This proposal describes multiple frame operation for MMR-BS and RS

MMR-BSs scheduling procedures and RSs response methods to the frame reception for multiple frame operation for the IEEE802.16 Relay TG

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.

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.

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>.
I. Introduction

So far, various approaches in relaying frame signal have been proposed. Except some proposals introducing additional RF channels in MMR network, we could categorize frame relay methods into two groups. The first is sub-frame partitioning in which a DL or an UL sub-frame is subdivided into sub-frame sectors for the hop links. A relay station may receive DL/UL bursts in the previous sub-frame sector and retransmit it onto the next link in the next sub-frame sector in the same frame. Using this method, most of proposed frame usages limit the maximum multi-hop capability to 2 or 3 hops because the frame header delivery can not be guaranteed. Furthermore many of these approaches assume analog repeating or direct transfer for the header(eg.MAP) of the frame to MS. These situations may affect various usage models and its extensions.

The second one is frame-by-frame relaying in which a relay station receives the whole-frame at current frame time period and retransmits it onto the next link at the subsequent frame time period.

Problems in Frame-by-Frame relaying
But this frame-by-frame relaying approach causes mutual interference between MMR-BS and RS, or RSs if the first and second frame signals are not same. Furthermore, in the real MMR environment, an MS can hear the different signals from BS and multiple RSs. It may cause multiple interferences to the MS especially in the MS or RS physical cell boundary which is widely spread within MMR cell coverage.

Problems in Sub-frame Partitioning
This approach has great advantage in utilization of AMC scheme and short relay delay. But multiple analog repeating cause SINR degradation and consequently limit hop distance. The other disadvantage is that this approach requires decoding/coding latency in the burst period.

II. Purpose

- to alleviate maximum hopping count limit for enhancement of network deployment flexibility
- to eliminate mutual interference b/w MMR-BS and RS, or b/w RSs
- to minimize the revision of legacy BS in PHY, MAC
- to simplify RS design variation from BS

III. Proposal for Multi-frame Operation

1. Overview

(1) Multi-frame concept
- A Multi-frame consists of \( L \) subsequent frames

\[
\text{LMF: length of Multi Frame} \\
\text{LMF=3 | LMF=1 | LMF=1 | LMF=4 | LMF=2 | LMF=3} \\
\text{frame | frame | frame | frame | frame | frame | frame | frame | frame | frame | frame | frame | time}
\]

(2) Dynamic Multi-frame according to MMR topology and load
The length of Multi-frame (LMF) is determined before the Multi-frame start time, in consideration of topology and traffic load.

\[ LMF = \text{the length of Multi-frame} = \max(MHR+1, 2 \times MHM - 1) \]

- **MHR**: the maximum hop distance of active RSs
- **MHM**: the maximum hop distance of MSs who have at least one UL burst at start of Multi-frame

**Example:**
- if no RS in a cell, \( LMF = \max(0+1, 2-1) = 1 \)
- else if there exist 1-hop RSs and 2-hop MSs {
  - if at least an MS has UL data to send, \( LMF = \max(1+1, 2 \times 2 - 1) = 3 \)
  - else no RS has UL data to send, \( LMF = \max(1+1, 0) = 2 \)
}

(3) Sample topology

![Diagram](image)

(figure 1) sample network topology and frame transmissions while \( k \)\textsuperscript{th} frame transmission at MMR-BS

In figure 1, let \( k \) be the elapsed number of frames from the Multi-frame have been started. Then \( k \) shall be in the range of \( 1 \leq k \leq LMF \) (length of Multi-frame). Furthermore, \( k \) shall be renewed and \( LMF \) shall be re-calculated before every Multi-frame starts. The \( h \)-hop RSs could start to transmit the frame after \( h \)-frame time passed from the frame transmission of MMR-BSs in accordance with the Multi-frame control message of received Multi-frame.

(4) Use of identical frame header
- Frame control header contains FCH and MAP (or DCD and UCD)
- apply identical frame control header to all the frames in a Multi-frame except for the frame number.
- no collision arises at identical frame control header though MMR-BS and RSs transmit different frames at the same time.
- RS ignore a burst if the burst is not related to the RS’s subordinates.

(5) Hop Channel (HC) Assignment example

(6) Link Flows example for the Sample topology
(direction, frame-time, Hop channel)
3. Main control flow for a Multi-frame in MMR-BS

- **Multi-frame start**
- Decide the length of MF using topology and load
- Assign a DL RS-CMD channel & UL RS-RPT channels
- Assign DL/UL Hop channel, DL/UL Management Channels
- Build RS-CMD message including:
  - (i) SF start frame number
  - (ii) SF end frame number
- Create common frame control information (MAP, FCH) applicable to all frames in the multi-frame
- Transmit/receive the frame and its contents
- **Multi-frame end**
4. RS Operation

<frame retransmission at the subsequent frame>

1. Wait for a frame header
2. Check CRC ok?
   - Yes: Change the frame number to the next number, reassemble new header
   - No: Check frame header transmission condition at the next frame time
3. Yes: Transmit the frame header in frame synch. to the MMR-BS
4. No: Wait for a frame header

<DL burst retransmission at the subsequent frame time at RS>

1. Wait for decision of frame header transmission
2. Exist DL bursts of own subordinates?
   - Yes: Transmit received bursts timely
   - No: Wait for decision of frame header transmission
<UL burst retransmission at the subsequent frame time at RS>

wait for a frame header from the superordinate

exist UL burst from own subordinate?

Yes

prepare the UL data and control bursts

transmit UL bursts transmit in the UL burst channels timely

No

<UL Ranging information relay at RS>

wait for UL ranging and control info. from MSs

reformat update the received info.

exist UL RS report channel?

send the info. using the RS report channel

IV. Advantage
o adaptive throughput enhancement using dynamic frame utilization. If there are a few active RSs, the throughput converges into legacy system.
o elimination of mutual interference b/w MMR-BS and RS, or b/w RSs
o minimal changes in legacy BS in S/W, no change in PHY/MAC of legacy BS.
o common control signal of MMR-BS needs not to be strong and safe. (eg. MAP, UL ranging)

V. Related ToC

6.3.2.3 MAC management message
6.3.6.7.2 Centralized scheduling
6.3.26 Relay Operation for Multi-frame Mode (appended subsection)

VI. Text Proposal

+++-----------------------------------+++.........................................................

6.3.2.3 MAC management message

Append following two rows into Table 14:

<table>
<thead>
<tr>
<th>Type</th>
<th>Message name</th>
<th>Message description</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>??70</td>
<td>RLY-CMD</td>
<td>Relay Request</td>
<td>Basic</td>
</tr>
<tr>
<td>??71</td>
<td>RLY-RPT</td>
<td>Relay Report</td>
<td>Basic</td>
</tr>
</tbody>
</table>

Append following text into subsection of 6.3.2.3

6.3.2.3.??70 Relay command message

The same RLY-CMD messages shall be transmitted to the relay group by MMR-BS at every frame within the corresponding Multi-frame.

Table xx --- RLY-CMD message format

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLY-CMD_message_format()</td>
<td></td>
<td>To multicast id of relay group</td>
</tr>
<tr>
<td>_Management Message Type = ??70</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>_Multi-frame Identification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>_Start frame number</td>
<td>8</td>
<td>The least significant 8 bits</td>
</tr>
<tr>
<td>_End frame number</td>
<td>8</td>
<td>The least significant 8 bits</td>
</tr>
<tr>
<td>_N_Relays</td>
<td>8</td>
<td>The number of relays to be received a command body</td>
</tr>
<tr>
<td>_For (i=0; i&lt; N_Relays; i++)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>____CID</td>
<td>16</td>
<td>Relay CID</td>
</tr>
<tr>
<td>____Length of command body</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>____Command Body</td>
<td>variable</td>
<td>Command dedicated to specific RS</td>
</tr>
<tr>
<td>____Padding</td>
<td>v</td>
<td>Number of bits required to align to byte length. Shall be set to zero.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
An MMR-BS generates RLY-CMDs in the format shown in Table xx, including all of the following parameters:

**Start frame number**
Start frame number of current Multi-frame. The value is the least significant 8 bits of the start frame

**End frame number**
End frame number of current Multi-frame. The value is the least significant 8 bits of the end frame

**Command Body**
This parameter reserved for future use of higher layer. It may contain routing information to specific RS or RS’s behavior to MS’s association.

Append following text into subsection of 6.3.2.3

### 6.3.2.3.??71 Relay report message

A RLY-RPT message shall be transmitted by an RS using UL burst allocation to the RS. An RS shall generate RLY-RPT in the form shown in Table yy.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLY-RPT_message_format()</td>
<td></td>
<td>From RS via UL unicast</td>
</tr>
<tr>
<td>Management Message Type</td>
<td>8</td>
<td>Length of report body</td>
</tr>
<tr>
<td>Length of report body</td>
<td>4</td>
<td>Length of the slot</td>
</tr>
<tr>
<td>Report Body</td>
<td>variable</td>
<td>Number of bits required to align to byte length. Shall be set to zero.</td>
</tr>
<tr>
<td>Padding</td>
<td>v</td>
<td></td>
</tr>
</tbody>
</table>

**Report Body**
This parameter is reserved for future use. It may contain ranging information from MSs and/or neighbor information.

6.3.6.7.2 Centralized scheduling

*Append following sentences in section 6.3.6.7.2*

1. **Multi-frame Mode (optional)**
   A Multi-frame(MF) is comprised of a set of subsequent frames according to network topology and traffic load. Before issuing a Multi-frame, an MMR-BS should determine the length of next Multi-frame, total number of frames in the Multi-frame, and assign Hop Channel in it with reference to the routing topology and traffic load. The routing topology will be maintained by path management described in 6.3.25. The Multi-frame mode is based on frame by frame relaying principle. So the length of Multi-frame should guarantee burst delivery from/to the designated MS.

   The Length of Multi-frame (LMF) may be calculated as follows:
LMF = max. \( (MHR+1, 2*MHM - 1) \)

where,

- \( MHR \) = the maximum hop distance of connected RSs within the MMR network
- \( MHM \) = the maximum hop distance of MSs who have at least one UL burst which is supposed to be served by MMR-BS at the start of MF

A hop channel is a collection of bursts defined within a Multi-frame, for a relay path. The bursts for the channel have to locate same position and to have the same MCS in each frame of the Multi-frame, so that the FCH and MAP message shall be the same in each frame excluding frame number.

A hop channel is a collection of bursts defined within a Multi-frame, for a relay path. The bursts for the channel have to locate same position and to have the same MCS in each frame of the Multi-frame, so that the FCH and MAP message shall be the same in each frame excluding frame number.

**Figure xxx---Multi-frame control flow at MMR-BS**

Create following section

6.3.??26 Relay Operation for Multi-frame Mode

6.3.??26.1 Frame relaying at the subsequent frame time at RS

After successful reception of the frame header including Preamble, FCH and MAP for incoming frame at an RS, the RS shall reconstruct the frame with the frame number increased by 1. With the synchronization of the
subsequent frame, the RS shall retransmit the reconstructed frame if the following conditions are met:

C1: the value of modulo $2^8$ of revised frame number is within the Start frame number and End frame number parameter in the RLY-CMD message

C2: there is no DL burst retransmission within the DL burst period of current frame

C3: No UL burst transmission is expected at subsequent frame period.

In the reconstruction of the frame, RS shall follow the procedures of following subsection 6.3.26.2, 6.3.26.3 for DL/UL bursts.

![Diagram](image_url)

**Figure xxx---Frame relaying flow in RS**

**6.3.26.2 DL/UL burst relaying at the subsequent frame time at RS**

DL burst relaying is made only when all the conditions C1, C2, C3 in 6.3.26.1 satisfied and the bursts to be relayed within subsequent frame are related to the RS’s subordinate MSs or RSs.

UL burst relaying should be made at subsequent frame whenever new UL burst was received in current frame.

**6.3.26.3 UL Ranging information relaying at RS**

When ranging information is received from MSs, RS may decode and reassemble into RLY-RPT channels.

If there is no RLY-RPT burst to the RS at subsequent frame period, the RS should store the information for next chance.