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Re:	A response to the call for technical proposals for the Relay TG, see IEEE 80216j-06/027.pdf
Abstract	This proposal describes multiple frame operation for MMR-BS and RS
Purpose	MMR-BSs scheduling procedures and RSs response methods to the frame reception for multiple frame operation for the IEEE802.16 Relay TG
Notice	
Release	
Patent Policy and Procedures	

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>.

Multiple Frame Concept for MMR Operation

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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.

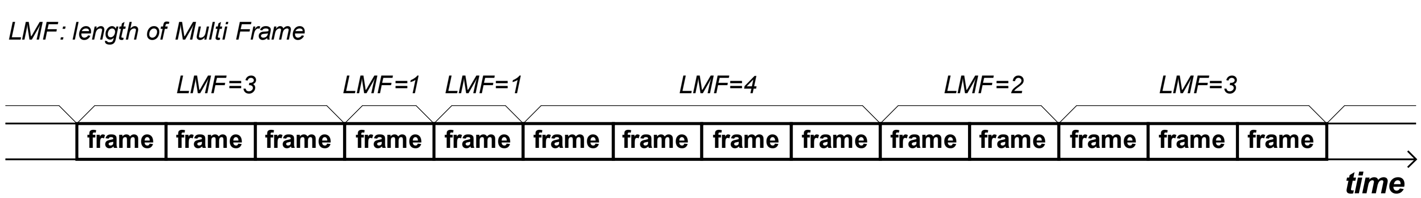
II. Purpose

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



(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 = the length of Multi-frame = max (*MHR*+1, 2 * *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

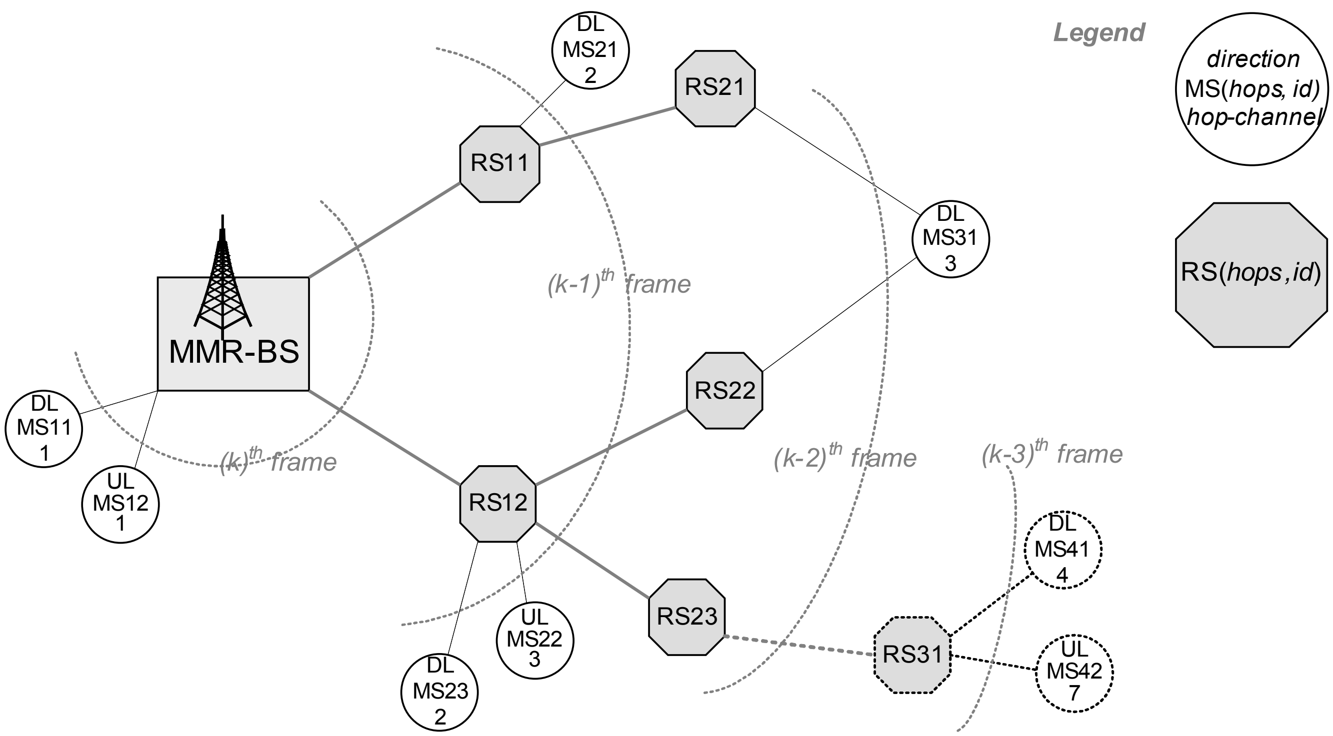
else if there exist 1-hop RSs and 2-hop MSs {

if at least an MS has UL data to send, *LMF* = max (1+1, 2*2-1) = 3

else no RS has UL data to send, *LMF* = max (1+1, 0) = 2

}

(3) Sample topology



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

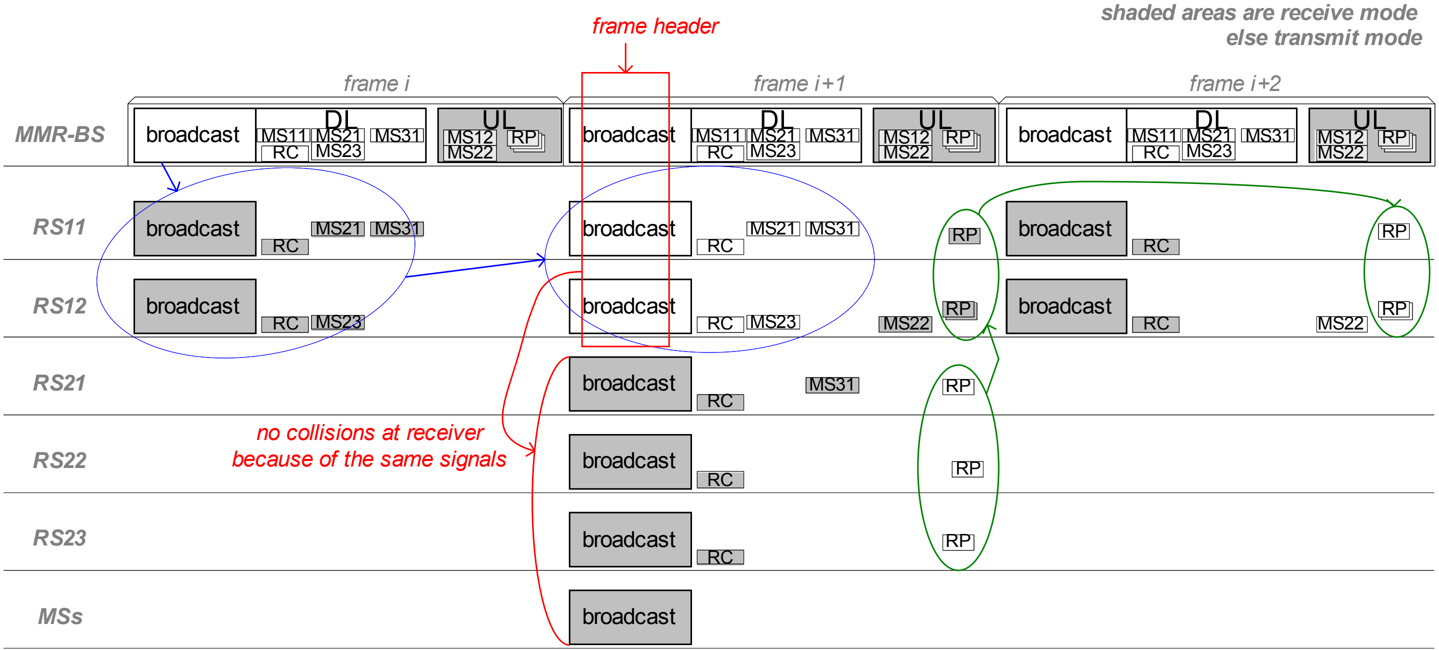
In figure 1, let *k* be the elapsed number of frames from the Multi-frame have been started. Then *k* shall be in the range of $1 \leq k \leq LMF$(length of Multi-frame). Furthermore, *k* shall be renewed and *LMF* shall be re-calculated before every Multi-frame starts.

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)

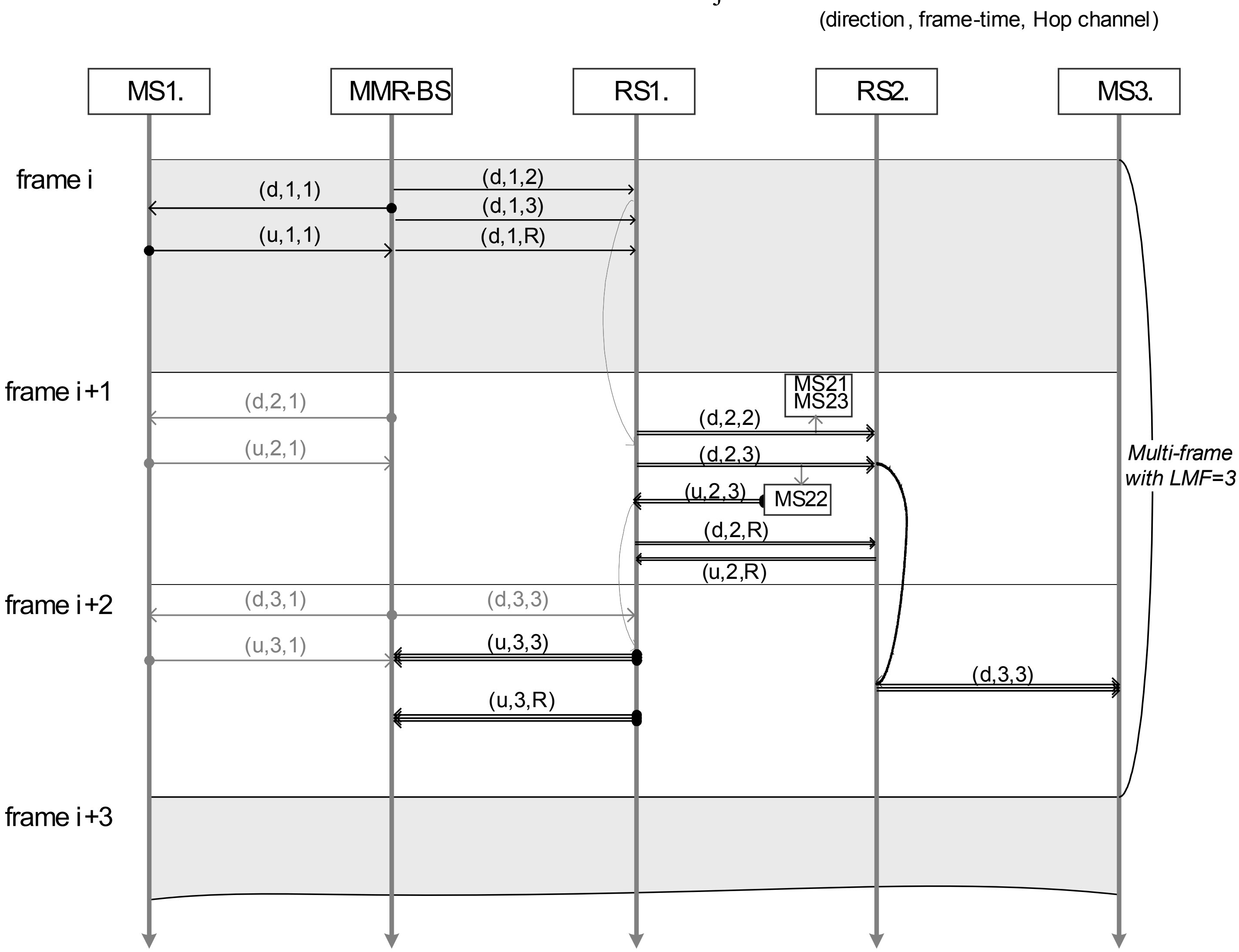
- apply identical frame control header to all the frames in a Multi-frame except for the frame number.
- no collision arises at identical frame control header though MMR-BS and RSs transmit different frames same time.
- RS ignore a burst if the burst is not related to the RS's subordinates.



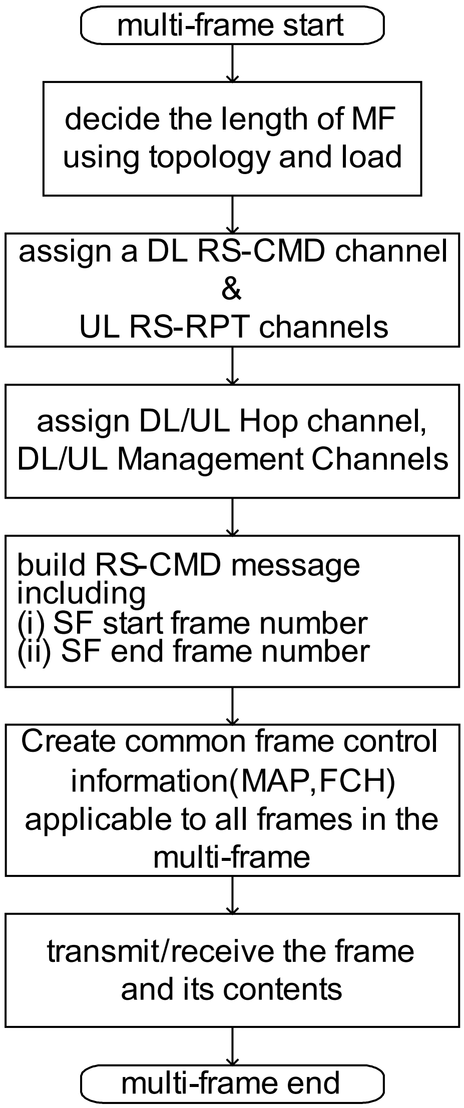
(5) Hop Channel(HC) Assignment example

assignment (hop based)	frame control info.		RS Control	HC1	HC2	HC3	common access	RS Report	HC3	HC1
	Forward to MS						Backward to MMR-BS			
frame i	PR	FCH MAP	BS→RS1.	BS→MS1.	BS→RS1.	BS→RS1.	UL access & control	RS1.→BS	-	MS1.→BS
frame i+1	PR	FCH MAP	RS1.→RS2.	BS→MS1.	RS1.→MS2.	RS1.→RS2.	UL access & control	RS2.→RS1.	MS2.→RS1.	MS1.→BS
⋮										
frame i+L-1	PR	FCH MAP	-	BS→MS1.	-	RS2.→MS3.	UL access & control	RS1.→BS	RS1.→BS	MS1.→BS
	identical at every frame in the super frame excluding frame number		RS control information	may different bursts by frame, in Hop Channel1		should be the same bursts by frame	only for one hop access never used for relay channel	RS control information including access data from MSs	should be the same bursts by frame	may different bursts by frame, in Hop Channel1

(6) Link Flows example for the Sample topology

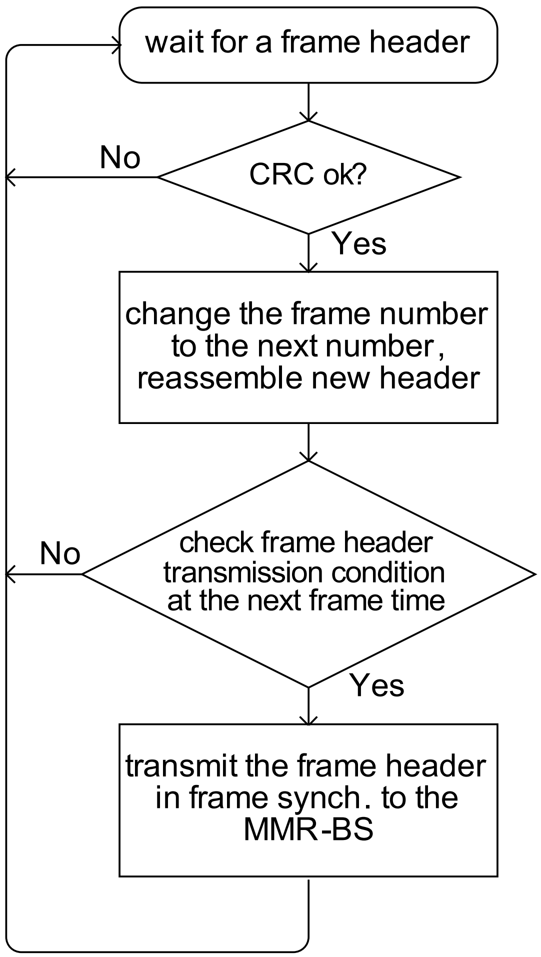

(direction, frame-time, Hop channel)
MS1.
MMR-BS
RS1.
RS2.
MS3.
frame i
(d,1,2)
(d,1,1)
(d,1,3)
(u,1,1)
(d,1,R)
frame i+1
MS21
MS23
(d,2,1)
(d,2,2)
(u,2,1)
(d,2,3)
Multi-frame
with LMF=3
(u,2,3)
MS22
(d,2,R)
(u,2,R)
frame i+2
(d,3,1)
(d,3,3)
(u,3,1)
(u,3,3)
(d,3,3)
(u,3,R)
frame i+3

3. Main control flow for a Multi-frame in MMR-BS

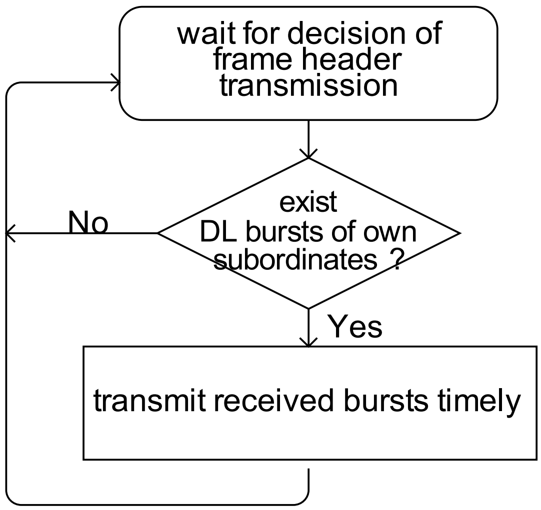


4. RS Operation

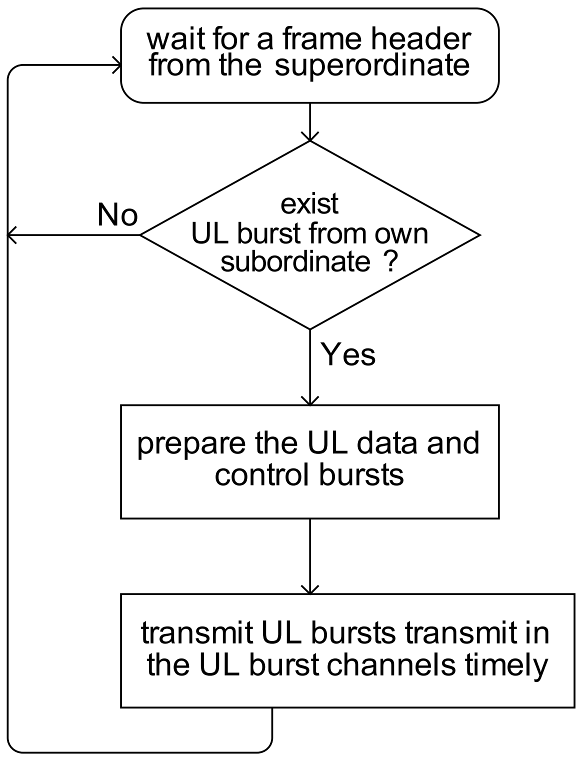
<frame retransmission at the subsequent frame>



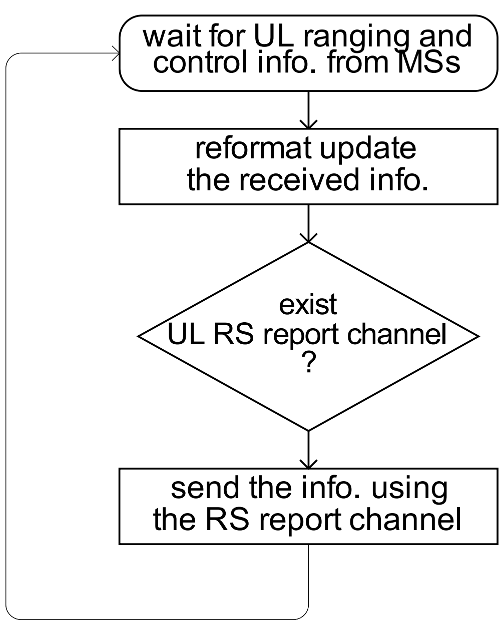
<DL burst retransmission at the subsequent frame time at RS>



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



<UL Ranging information relay at RS>



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

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6.3.2.3 MAC management message

Append following two rows into Table 14:

Type	Message name	Message description	Connection
??70	RLY-CMD	Relay Request	Basic
??71	RLY-RPT	Relay Report	Basic

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

Syntax	Size	Notes
RLY-CMD_message_format() {		To multicast id of relay group
Management Message Type = ??70	8	
Multi-frame Identification		
Start frame number	8	The least significant 8 bits
End frame number	8	The least significant 8 bits
N_Relays	8	The number of relays to be received a command body
For (i=0; i< N_Relays; i++) {		
CID	16	Relay CID
Length of command body	8	
Command Body	*variable*	Command dedicated to specific RS
Padding	v	Number of bits required to align to byte length. Shall be set to zero.
}		
}		

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 yy --- RLY-RPT message format

Syntax	Size	Notes
RLY-RPT_message_format() {		From RS via UL unicast
Management Message Type = ??71	8	
Length of report body	4	Length of the slot
Report Body	*variable*	
Padding	v	Number of bits required to align to byte length. Shall be set to zero.
}		

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.

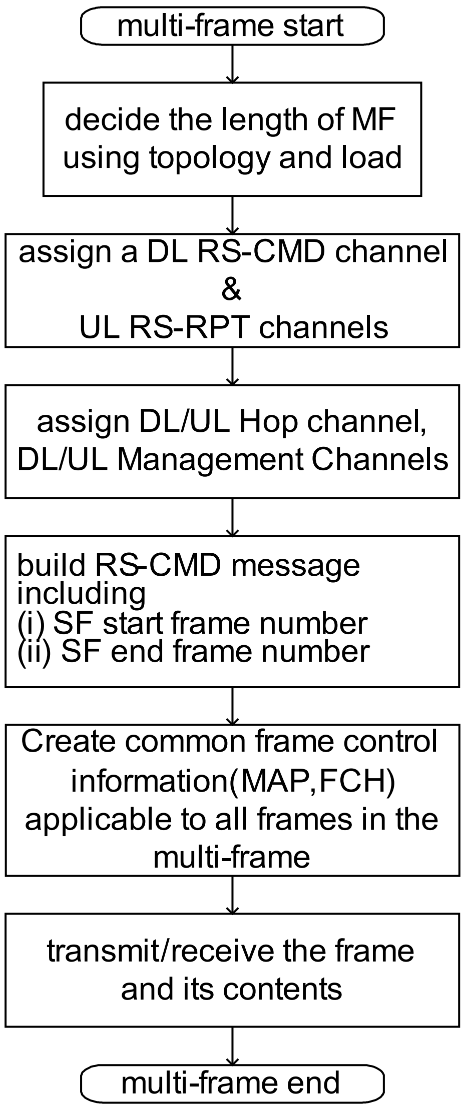

Figure xxx---Multi-frame control flow at MMR-BS

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.

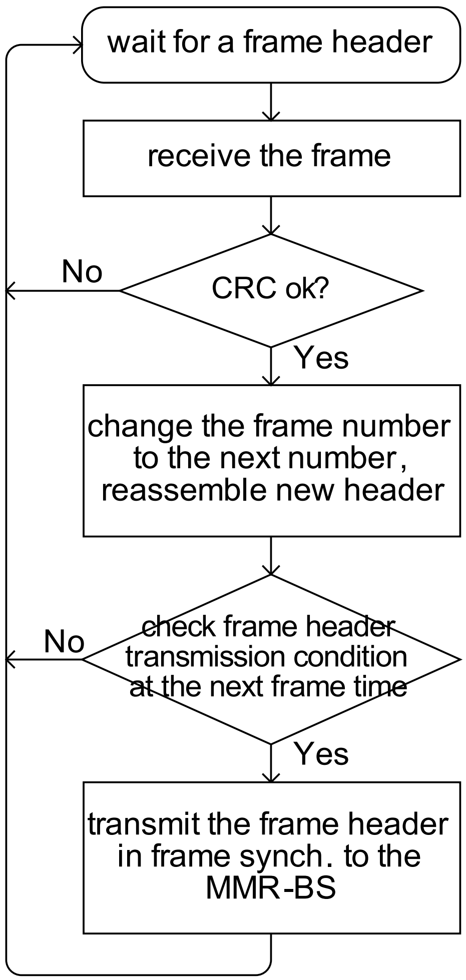

Figure xxx---Frame relaying flow in RS

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.