)		Including paths needed to be deleted
{		
Del_Path_Num	4	Number of path to be deleted

for i = 1 to Del_Path_Num		The paths to be deleted list
{		
Del_Path_Indicator	2	0x0: Delete the whole path 0x1: Delete the appointed CIDs in the path 0x2: Delete all CIDs except appointed CIDs 0x3: Delete all CIDs in the path but keep the path ID
Del_PathIDi	12	
if(Del_Path_Indicator = 0x1)		
{		
Del_CID_Num	4	The number of CIDs to be deleted in the path
for j = 1 to Del_CID_Num		
{		The CID list to be deleted in the path
Del_CIDj		
}		
}		
else if(Del_Path_Indicator = 0x2)		
{		
Keep_CID_Num	4	The number of CIDs to be kept in the path
for j = 1 to Keep_CID_Num		
{		
Keep_CIDj		The CID list to be kept in the path
}		
}		
}		
}		
Padding bits		

6.3.2.3.xy Path Update Feedback (PATH-Update-RSP) message

Temporary Table 2. PATH-Update-RSP Message Format

Syntax	Size (bits)	Notes
Message Type = PathUpdateFeedback	8	
Transaction ID	8	
PathUpdate_Feedback_Indicator	2	Bit#0=1: Including feedback for a new added path Bit#1=1: Including feedback for a deleted path
If (PathUpdate_Feedback_Indicator[0] = 1)		
{		
Add_Path_Num	4	Number of added path in the message
for i = 1 to Add_Path_Num		
{		
Add_PathIDi	8	Added path ID
Add_Status	1	The feedback for the added path ID
If(Add_Status = NAK)		
{		
Add_Bitmap	Variable	Feedback for each CID, the length of Bitmap equal to the length of CID list in the rout update message
for i = 1 to #NAKsInAddBitmap		The number of NAK in the Add_Bitmap
{		
Add_Error_Code	2	Error code for the NAK
}		
}		
}		
}		
if(PathUpdate_Feedback_Indicator[1] = 1)		Including feedback for the deleted path

{		
Del_Path_Num	4	
for j = 1 to Del_Path_Num		
{		
Del_PathIDj	8	Deleted Path ID
Del_Status	1	Feedback for the deleted path
If(Del_Status = NAK)		
{		
Del_Bitmap	Variable	Feedback for each CID, the length of Bitmap equal to the length of CID list in the rout update message
for i = 1 to #NAKsInDelBitmap		Number of NAK in the Del_Bitmap
{		
Del_Error_Code	2	Error code for the NAK
}		
}		
}		
}		
Padding bits		

6.3.25 Relay path management and routing

6.3.25.1 Relay Path ID and Routing Database

Relay path ID (RPID) is used to identify a relay path within an MMR-cell. Once a relay path is setup, it is assigned a relay path ID and all changes on that relay path (such as path selection, path adding, path deletion etc.) can be based on the relay path ID.

Each MMR-BS and RS has a RDB (Routing Database). The RDB provides the mapping between CIDs, relay path IDs, and the next-hop RS ID. The RDB structure is shown in Figure XXX.

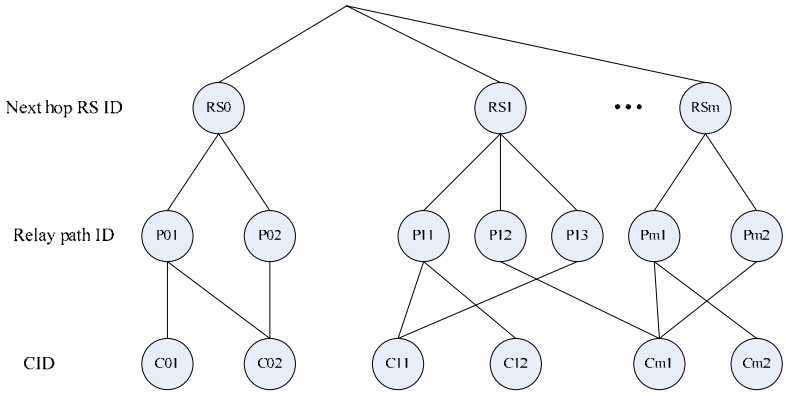

Figure XXX: Structure of routing database

In the RDB, one CID may be associated with one or several relay path IDs. One relay path ID is associated with one next-hop RS ID and one next-hop RS ID may be associated with several relay path IDs. The set of relay path IDs associated with different next-hop RS ID cannot intersect. The next-hop RS ID with a null value means that the corresponding relay path IDs terminate at current RS, no RS is needed in the next hop.

When a RS receive a MAC PDU, it should compare the CID in a MAC PDU with the CID in its own RDB to determine whether the PDU should be relayed or not and where be relayed.

The relay path setup and management procedure is a routing database update procedure. Updating RSs' routing databases is triggered by events in the network.

6.3.25.2 Triggering conditions for routing database update

Since the MPDU routing is based on the CID field in the MPDU header, the routing database update should be triggered when one of the following events occurs:

(a) MS/RS network entry;

(b) Establishment of secondary management connection;

(c) MS handover;

(d) MS de-registration;

(e) DSA (Dynamic Service Addition)

(f) DSD (Dynamic Service Deletion)

(g) BS detection of MS connection lost;

(h) BS decision to change the relay path of certain CID for load balancing or other purposes.

6.3.25.3 RDB (Routing Database) update procedure

When a triggering condition occurs, the MMR-BS should initiate the routing database update procedure, which is comprised of the following steps:

(a) MMR-BS generates a relay path update command according to the triggering condition to update each affected RS's RDB;

(b) MMR-BS transmits the relay path update command in a relay path update message to the first-hop RS such that each affected RS is reached;

(c) When an RS receives a relay path update command, it performs the following:

(d) Updates its RDB according to the command,

1) Modifies the command by removing the information that is only relevant for itself in order to reduce the bandwidth of the command,

2) Transmits the command to the appropriate next-hop RS.

This procedure continues until the relay path update command reaches the final RS, i.e., the RS at the end of the relay path.

(e) The final RS updates its RDB accordingly, then generates a relay path update feedback message and transmits it to the MMR-BS.

(f) The relay path update procedure is successful when the MMR-BS receives a relay path update feedback message with a positive acknowledgement.

4 References

[1] Jerry Sydir, et. al., Harmonized Contribution on 802.16j (Mobile Multihop Relay) Usage Models, IEEE 802.16j-06/015.

[2] Roger Peterson, et. al., Harmonized definitions and terminology for 802.16j Mobile Multihop Relay, IEEE 802.16j-06/014.

[3] Hyunjeong Kang, et. al., Proposed Technical Requirements for IEEE 802.16 Relay TG, IEEE 802.16j-06/016.