

Detailed Proposal for ARQ Baseline

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This

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This document is to be presented to 802.16 TG3, TG4 and MAC groups outline the merge of ARQ proposal for 802.16 MAC

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Detailed Proposal for ARQ Baseline

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- Based on
 - 802.16.3c-01/60
 - 802.16.3p - 01/52
 - 802.16.3c-01/40
 - 802.16.3c-01/38
 - 802.16.4c-01/32

General

- The ARQ implementation is obligatory
- The ARQ invocation is optional, per connection. ARQ can be enabled only for the unicast transmissions
- Sequential Numbers are used to identify the retransmitted portions of data
- ARQ is supported for unicast connections only

ARQ Scope = Connection

- Sequential Numbers are unique (within the transmission window) as considered within the scope of the connection
- ARQ operations are defined in the scope of 802.16 MAC connection including:
 - ARQ invocation (thus presence of ARQ Sub-header). Decision on ARQ invocation should be done at the step of the connection creation/change
 - ARQ parameters
 - ARQ state variables

ARQ Unit: Requirements

- ARQ should be effective in the support of QoS requested by the upper layers
 - Max delay, max # of retransmissions
- ARQ definition should be generic enough to efficiently serve the applications that differ in
 - Granularity (size of retransmission units)
 - Restrictions on the Tx window
 - Restrictions on the overhead of ARQ

ARQ Unit: Requirements

QoS Support

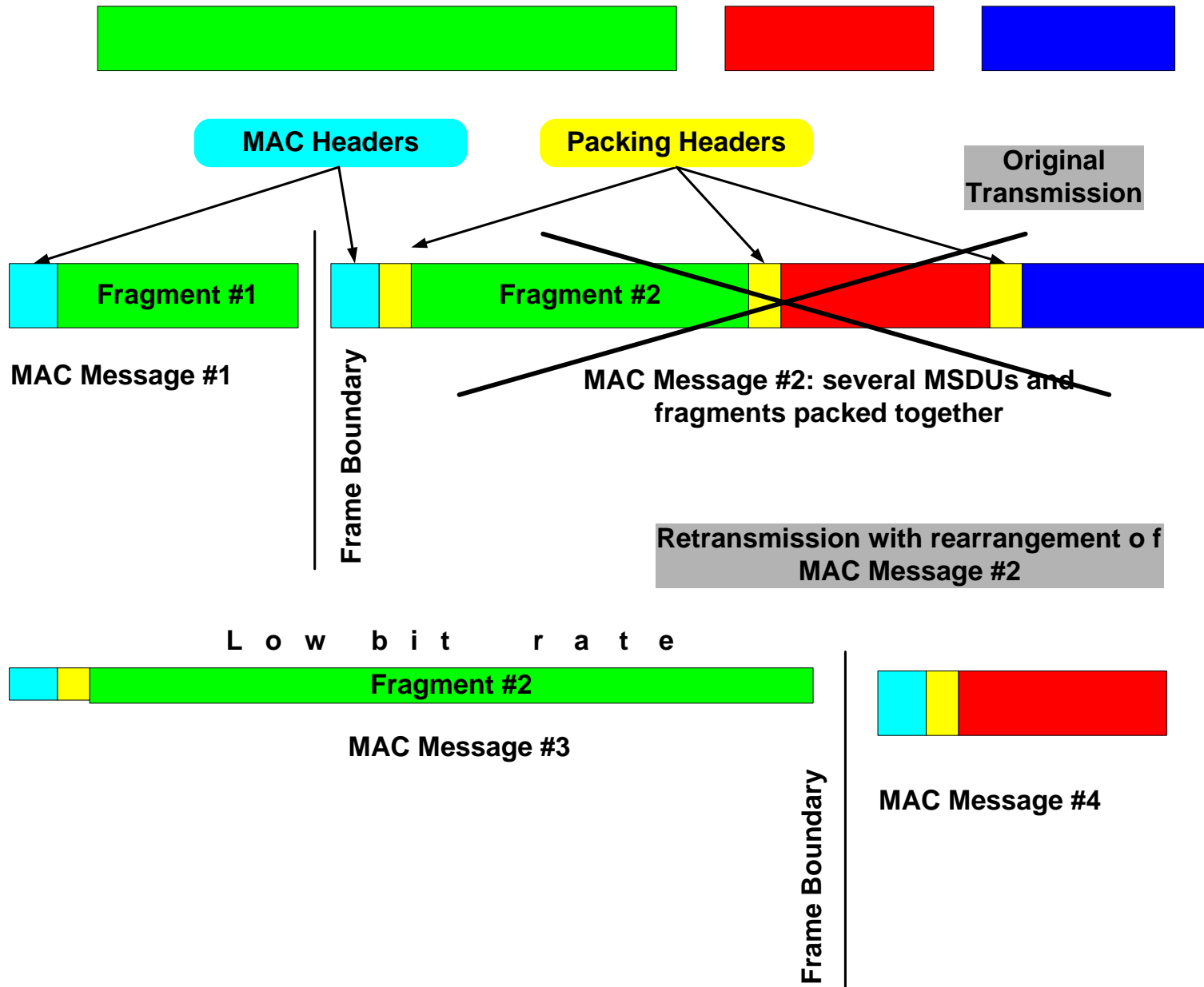
- To provide QoS (e.g. **Maximum Downlink Latency, Minimum Reserved Traffic Rate**), certain decisions should be done *per packet*, for example, decision to discard the packet already delayed for too much time
- So we need to keep track of each packet e.g. of the overall processing time of VoIP packets

ARQ Unit: Requirements

Granularity

- In retransmissions, we generally don't have the same capacity conditions as for the initial transmissions: another space in the frame, another recommended rate
- So we need a FLEXIBILITY mechanism to change the portions of data between retransmissions and thus the granularity of the retransmissions becomes an issue

ARQ Unit: Granularity- cont.



ARQ Unit: Requirements

Restrictions on the Tx Window vs. Overhead

- For the low BER situations, it is better to provide less overhead by numbering: small number of bits, more large data pieces numbered
- For the applications, sensitive to round-trip delay, it is better to provide larger Tx Window thus more bits in the sequential number needed

ARQ Blocks / Mode

- An **ARQ Block** is employed as an identifiable logical unit
- The transmitted MSDUs and the MSDU fragments are logically divided into blocks of the fixed size. The blocks *never change* but MAY be arranged differently when retransmitting the data.

ARQ Blocks

- The last block in the MSDU/fragment **MAY** be smaller than **ARQ_BLK_SIZE**, such a block is called “incomplete block”
- Once defined as a piece of data, block never changes (split or recombined)

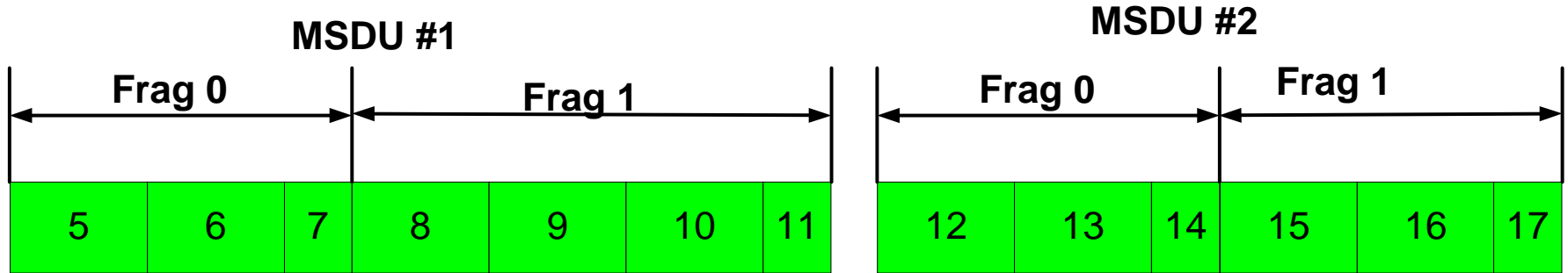
ARQ Blocks

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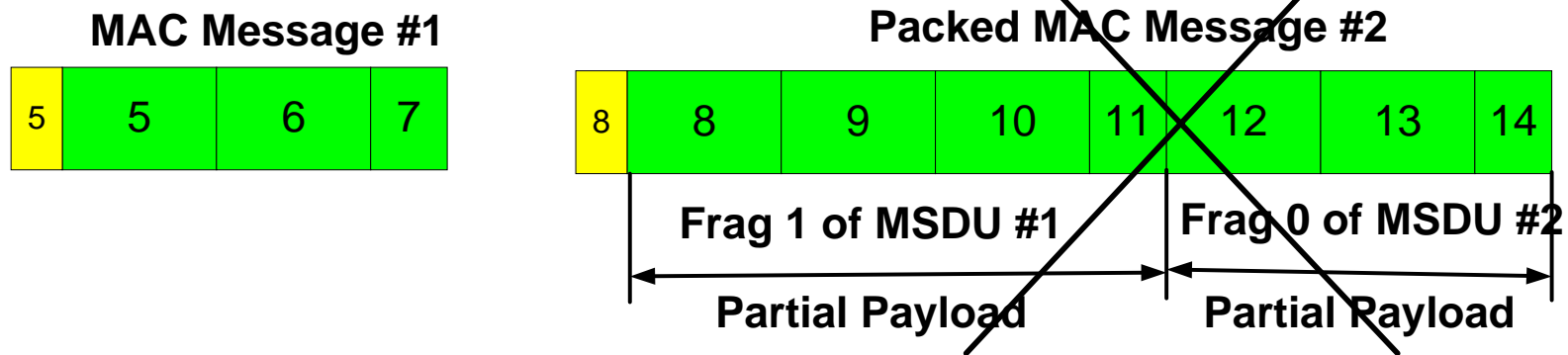
ARQ Blocks

- Only contiguous Block Sequential Numbers may appear within a single MAC Message
- An incomplete block may be appear only at the end of a MAC Message or at the end of partial payload in the case of packed MAC Message
- Each MAC Message gets a Sequential Number, which is the Sequential Number of the FIRST, block in the MAC Message. This number is encoded in the ARQ sub-header

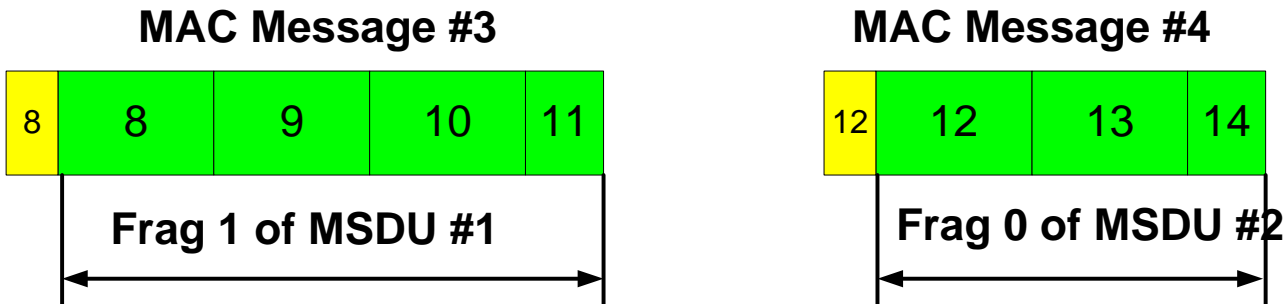
ARQ Blocks



Original Transmission



Retransmission

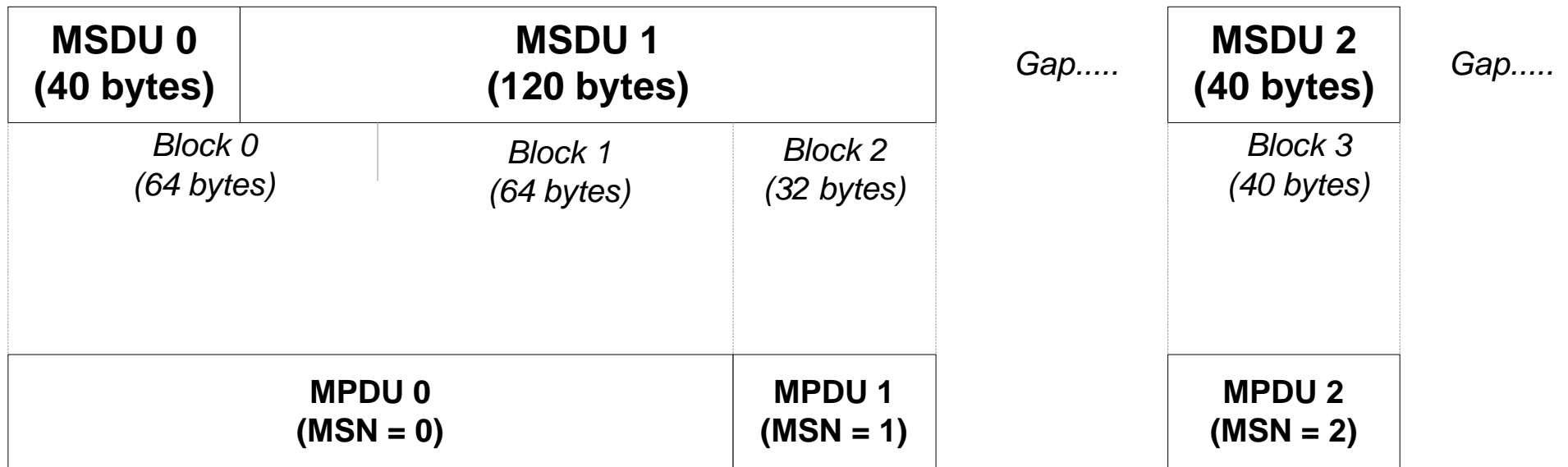


MPDU Sequence Numbering Mode

- Each MPDU is assigned a sequence number irrespective of the number of bytes in the MPDU
- Unit of retransmission is MPDU
- The next expected MPDU number is calculated as the last received MPDU sequence number + 1

MAC PDU Numbering

Default case - Dynamic Block Size



MPDU 0
(132 bytes [Blocks 0 and 1 + 2 PSH of 2 bytes each] of payload + MAC header)

Block Size = 132 bytes

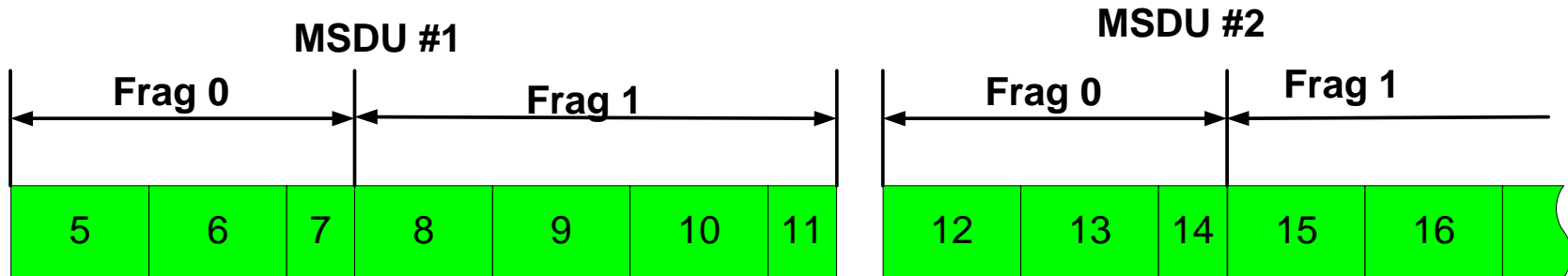
MPDU 1
(32 bytes [Block 2] of payload + MAC header)

Block Size = 32 bytes

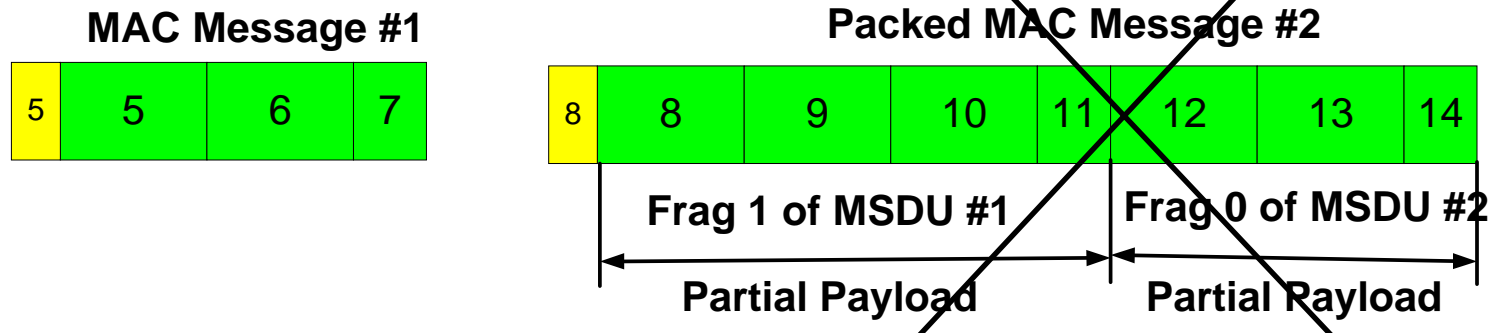
MPDU 2
(40 bytes [Block 3] of payload + MAC header)

Block Size = 40 bytes

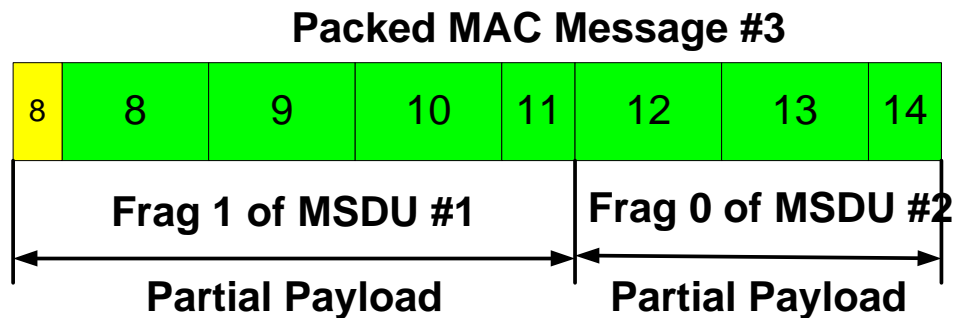
ARQ Blocks



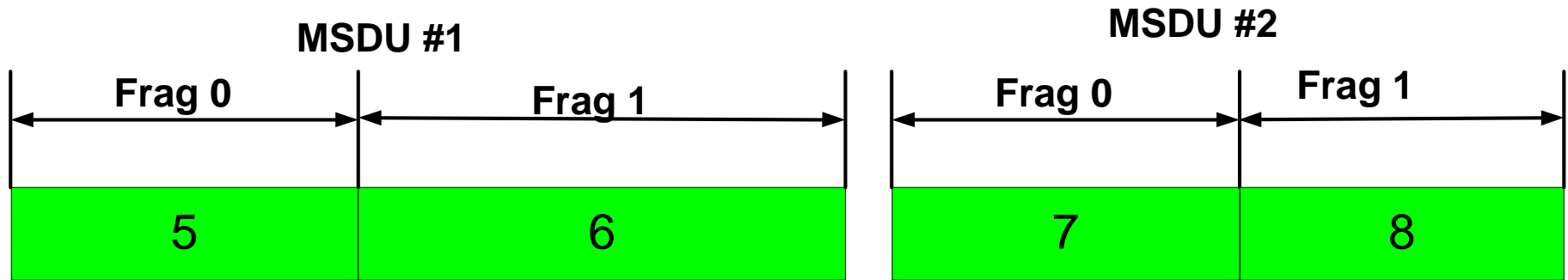
Original Transmission



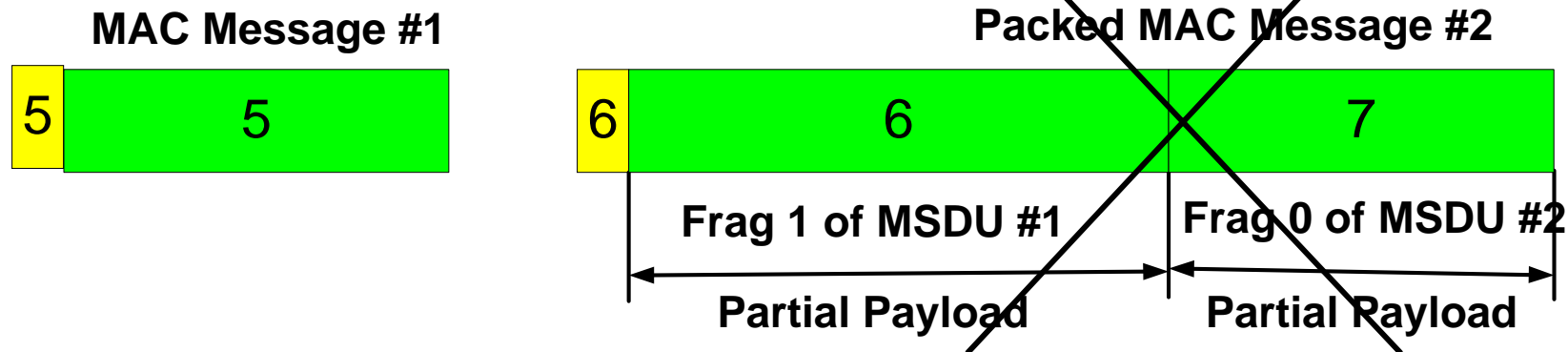
Retransmission without rearrangement of MAC Messages



ARQ Blocks: Back to Fragments if Block Size > max MSDU size



Original Transmission



Retransmission



ARQ Sub-header

Usage of Short / Long format is specified by the Payload type field of the MAC Header

Short Number

FC(2)	SN (6)
-------	--------

Long Number: 14 bits

FC(2)	SN (6)
BSN (8) - Cont.	

Long Number: 11bits

FC(2)	Rsvd(3)	SN (3)
BSN (8) - Cont.		

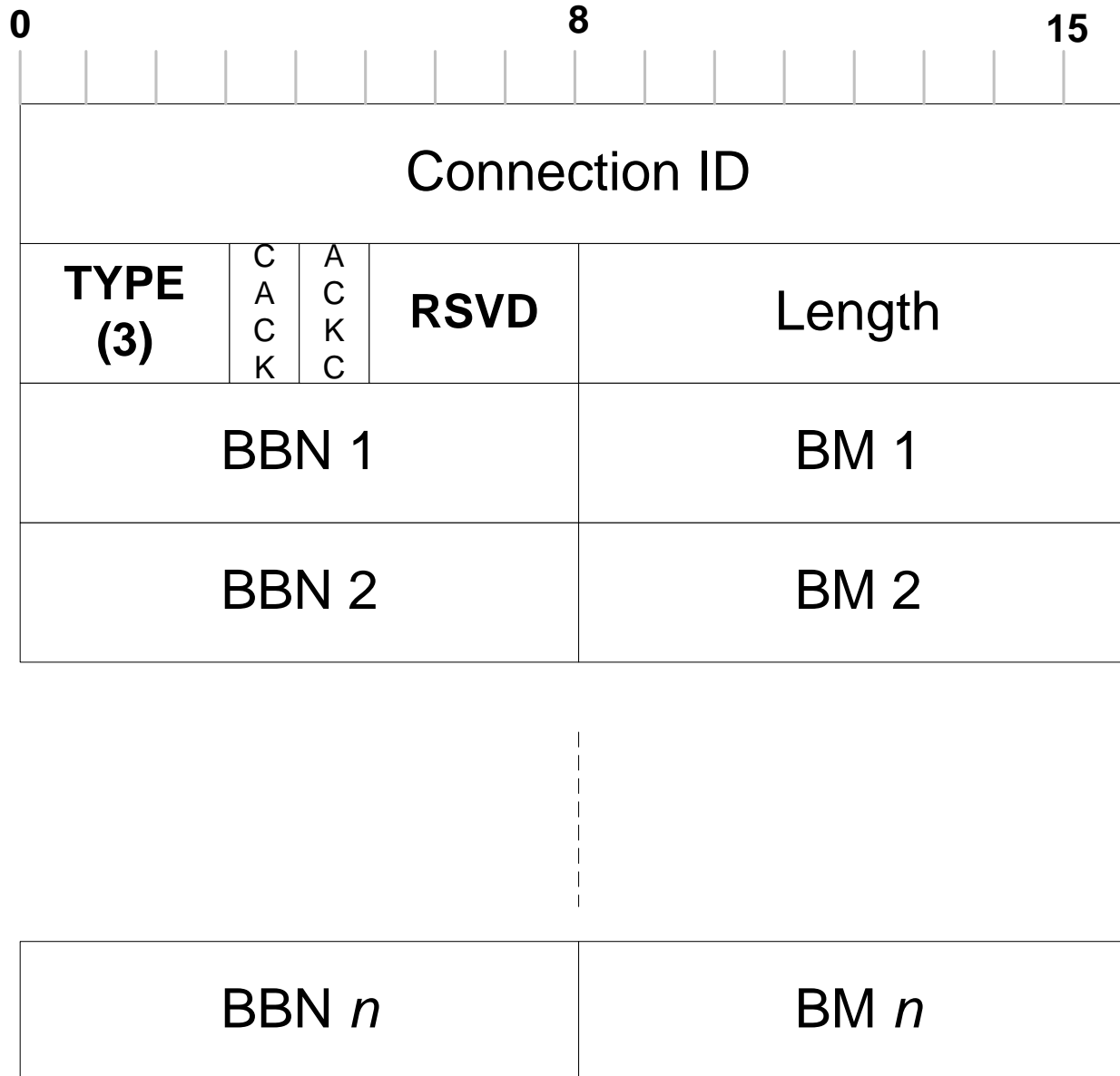
ARQ Feedback Encoding options

- MAC Messages
- Sub-headers
- Partial Payloads

ARQ Control Message Fields

- CID: ID of Connection for which the message was generated
- Type: the type of the message. For ACK/NACK Type = 001
- CACK Flag = '1' if Cumulative Acknowledgement
- ACKC Flag – ACK congestion flag
- Length = number of ACK maps
- ACK MAP = BBN (Bitmap Block Number) + BM (bitmap)

ARQ Feedback Signaling Messages



ARQ Feedback Signaling Modified BR Header

HT=1 (1)	EC=0 (1)	Type = "ACK"	Rsvd	ACK/NAC	BSN(6)
BSN (8)			CID (8)		
CID - cont (8)			HCS (8)		

ARQ Sub-header fields

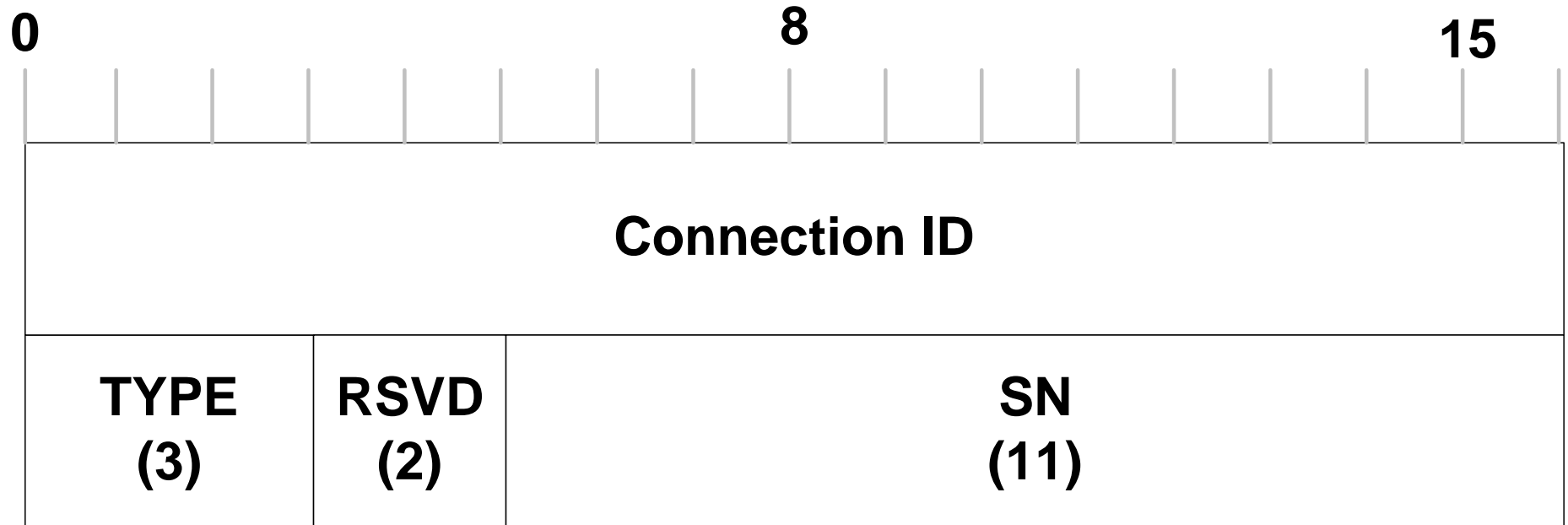
- FC – Fragmentation Control
- SN – a number assigned to MPDU
 - MPDU Sequential Number in MPDU numbering mode
 - Block Sequential Number of the first block, in Block Numbering Mode

Elements of ARQ Feedback – *Sub-headers and Partial Payloads*

- The Last bit is used to mark the last ARQ IE in the Sub-header.
- BM Flag= 1 means presence the BM field
- The BSN value means acknowledging all the blocks with the Sequential Number < BSN within the transmission window.
- BM means the bitmap that contains ‘1’ for NACK and ‘0’ for ACK for the blocks from $BSN*8$ to $(BSN*8+7)$

ARQ Feedback Signaling Messages

Reset & *Discard* Messages



Piggybacking ACKs using the Packing Function: Change in the Packing Sub-header needed

FC(2)	Partial Payload Type = 001	Partial Payload Length (3)
Partial Payload Length - cont. (8)		

ARQ Feedback IEs

Cumulative ACK-Short

Last	BM Flag=0	SN (6)
CID(8)		
CID (8) - Cont.		

ARQ Feedback IEs

Cumulative ACK/NACK-Short

Last	BM Flag =1	SN (6)
BM (8)		
CID(8)		
CID (8) - Cont.		

ARQ Feedback IEs

Cumulative ACK-Long

Last	BM Flag=0	SN (6)
SN(8) - Cont.		
CID(8)		
CID (8) - Cont.		

ARQ Feedback IEs

Cumulative ACK-Long

Last	BM Flag=0	ACK / NACK	F	Rsvd
SN(8)				
SN(8) - Cont.				
CID(8)				
CID (8) - Cont.				

ARQ Feedback IEs

Cumulative ACK/NACK-Long

Last	BM Flag=1	SN (6)
SN(8) - Cont.		
BM(8)		
CID(8)		
CID (8) - Cont.		

ARQ Feedback Signaling

Partial Payload

Cumulative ACK/NACK-Long

Type(3)		FC(2)	Length(3)
Length(11) - Cont.			
Rsvd	BM Flag=1	SN (6)	
SN(8) - Cont.			
BM(8)			
CID(8)			
CID (8) - Cont.			