Proposal for IEEE 802.16m MAC Header and Subheader

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*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Re: IEEE 802.16m-08/033 – Call for Contributions and Comments on Project 802.16m System Description Document (SDD), on the topic of "MAC: Data Plane"

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

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Introduction

- This contribution proposes the power saving schemes that address the following TGm SRD (IEEE 802.16m-07/002r4) requirements:
  - Section 6.10 System overhead:
    - "Overhead, including overhead for control signaling as well as overhead related to bearer data transfer, for all applications shall be reduced as far as feasible without compromising overall performance and ensuring proper support of systems features."

Overview

- Two types of MAC PDUs formats are considered
  - MAC PDU with payload encapsulated
  - MAC PDU without payload encapsulated
- MAC PDU with payload encapsulated
  - Two versions of header are considered, to optimize the overhead for different types of traffic
    - Short version – for small packet (e.g. VoIP) type of traffic
    - Normal version
  - The version used is negotiated during connection setup
- Control MAC PDU (without payload)
  - Multiple types of control MAC header
  - Fixed length
- MAC sub-header is used to carry additional control information for MAC PDU with and without payload

Short Version of MAC Header with Payload

- Suitable for service flow with
  - No encryption required due to too much overhead on small packet
  - No ARQ required due to delay sensitive nature of the traffic
  - No fragmentation required.
  - Limited types of lengths
  - Example service: VoIP
- Design principle
  - Minimum header size
  - SDU packing/concatenation is done outside of MAC PDU, i.e. each MAC PDU contains one SDU and multiple MAC PDU are concatenated to form a PHY SDU.
- Header format
  - HT: Header type; '1' indicates MAC PDU with payload or with subheaders only, '0' indicates MAC PDU without payload
  - FID: flow ID
  - Length type: to indicate 8 different lengths (negotiated definition of type and corresponding length at connection setup)

← 8 bits →		
HT = 1 (1)	FID (4)	Length type (3)

Figure 1

Normal Version of MAC Header with Payload (1/5)

- For service flow where
  - Encryption is required
  - Fragmentation and packing are possible
  - Any value of length is possible
- Design principle
  - Consolidate per MAC PDU information into the MAC header
    - Aggregate per-SDU information together in the MAC header to reduce overhead, i.e. no need for packing subheader
    - The SDU fragment sequence number is defined per service flow instead of per SDU, to reduce the overhead
  - Concatenate/packing of multiple SDUs within a MAC PDU to save security encryption overhead

Normal Version of MAC Header with Payload (2/5)

- Issue of 802.16e MAC PDU with packing of multiple SDUs within a MAC PDU
  - Packing sub-header (PSH) is per-SDU based where the FC (2) and FSN/BSN (11) and length (11) present separately for every SDU/fragment
    - FC field and FSN/BSN field can be replaced by packing format field and FSN/BSN field in the proposed MAC header described in the next 3 slides.
    - Lengths of each SDU can be collectively indicated in the proposed Length SH showin described in the next 3 slides
- Issue of concatenating upper layer data on MAC PDU level, i.e. one MAC PDU contains one SDU and multiple MAC PDUs are concatenated to form one PHY SDU
  - Security related information (e.g., PN (4) and IV (8)) incurs substantial overhead on each MAC PDU since 802.16e performs encryption on each MAC PDU
- Figure 2 shows the overhead reduction by introducing the new Normal version of MAC header
  - The MAC header overhead reduction is about 50% excluding encryption overhead.
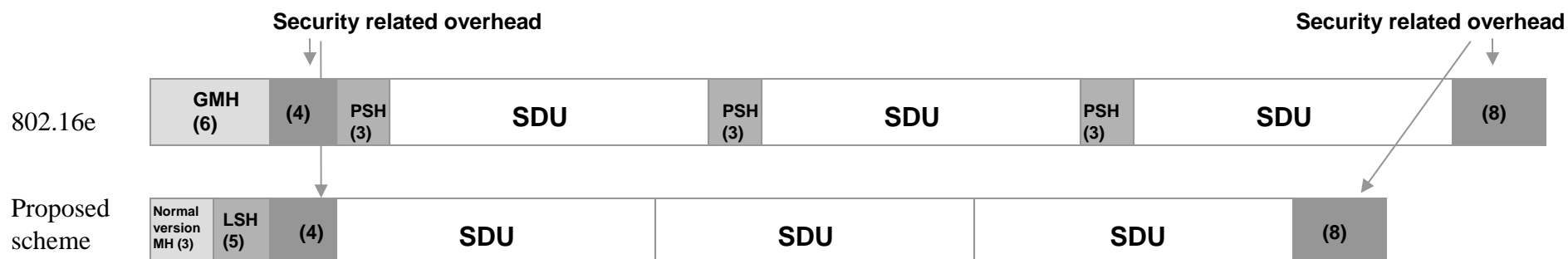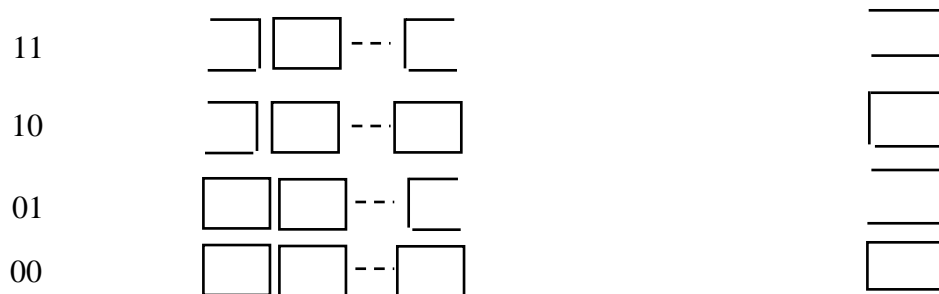
Figure 2

Normal Version of MAC Header with Payload (3/5)

- Refer to Figures 4 and 5 in subsequent slide
- FID (4 bits)
  - Flow ID of a MS
- Number of SDU (3 bits)
  - Indicate the number of SDUs in the payload (0-7)
    - 0 means only the MAC PDU only contains control subheaders, no payload
- FSN/BSN (11 bits)
  - The fragment sequence number or ARQ block sequence number of the first fragment of an SDU or the first ARQ block.
- Packing format (2 bits) – refer to Figure 3a and 3b below.
  - For the case of two or more SDU
    - Bit 1 = 1 indicates the first SDU is fragmented; 0 indicates first SDU is not fragmented
    - Bit 2 = 1 indicates the last SDU is fragmented; 0 indicates last SDU is not fragmented
  - For the case of single SDU
    - Bit 1, 2 = 10 indicates the payload is the first fragment of a SDU
    - Bit 1, 2 = 01 indicates the payload is the last fragment of a SDU
    - Bit 1, 2 = 00 indicates the payload is a entire SDU without fragmented
    - Bit 1, 2 = 11 indicates the payload is a middle fragment of a SDU

11

10

01

00

(a) MAC PDU consists of two or more SDUs

(b) MAC PDU consists of one SDU

Figure 3

Normal Version of MAC Header with Payload (4/5)

- ## PI – padding indicator (1 bit)
  - Indicate whether there are padding bits.
    - If PI = 1, there is padding and a Length sub-header is present after the 3-byte MAC header.
    - If PI = 0, there is no padding. If 'number of SDUs' is 1, Length subheader is not present. If 'number of SDUs' is greater than 1, Length sub-header is present after the 3-byte MAC header to indicate the length of the first ('number of SDUs' -1) SDUs.
  - Length subheader includes ('Number of SDUs' x 11) bits
    - Length SH is octet aligned
- ## SHI – sub-header indicator (1 bit)
  - Indicate whether other control sub-header(s) are present
- ## EKS (1 bits) – security key sequence number (two keys are assumed)

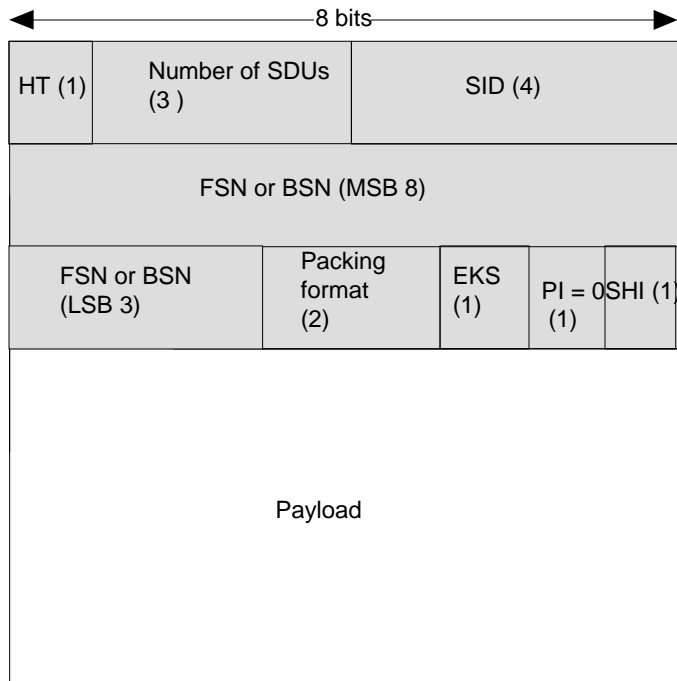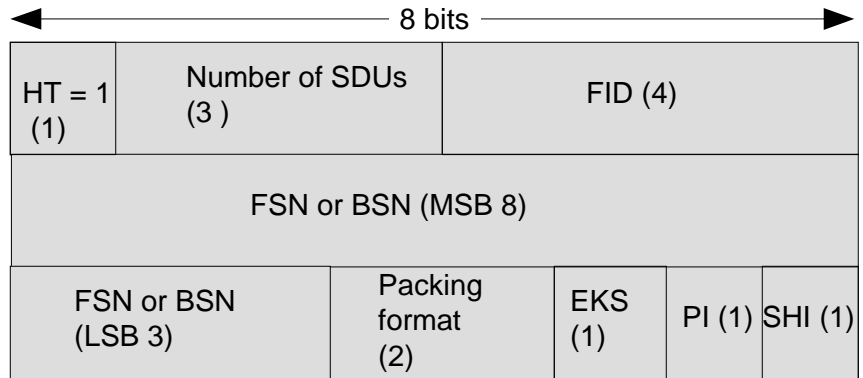# Normal Version of MAC Header with Payload (5/5)

Figure 4

8 bits

HT = 1 (1)	Number of SDUs (3)	FID (4)			
FSN or BSN (MSB 8)					
FSN or BSN (LSB 3)		Packing format (2)	EKS (1)	PI (1)	SHI (1)

8 bits

HT (1)	Number of SDUs (3)	SID (4)			
FSN or BSN (MSB 8)					
FSN or BSN (LSB 3)		Packing format (2)	EKS (1)	PI = 0 (1)	SHI (1)
Payload					

Figure 5a example of MAC PDU with single SDU, without padding

8 bits

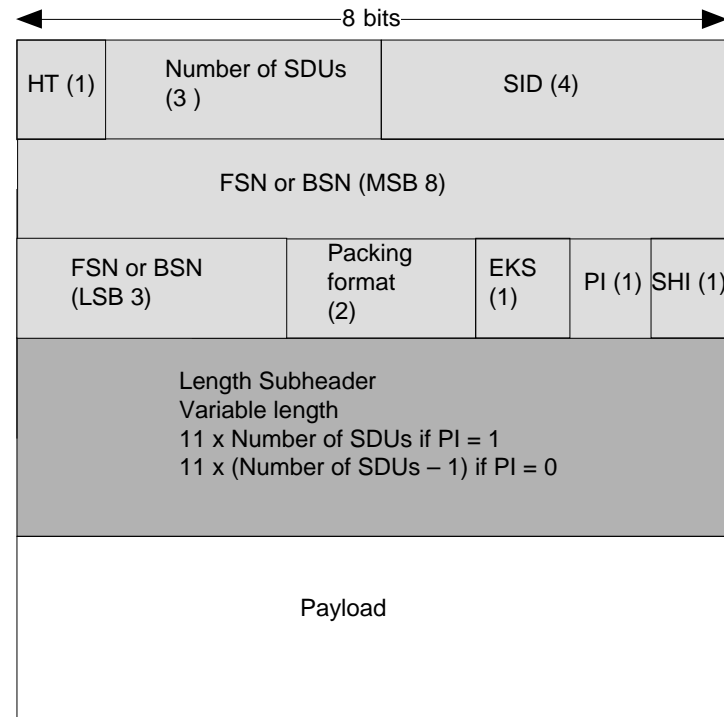| HT (1)	Number of SDUs (3)	SID (4)			
FSN or BSN (MSB 8)					
FSN or BSN (LSB 3)		Packing format (2)	EKS (1)	PI (1)	SHI (1)
Length Subheader Variable length 11 x Number of SDUs if PI = 1 11 x (Number of SDUs – 1) if PI = 0					
Payload					

Figure 5b example of MAC PDU with more than one SDUs with or without padding

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MAC PDU with Sub-header Only

- MAC PDU with sub-header only, without payload

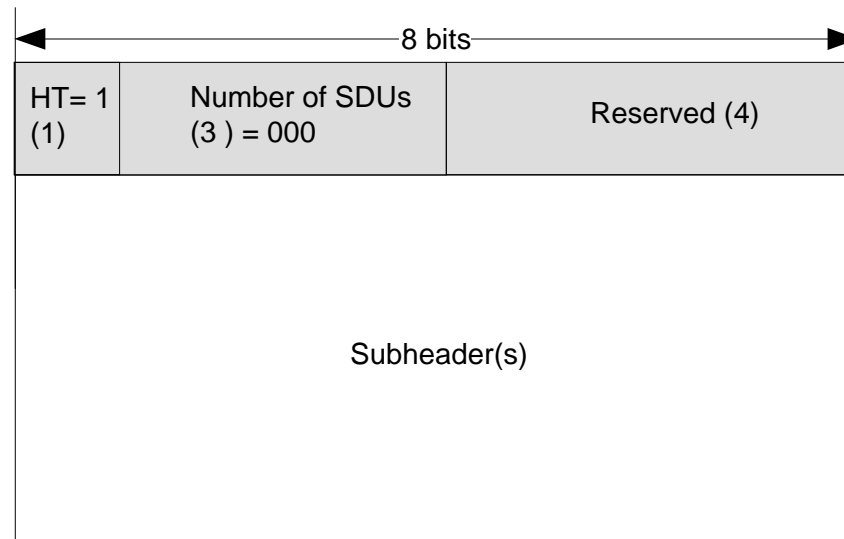| 8 bits		
HT= 1 (1)	Number of SDUs (3) = 000	Reserved (4)
Subheader(s)		

Figure 6

MAC Sub-Header

- Multiple types of sub-header should be considered to carry control information. ARQ feedback information can be one type of sub-header.
- For each type
  - Fixed length
  - Follow the MAC header if no Length sub-header or follows the Length sub-header
- Sub-header format
  - Sub-header type (4 bits): indicate 16 different sub-header
  - Last (1 bit): indicate whether this is the last sub-header
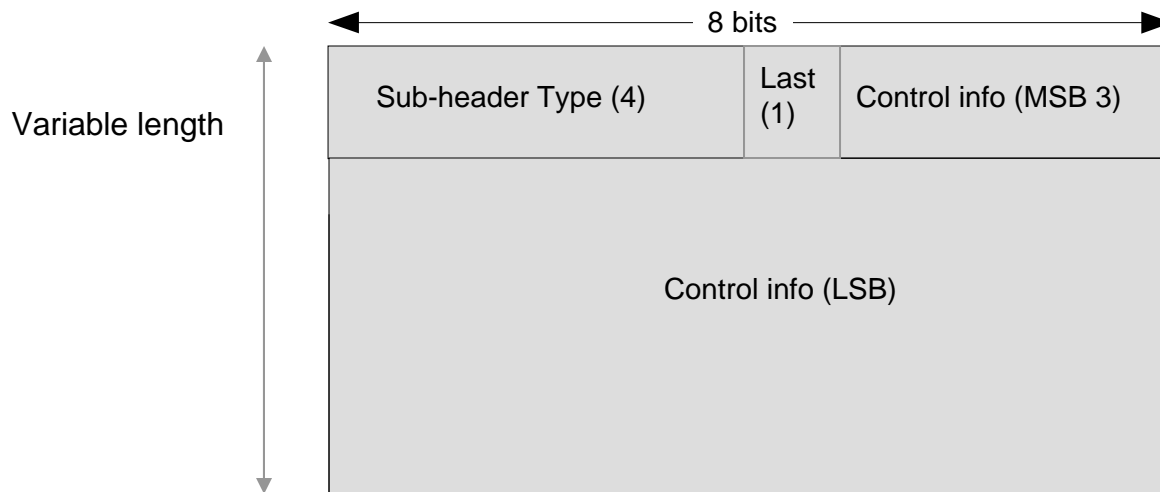 - Control info (3 to variable number of bits depending on the type)

Figure 7

MAC Control Header

- ## Multiple types of MAC control header should be considered
  - Format (fixed length)
  - Sent on UL either with other MAC PDU or stand alone following a ranging code transmission. The fixed length design allows BS to assign fixed UL resource following ranging from the MS.
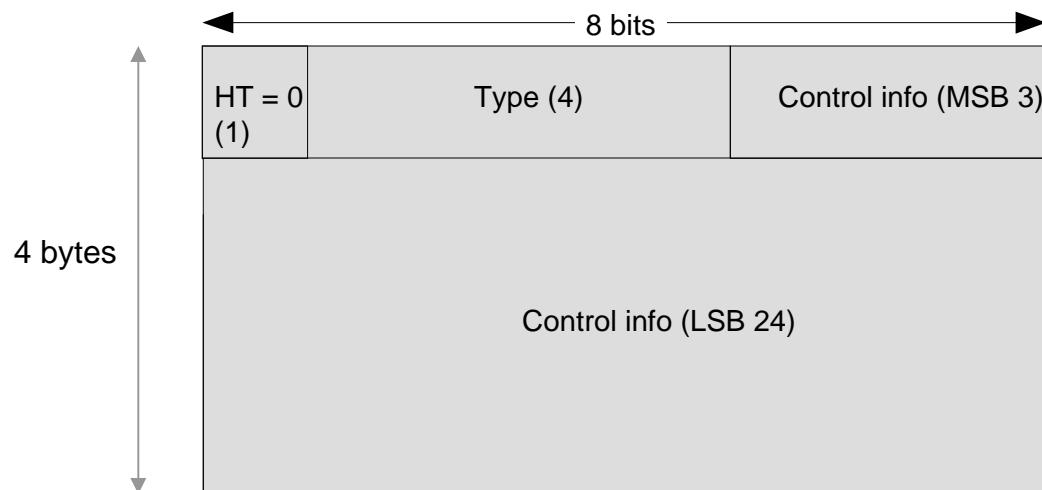 - Sent on DL either with other MAC PDU or stand alone

Figure 8

Proposed Text for SDD

[Add the following section and text to page 27, line 22]

10.x MAC headers and sub-headers

- *[include proposed text and figures in slides 4 – 12 here]*