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Re:	IEEE802.16j-07/019:" Call for Technical Comments Regarding IEEE Project 802.16j"
Abstract	This contribution proposes methods to provide mapping between bandwidth allocation from MAP messages to MAC PDUs at RS when centralized scheduling is used.
Purpose	Discuss and adopt proposed text in TG16j
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MAP and Data Association in RS for Centralized Scheduling

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Introduction

As defined in baseline document IEEE 802.16j-06/026r4, when centralized bandwidth allocation is used, the MR-BS shall determine the bandwidth allocations for all links (access and relay) in its MR-cell. For non-transparent RS, the MR-BS performs bandwidth allocations for all DL and UL links and sends scheduling result in MAP message to each RS via RS' basic connection. Data packets are relayed through the network using the bandwidth allocation over transport connections or tunnel connection. Hence, MAP messages and data packets using the bandwidth allocations are received by the RS through different connections asynchronously. A mapping (reference) is needed between bandwidth allocation and MAC PDUs to allow the RS transmitting the MAC PDUs to map them to the intended allocation.

This contribution proposes methods to provide the mapping between bandwidth allocation and MAC PDUs to be used by RS to determine the intended MAC PDUs for each allocation.

Problem Statement

As defined in the current baseline document, MAP messages and data packets using the bandwidth allocations are received by the RS through different connections asynchronously. Except when tunnel burst mode is used, MAC PDUs are relayed through the relay links instead of data burst. In addition, each data burst allocation can contain multiple MAC PDUs of different connections. To further explain the operation of MAC PDU relaying, an example is provided based on Tunnel Packet Mode. Figure 1 shows an example of a 3-hop relay with three tunnels, T1, T2 and T3, with each tunnel carrying one or two connections from MR-BS to RSs.

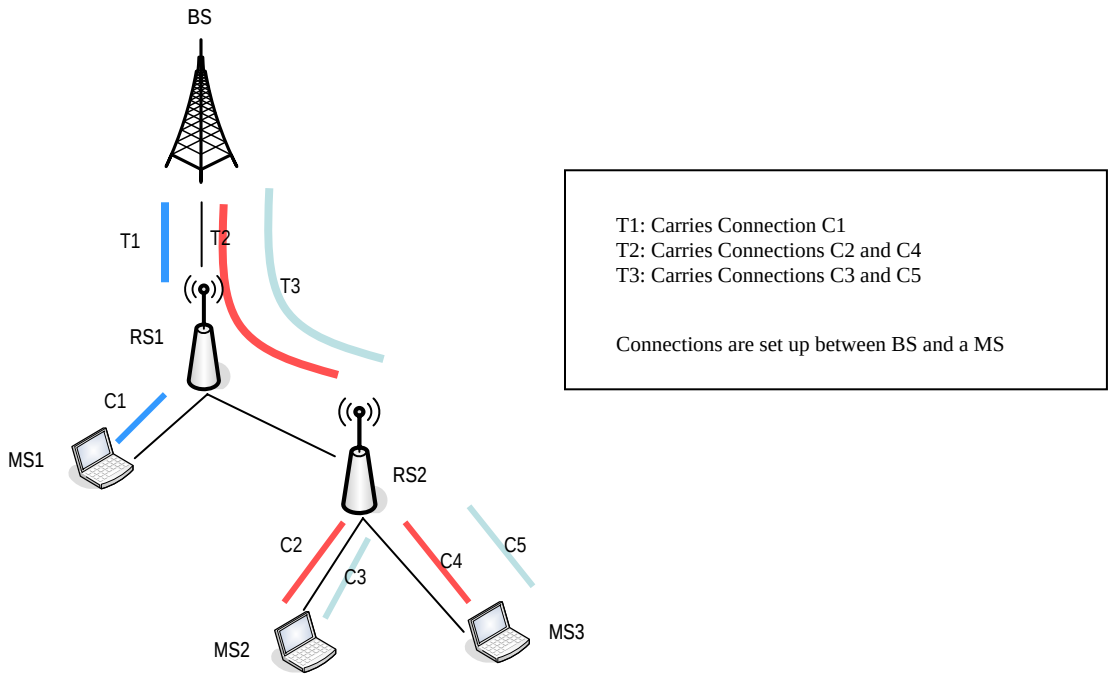

Figure 1 Example of 3-hop Relay

Figure 2 shows an example of MAC PDU relaying through the relay network illustrated in Figure 1. The color boxes represent the tunnel MAC PDUs transmitted over the tunnel of respective color. The grey box represents a data burst allocation. In this example, it is shown that MAC PDUs concatenated within one data burst over one relay link can be re-bundled with other MAC PDUs when transmitting over another relay link or access link. Figure 2 also shows that if a MAC PDU is lost over a relay link, e.g. MAC PDU T1 at frame 1, the RS may incorrectly transmit MAC PDUs received later, as indicated in Frame 4.

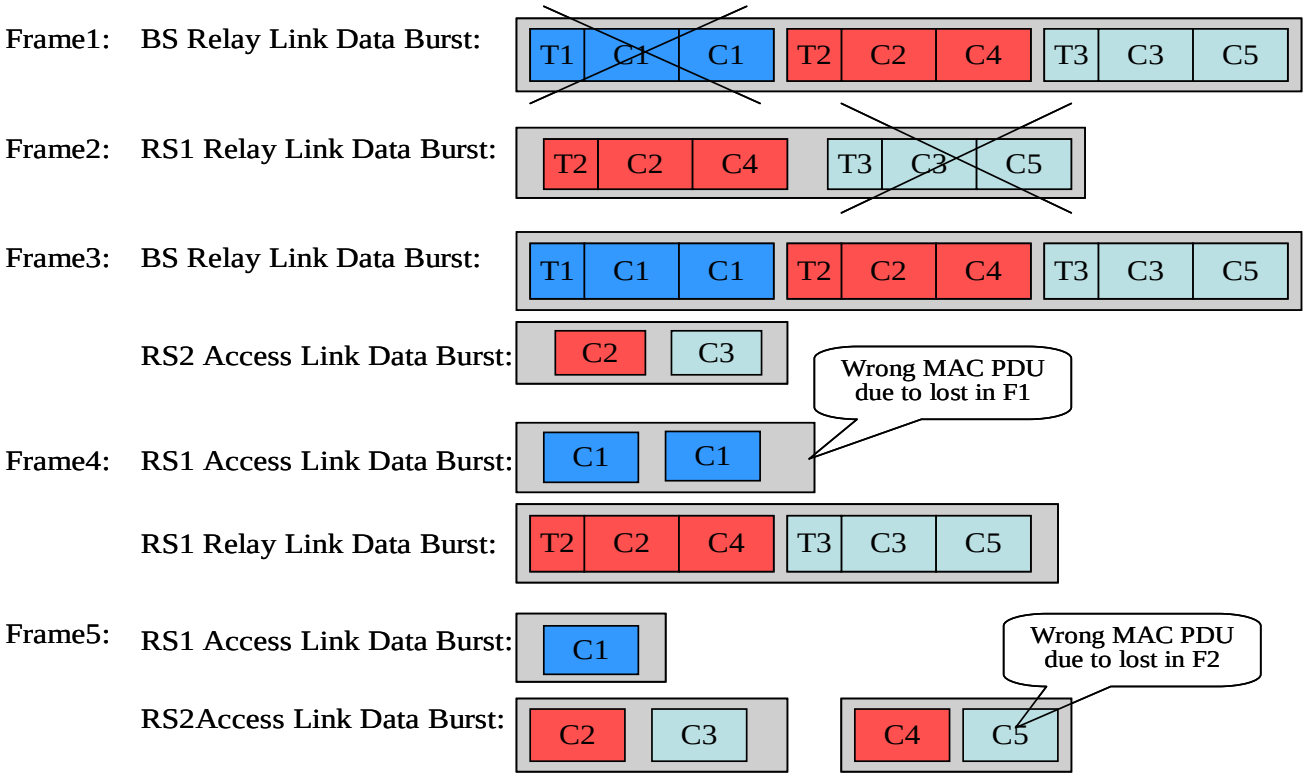

Figure 2. Example of MAC PDU relaying

As described in the example above, the following issues need to be resolved to allow RS to determine the intended MAC PDU for each allocation:

1. When relaying is not done per access-link data burst, RS needs to identify which MAC PDUs are intended for the allocation
2. RS needs to be able to detect lost packet (MAC PDU or data burst) and ignore an allocation if the intended data packets are lost over relay link. Without lost packet detection, the RS could potentially send “future” MAC PDUs (PDUs arrived at a later time) to the MS which could impact the QoS performance of the connections (such as impact on jitter control).

Proposed Solutions

There are multiple transmission options included in the baseline document, namely, tunnel packet mode, tunnel burst mode and station CID. To address the need of the different relay options, the solution proposed comprise two methods. The two methods are not optional, but rather complementary to each other. Depending on the

MAC PDU transmission option, one of the two methods will be used to provide MAP and data referencing.

Tunnel Packet Mode

This method is used for RS to determine MAC PDUs to be transmitted with an allocation when tunnel packet mode is used. This method can also be used for RS to determine the MBS data burst in relationship with MBS MAP. The method is defined as the following:

- A new Allocation subheader is defined which contains the following parameters:
    a. *Target Transmission Frame*: frame number of the frame that RS shall transmit the MAC PDU
    b. *Allocation Index*: Since each DL-MAP or R-MAP message contains multiple DL-MAP-IE, this index is used to point to the DL-MAP-IE in ascending order in DL-MAP message. An Allocation Index n represents the nth DL-MAP-IE in the DL-MAP message
    c. *Number of MAC PDUs*: Shall be set to the number of access link MAC PDUs in a group when per group allocation subheader is used. Multiple access link MAC PDUs may be grouped together when scheduled to be transmitted in the same data burst allocation in the access zone and are concatenated continuously in relay MAC PDU. When per group Allocation subheader is used, the next Allocation subheader shall point at the MAC PDU immediately after the last MAC PDU of the group.
    d. *Continuation*: Indicate the presence of another Allocation Subheader
- Multiple Allocation Subheaders might be included per relay MAC PDU.
    a. One Allocation subheader per RS shall be inserted if RS is required to transmit relay MAC PDU in a relay zone.
    b. One Allocation subheader per access link MAC PDU or per group of access link MAC PDUs shall be included. The per group Allocation subheader is only used when a group of MAC PDUs is scheduled to be transmitted in the same data burst allocation in the access zone and the group of MAC PDUs are concatenated continuously in relay MAC PDU.
- The order in which Allocation subheader is included shall be
    a. Allocations for relay zone first. With allocation for relay zone, the Allocation subheader associated with RS that is nearest to the MR-BS shall be included first.
    b. Then allocation for access zone. With allocations for access zone, the Allocation subheaders shall follow the order of its associated MAC PDU within relay MAC PDU.

Figure 3 shows an example of relay MAC PDU with Allocation subheader

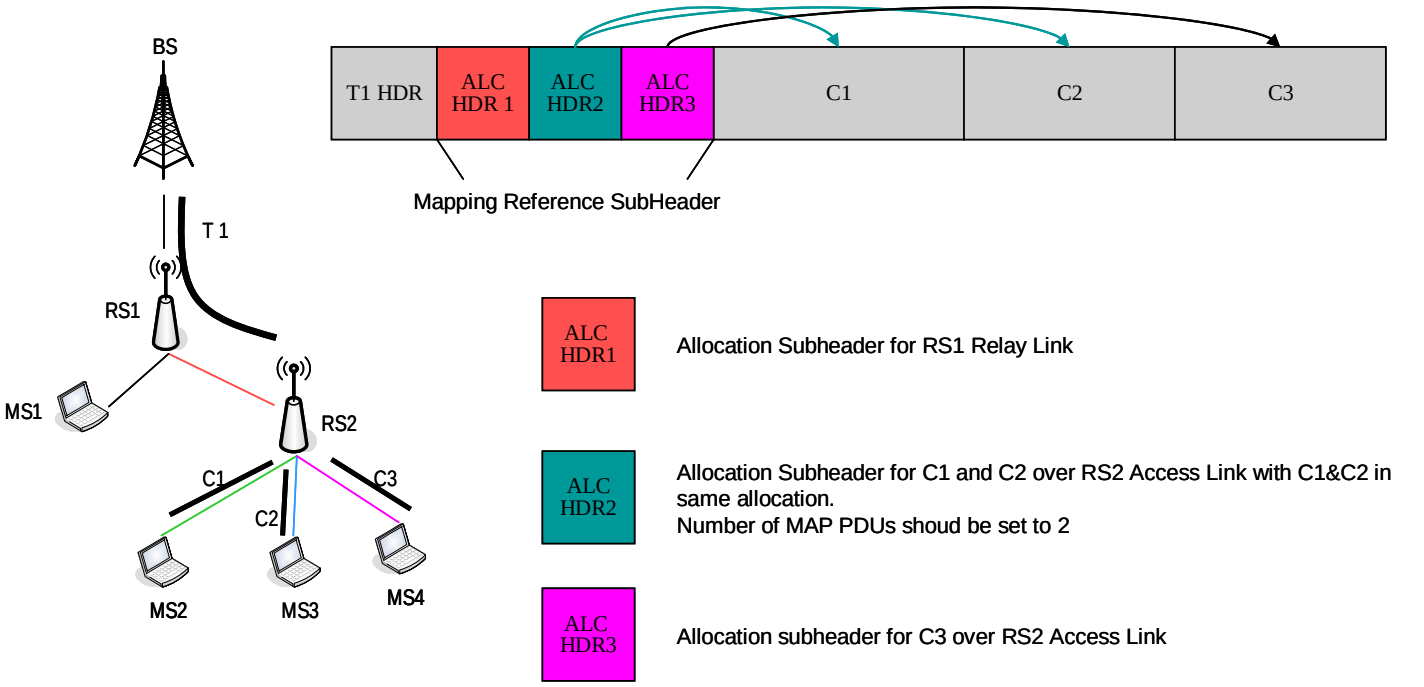

Figure 3 Example of Relay MAC PDU with Allocation Subheader

Tunnel Burst Mode and Station CID

This method is defined for transmission without relay MAC header. The method is defined as following:

- DL Allocation Reference IE is defined in the format of DL-MAP extended-2 IE
  - DL Allocation Reference IE is used to include a reference to MAC PDUs for each allocation and should follow its associated DL-MAP-IE immediately. The associated DL-MAP-IE includes data burst allocation for which DL Allocation Reference IE is providing a reference to the MAC PDUs concatenated in the data burst.
  - DL Allocation Reference IE contains the following parameters per connection included in data burst:
    a. *CID*: Identity of the connection that is transmitting. For Tunnel Burst mode, CID should be tunnel CID when sending over relay zone or RS management CID.
    b. *Total Data Allocated*: Total data allocated for this connection, in unit of bytes.
    c. *Received Frame*: Frame number where the MAC PDUs should be received by the RS
  - RS stores the frame number in which each MAC PDU is received and uses the stored frame number to match what's included in DL Allocation Reference IE.
  - If RS cannot find any MAC PDU that matches the DL Allocation Reference IE, it should ignore the DL allocation.
  - DL Allocation Reference IE is included in both R-MAP and DL-MAP used by RS
  - RS removes DL Allocation Reference IEs from MAP message before broadcasting in access zone or relay zone.
- UL Allocation Reference IE is defined in the format of UL-MAP extended-2 IE

- UL Allocation Reference IE is used to include a reference to preferred MAC PDUs for each allocation and should follow its associated UL-MAP-IE immediately. The associated UL-MAP-IE includes data burst allocation for which UL Allocation Reference IE is providing a reference to the preferred MAC PDUs to be relayed in uplink data burst
- UL Allocation Reference IE contains the following parameters:
  a. *CID*: Identity of a preferred connection to use the relay burst allocation. For Tunnel Burst mode, CID should be tunnel CID when sending over relay zone or RS management CID.
- RS should use UL Allocation Reference IE as a reference to determine the MAC PDUs to be preferentially relayed in the burst allocation. However, if MAC PDUs that match the UL Allocation Reference IE specification are not sufficient to fill the burst allocation, the RS may fill the remainder of the burst with other MAC PDUs.
- UL Allocation Reference IE should only be included in R-MAP used by RS
- .

Proposed Text

[Change Table 7a and Figure 22.]

6.3.2.1.1.1 Relay MAC PDU header format

Table 7a—Relay MAC PDU header

Syntax	Size	Notes
MAC Header() {		
HT	1 bit	
if (HT == 0) {		
~~Reserved~~ ALC	~~1 bit~~ 1 bit	~~Currently reserved. Content is subject to further discussion~~ Indicate the inclusion of Allocation Subheader
RMI	1 bit	Relay mode indication (RMI) is used to indicate whether this MAC header is GMH or Relay MAC header RMI = 0: use GMH RMI = 1: use relay MAC header
Reserved	7 bits	Currently reserved. Content is subject to further discussion
Priority	3 bits	Priority of the associated tunneled MPDU
LEN	11 bits	
CID	16 bits	May be tunnel CID or basic CID of the RS
HCS	8 bits	Header check sequence

}		
else if (HT == 1) {		If no payload is attached
Use legacy 802.16e or 802.16j format	39 bits	
HCS	8 bits	
}		
}		

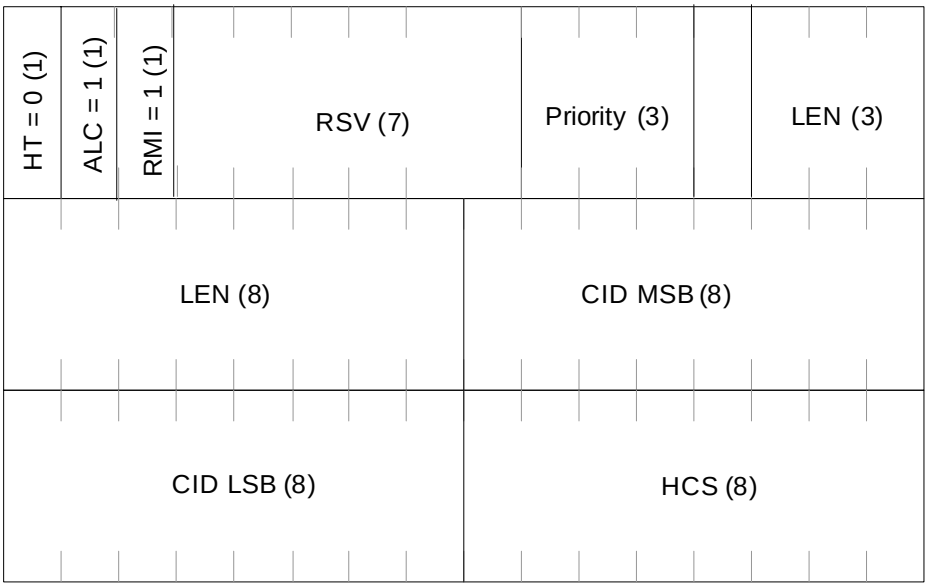

Figure 22a—Header format of relay MAC PDU with payload

[Insert new section 6.3.2.2.8 on Page 14.]

6.3.2.2.8 Relay MAC Subheader

Relay MAC Subheaders shall only be included in Relay MAC PDU with Relay MAC PDU header.

6.3.2.2.8.1 Allocation Subheader

When Tunnel Packet Mode is used or when MBS MAC PDU is being relayed, Allocation subheaders shall be included in all DL relay MAC PDUs. For each DL MAC PDU, there shall be one Allocation subheader per RS if RS transmits the relay MAC PDU in a relay zone. Additionally, each DL MAC PDU shall include one Allocation subheader per access link MAC PDU or per group of access link MAC PDUs. MAC PDUs are

defined to be in the same group if the MAC PDUs are scheduled to be transmitted in the same data burst in the access zone and are concatenated continuously in relay MAC PDU. The order in which Allocation subheader is included in a MAC PDU shall be Allocation subheaders for relay zone then Allocation subheaders for access zone. If there are multiple Allocation subheaders for relay zone, the Allocation subheader associated with RS that is nearest to the MR-BS shall be included first. If there are multiple Allocation subheaders for access zone, the Allocation subheaders shall follow the order of its associated MAC PDU in relay MAC PDU.

Table XXX Allocation Subheader

Syntax	Size	Notes
Allocation Subhheader{		
Target Transmission Frame	6 bits	LSB 6 bits of frame number of the frame that RS shall transmit the MAC PDU
Allocation Index	6 bits	Since each DL-MAP message contains multiple DL-MAP-IE, this index is used to point to the DL-MAP-IE in ascending order in DL-MAP message. An Allocation Index n represents the (n+1)th DL-MAP-IE in the DL-MAP message
Number of Additional MAC PDUs in a Group	3 bits	Shall be set to the number of additional access link MAC PDUs besides the first PDU. When set to 0, this indicates that the Allocation Subheader pertains to a single MAC PDU. When set to non-zero value, this indicates that a group allocation subheader is being defined. Multiple access link MAC PDUs may be grouped together when scheduled to be transmitted in the same data burst allocation in the access zone and are concatenated continuously in relay MAC PDU. When per group Allocation Subheader is used, the next Allocation Subheader shall point at the MAC PDU immediately after the last MAC PDU of the group.
Continuation	1 bits	When set to 1, another Allocation Subheader shall be included after the current subheader. When set to 0, no more Allocation Subheader shall follow.
}		

[Insert following to section 6.3.3.7.7 on Page 76.]

6.3.3.7.7 Optional MAC support of the PHY for relaying

6.3.3.7.7.1 DL MAP and Data Association at RS with Centralized Scheduling

When centralized scheduling is used, MR-BS allocates resource for all links (including access and relay) within MR-cell. The bandwidth allocation information is sent to RS via RS's basic connection using MAP message.

When Tunnel Packet Mode is used or when MBS MAC PDU is being relayed, Allocation Subheaders shall be included in all DL relay MAC PDUs. RS shall use Allocation Subheader attached to the relay MAC PDU to determine when the MAC PDU is to be transmitted. The RS shall transmit the MAC PDU at the Target Transmission Frame and shall use the bandwidth allocation specified by the DL-MAP-IE indexed by Allocation Index. For relay zone transmission, the RS shall use the first Allocation Subheader following the relay MAC header to determine the transmission time of the MAC PDU. Before relaying the MAC PDU in relay zone, the RS shall remove the first Allocation Subheader. For access zone transmission, RS shall use the remaining Allocation Subheaders to associate each MAC PDU with bandwidth allocation in the DL-MAP message. If no matching bandwidth allocation is found for a MAC PDU, the MAC PDU is discarded.

When Tunnel Burst mode or station CID mode is used, DL_Allocation_Reference_IE shall be included in DL-MAP and R-MAP messages sent to the RS via RS's basic connection. Each DL_Allocation_Reference_IE is associated with a DL-MAP-IE with DIUC 0-12. The DL_Allocation_Reference IE shall follow the associated DL-MAP-IE immediately in DL-MAP or R-MAP message. RS shall use DL_Allocation_Reference_IE to determine the transmitting MAC PDUs for this bandwidth allocation. The RS shall only transmit MAC PDUs in this allocation if the MAC PDUs belongs to the connection identified by the CID and was received by the RS at the Received Frame. CID and Received Frame are both included in DL_Allocation_Reference_IE. In addition, the sum of MAC PDUs' length shall equal to Total Data Allocated as indicated in DL_Allocation_Reference_IE. If no matching MAC PDUs are found, the RS shall ignore DL-MAP-IE allocation. RS shall remove all DL_Allocation_Reference_IE from DL-MAP and R-MAP before broadcasting the messages over access zone and relay zone.

6.3.3.7.7.2 UL MAP and Data Association at RS with Centralized Scheduling

UL_Allocation_Reference_IE may be included in R-MAP messages sent to RS via broadcast connection and basic connection. Each UL_Allocation_Reference_IE is associated with a UL-MAP-IE with UIUC 0-10. If present, the UL_Allocation_Reference IE shall follow the associated UL-MAP-IE immediately in R-MAP. RS should use UL_Allocation_Reference_IE to determine the preferred MAC PDUs for this bandwidth allocation. The RS should preferentially transmit MAC PDUs using the bandwidth allocation for the connection(s) identified by CID in the UL Allocation Reference IE. If MAC PDUs matching the CID(s) in the UL Allocation Reference IE are insufficient to fill the bandwidth allocation, the RS may fill the allocation with other MAC PDUs that are waiting to be relayed upstream.

[Modify section 8.4.5.3, table 385 on Page 153]

Extended-2 DIUC (hexadecimal)	**Usage**
…	…
0E	AAS_SDMA_DL_IE
0F	~~*Reserved*~~ *DL* Allocation Reference IE

[Insert section 8.4.5.3.29, table 385 on Page 153]

8.4.5.3.29 DL Allocation Reference IE format

MR-BS may transmit DL_Allocation_Reference_IE when sending DL-MAP and R-MAP messages to RS to inform RS the bandwidth allocation of RS' access zone and relay zone. When included, the DL_Allocation_Reference_IE shall follow the associated DL-MAP-IE immediately. The associated DL-MAP-IE includes data burst allocation for which DL Allocation Reference IE is providing a reference to. DL_Allocation_Reference_IE shall be removed from the MAP messages by RS before broadcasting.

Syntax	Size	Notes
DL_Allocation_Reference_IE(){	-	-
Extended-2 DIUC	4 bits	DL_Allocation_Reference_IE=0xF
Length	8 bits	
Num_Connections	4 bits	Number of connections included in the associated allocation
for(i=0;i<Num_Connections;i++) {		
CID	16bits	CID of connection
Total Data Allocated	12bits	Total data allocated for this connection, in unit of bytes.
Received Frame	4 bits	LSB of frame number where the MAC PDUs are received by the RS.
}		
}		

[Modify table 290c, insert after table 427 on Page]

Extended-2 DIUC	**Usage**

(hexadecimal)	
00	CQICH_Enhanced Allocation_IE
01	HO_Anchor_Active_UL-MAP_IE
02	HO_Active Anchor UL MAP
03	Anchor_BS_switch_IE
04	UL_sounding_command_IE
05	Reserved
06	MIMO UL Enhanced IE
07	07 HARQ UL MAP IE
08	HARQ ACKCH Region Allocation IE
09	UL Allocation Reference IE
09A…0D	Reserved
0E	AAS_SDMA_UL_IE
0F	Feedback_polling_IE

[Insert section 8.4.5.4.31]

8.4.5.4.31 UL Allocation Reference IE format

MR-BS may transmit UL_Allocation_Reference_IE when sending R-MAP messages to RS. When included, the UL_Allocation_Reference_IE shall follow the associated UL-MAP-IE immediately. The associated UL-MAP-IE specifies data burst allocation for which UL Allocation Reference IE provides additional information as to which MAC PDUs should be given preferential use of the allocation.

Syntax	Size	Notes
UL_Allocation_Reference_IE(){	-	-
Extended-2 UIUC	4 bits	UL_Allocation_Reference_IE=0x9
Length	8 bits	
Num_Connections	4 bits	Number of connections included in the associated allocation
for(i=0;i<Num_Connections;i++) {		
CID	16bits	CID of connection
}		

}		

Reference

[1] “Air Interface for Fixed and Mobile Broadband Wireless Access Systems - Multihop Relay Specification”, IEEE 802.16j-06/026r4, June 2007

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