MAC PDU and GMH Design

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Venue:

Re: MAC: Data Plane; in response to the TGm Call for Contributions and Comments 802.16m-08/033 for Session 57

Base Contribution:

This is the base contribution.

Purpose:

To be discussed and adopted by TGm for the 802.16m SDD

Motivation

- 802.16e GMH and MAC PDUs include unnecessary overhead
  - Some fields in GMH are not needed, or can be signaled using other mechanisms
  - Encoding of subheader and extended subheader can be further optimized
  - Using HCS and CRC simultaneously is not necessary
- Optimization of GMH and MAC PDUs in .16m is needed
  - Reduce size of GMH
  - Remove unnecessary overhead in MAC PDUs
  - Introduce new features

GMH Optimization – Removal of EC bit

- Each transport connection is mapped to a Security Association (SA).
- The mapping is achieved during DSA/DSC procedure.
- Therefore, the connection index in the GMH already indicates whether the payload is encrypted or not, and there is no need to include EC bit.

GMH Optimization – CRC, HCS and CI bit

- When HARQ is enabled for a connection, the associated MAC PDUs are protected with HARQ CRC. In such case, there is no need to use CRC or HCS to protect the MAC PDU or GMH.
- It is the service flow requirement that whether or not CRC shall be enabled to protect the traffic. Therefore it shall be determined during service flow setup.
  - If such bit is set, then CRC shall be attached unless HARQ is enabled and HCS shall be omitted from the GMH.
- In general, the following default protection rules can be applied:
  - If HARQ is enabled for the connection, CRC for the MAC PDU and HCS for the GMH is not present.
  - If HARQ is not enabled for the connection and if CRC is enabled, CRC shall be attached to the MAC PDU and HCS in the GMH is not present.
  - If neither HARQ nor CRC is enabled for the connection, HCS shall be present in GMH.
  - Using such default rule, there is no need to include CI bit in GMH.
- The management connections shall always be protected with CRC unless HARQ is enabled for these connections.

GMH/MPDU optimization – Masked CRC/HCS

- When power is not an issue for devices such as laptop, the MS can decode all the received MPDU to find out if the data is for itself or not. Therefore, no Station identifier (STID) needs to be included in DL-MAP.
- Possible issues: if STID in DL-MAP is erroneous and not detected by the MAP CRC, the MS with the wrong STId assumes the data is for itself.
- To address this issue, the HCS or CRC whichever is present can be masked with STID.
  - If HARQ is enabled, HARQ CRC is masked with STID.
  - If HARQ is not enabled and CRC is enabled, CRC is masked with STId.
  - Otherwise, HCS is masked with STId.
- Three possible schemes to mask CRC/HCS using STId
  - Xor STID with the LSBs of CRC (CRC16 or CRC32)
  - Xor first byte and second byte of STID and then xor with HCS
  - STID is appended to the end of GMH when CRC or HCS is calculated

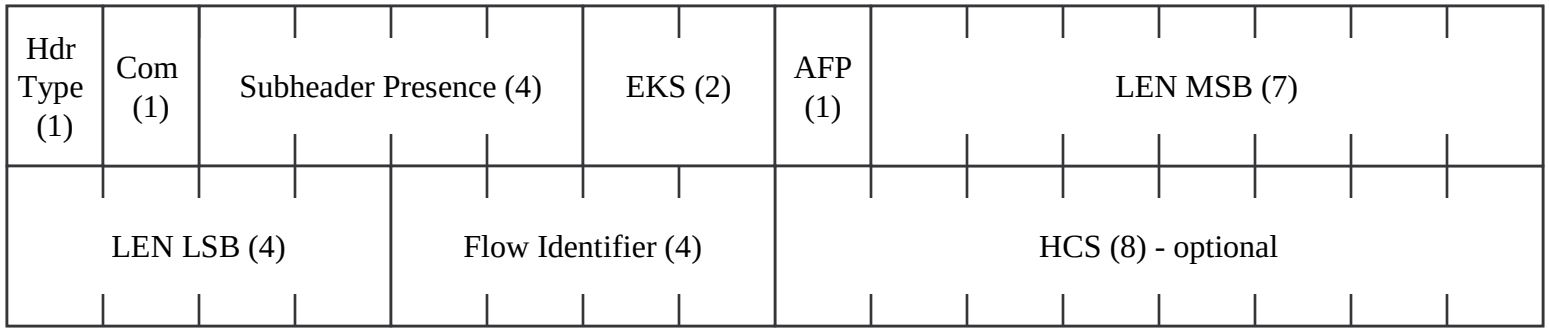
GMH optimization – Subheader Presence Indication (1)

- The Type field in .16e GMH indicates the presence of subheaders and extended subheaders.
- FSN size is defined in the FSN size TLV in DSA messages during service flow setup. Thus the connection index already indicate the size of FSN, and there is no need to have Extended Type bit in the Type field in GMH.
- Only 4 bits are needed to indicate the presence of Fragment subheader, Packing subheader, Extended Packing subheader, Grant management subheader/Fast-feedback allocation subheader, and Extended subheaders.
  - Bit #3: presence of Extended Subheader (see slide #12)
  - Bit #2 and #1: presence of fragmentation, packing and/or extended packing subheader
    - 00: fragmentation subheader
    - 01: packing subheader
    - 10: extended packing subheader
    - 11: reserved
  - Bit #0: presence of FFSH (DL) or GMSH (UL)

GMH optimization – Subheader Presence Indication (2)

- An alternative approach is to include subheader presence indication in a new subheader (i.e., presence indication subheader), and only use one-bit in GMH to indicate the presence of subheader or not.
- However, this may lead to larger overhead.
  - FSH/PSH/EPSH is normally present in every MPDU.
    - For ARQ enabled connection, FSH/PSH/EPSH is used to carry ARQ BSN.
    - For non-ARQ enabled connection, FSH/PSH/EPSH is used to carry FSN for the purpose of in-order delivery.
  - Therefore, the presence indication subheader will normally be present, which introduces at least 8-bit overhead to the MAC PDU, instead of 4-bit overhead as proposed in the last slide.

Proposed Normal GMH Format

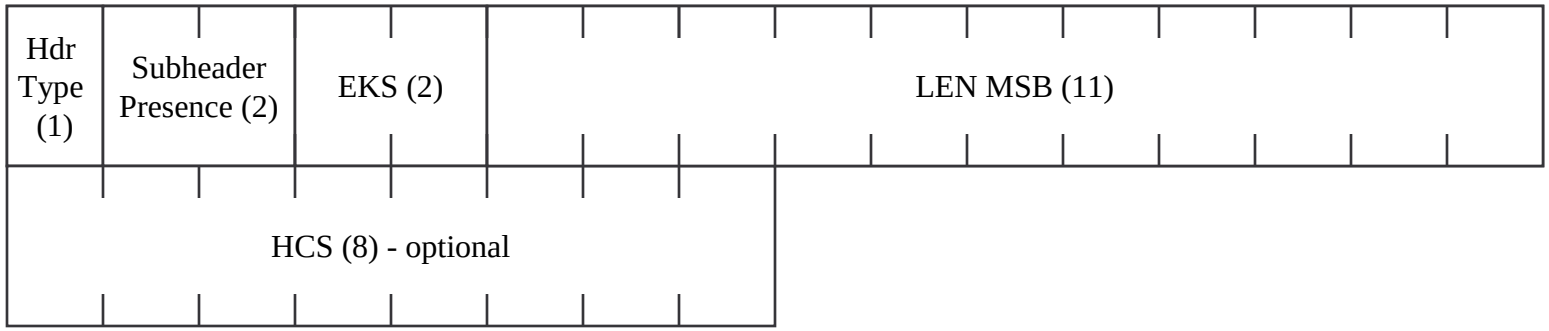


- Hdr Type: Header Type (0 - GMH)
- Com: Indicate the GMH format (0 - normal GMH)
- Subheader Presence: Indicate presence of subheaders or extended subheader in the payload
- EKS: Encryption key sequence
- AFP: Indication of presence of ARQ feedback payload
- Flow identifier: Flow identifier of the connection
- LEN: the length of the MAC PDU including MAC header and CRC if present
- HCS: header check sequence (only present when neither HARQ nor CRC is enabled for the connection)

GMH for Multicast/Broadcast

- Special station identifier are reserved for multicast/broadcast connections.
- No flow identifier is used for multicast/broadcast MPDUs
- ARQ is not used for multicast/broadcast connections.
- Therefore information such as AFP, flow identifier doesn't needs to be included in the MAC header for multicast/broadcast connections.
- A different header format can be defined for multicast/broadcast connection.
  - No special Header Type needs to be reserved to differentiate between multicast/broadcast GMH format and normal GMH.
  - The station identifier included in DL control and signaling information indicates the header format for the MAC PDU.

Proposed Multicast/Broadcast GMH Format

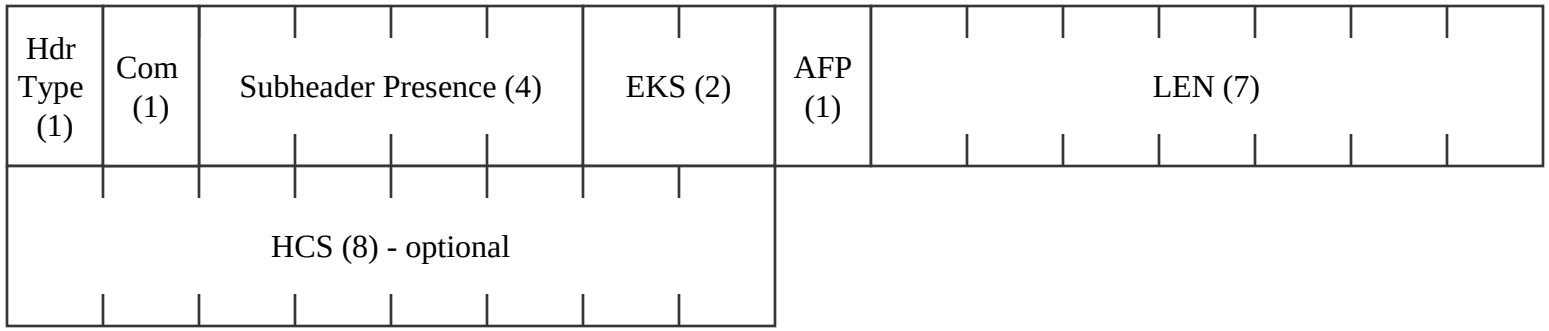


- Hdr Type: Header Type (0 - GMH)
- Subheader Presence: Indicate presence of subheaders
  - 00: no subheader is present
  - 01: presence of fragment subheader
  - 10: presence of packing subheader
  - 11: reserved
- EKS: Encryption key sequence
- LEN: the length of the MAC PDU including MAC header and CRC if present
- HCS: header check sequence (only present when neither HARQ nor CRC is enabled for the connection)

GMH Optimization – Compressed GMH

- The resource assigned in persistent allocation is for a specific connection. Therefore, flow identifier is not needed in the GMH.
- Persistent allocation is normally used for periodical traffic such as VoIP with small size packet. Therefore, the length of MPDU is normally small.
- A compressed GMH can be used instead of normal GMH for persistent allocation to further reduce GMH overhead.

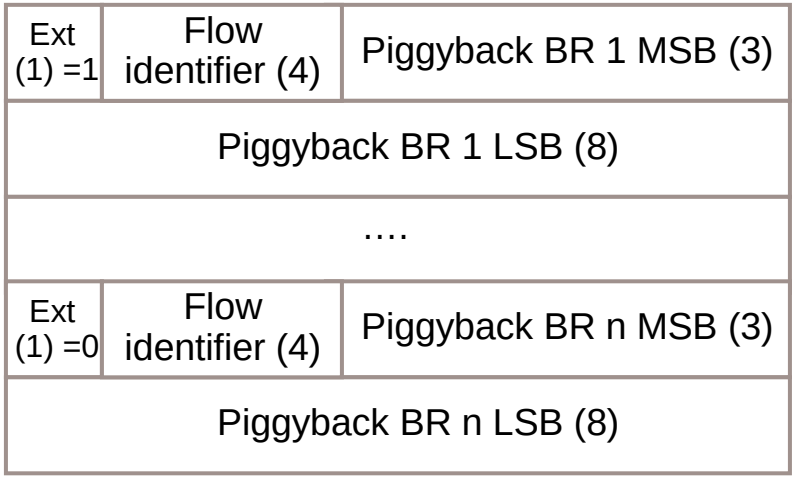
Proposed Compressed GMH Format



- Hdr Type: Header Type (0 - GMH)
- Com: Indicate the GMH format (1- compressed GMH)
- Subheader Presence: Indicate presence of subheaders in the payload
- EKS: Encryption key sequence
- AFP: Indication of presence of ARQ feedback payload
- LEN: the length of the MAC PDU including MAC header and CRC if present
- HCS: header check sequence (only present when neither HARQ nor CRC is enabled for the connection)

GMH optimization – Piggyback BR

- In 802.16e, the piggyback bandwidth request carried in grant management subheader can only be applied to the CID carried in the GMH
- It happens very often that MS needs b/w for other connections



Optimization in .16m

- Each piggyback BR contains Ext bit, flow identifier and requested bandwidth
- Multiple piggyback BRs may be present in one grant management subheader
- Ext bit indicates if more piggyback BR follows

GMH Optimization – Extended Packing Subheader (1)

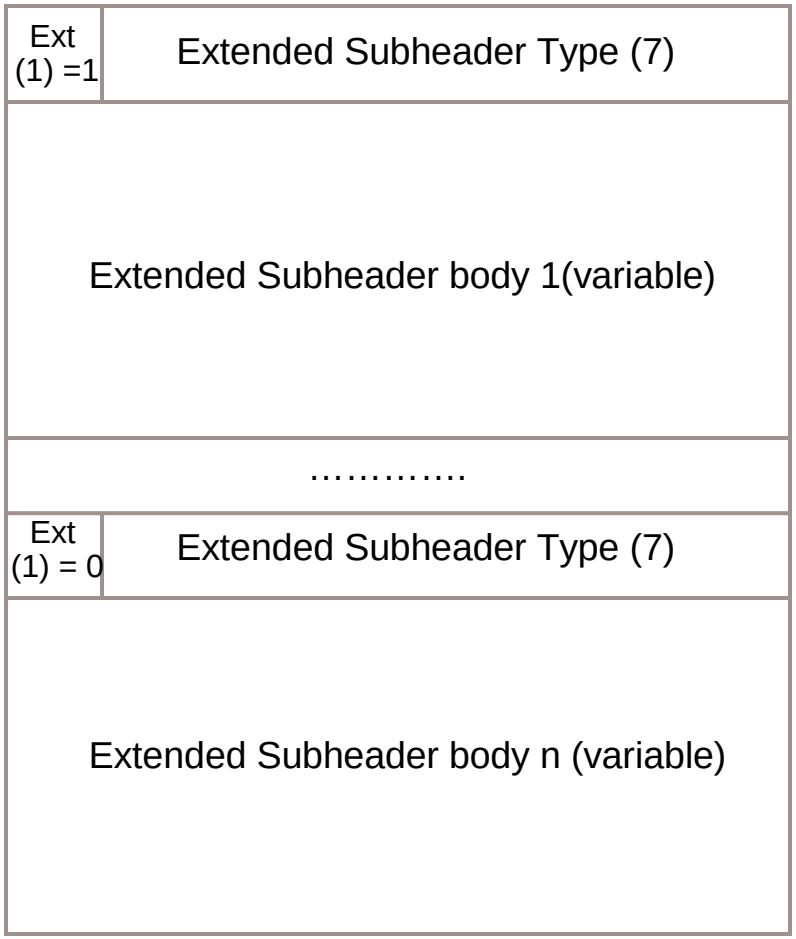
- In 802.16e, packing is only applied to the SDUs belonging to the same connection of an MS. If SDUs from different connections of an MS need to be sent in one burst, only concatenation can be used. This introduce overhead.
- In 802.16m, an Extended Packing Subheader (EPSH) can be used to pack SDUs from different connections of an MS into one MAC PDU.

Syntax	Size	Notes
Extended Packing Subheader() {		
FSI	1	First SDU Indication – indicate if it is the 1st SDU/SDU fragment for the same connection
If (First SDU Indication == 1) {		
Flow identifier	4	Flow identifier
EKS	2	Encryption Key Sequence
} else {		
Rsv	6	Reserved
}		
FC	2	Same as defined in PSH
If (ARQ-enabled Connection)	-	
BSN	11	Same as defined in PSH
else {	-	
if (Extended Type)	-	
FSN	3	Same as defined in PSH
else	-	
FSN	11	Same as defined in PSH
}	-	
Length	11	SDU/SDU fragment length including EPSH
Rsv	1	Reserved
}		

GMH Optimization – Extended Packing Subheader (2)

- The SDU/SDU fragments belonging to the same connection are packed adjacent to each other.
  - The first SDU/SDU fragment belong to the same connection uses the EPSH with the First_SDU_Indication (FSI) bit set to 1 and the FId and EKS fields in the EPSH contains the FId and EKS for the connection.
  - All the other SDUs/SDU fragments in the same connection is packed afterward, with the FSI bit in EPSH set to 0, and assumes that the same FId and EKS fields defined in the EPSH for the first SDU/SDU fragment with the same connection apply.
- When EPSH is present, the Flow identifier and EKS fields in the GMH is not valid.
- If CRC is enabled for the connection, it is used to protect all the SDU/SDU fragment belonging to the same connection.
  - If CRC is enabled for the SDUs/SDU fragments for the first connection, the CRC shall protect the GMH and all the other subheaders/extended subheaders before the first EPSH plus SDUs/SDU fragments on the first connection; otherwise, HCS is included in the GMH.
  - If CRC is enabled for the following SDU/SDU fragments, the CRC shall protect the SDU/SDU fragments together with correspondent EPSH for the same connection.

GMH optimization – Extended Subheader

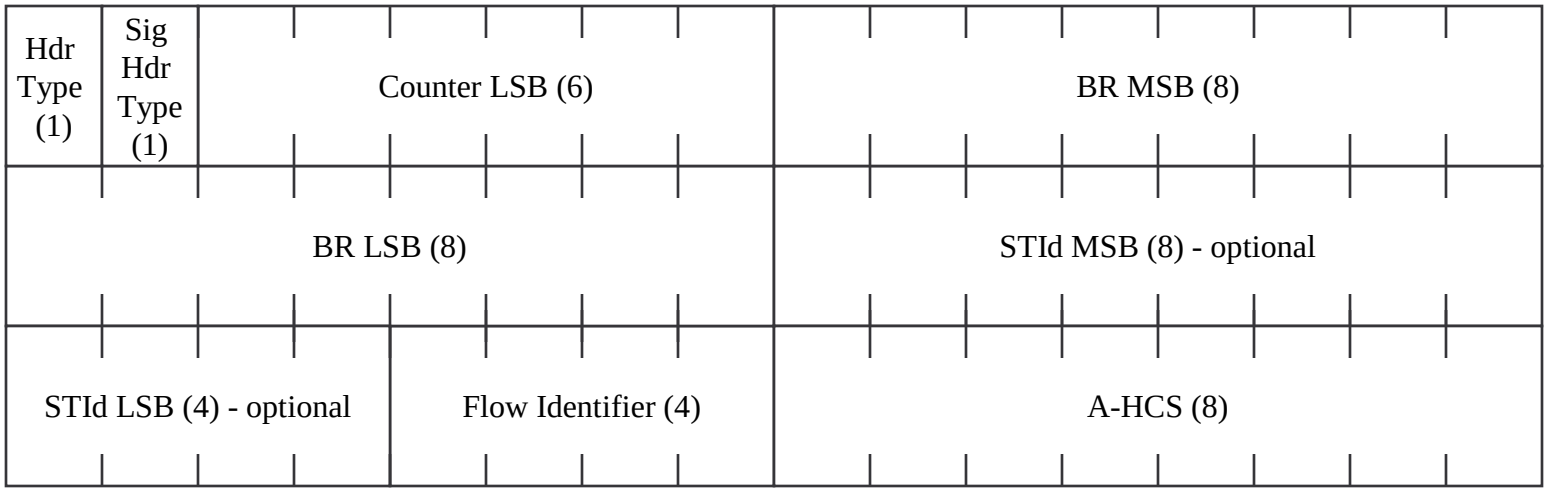


- Use the Ext bit to indicate if there is another extended subheader follows
- There is no need to have Extended Subheader Group Length

Signaling Header optimization – BR Header

- Issues with .16e Bandwidth request and other signaling headers
  - Bandwidth Request and other signaling headers are not protected
    - Any entity can generate BR and other signaling header on behalf of another MS. BS cannot verify if the request is sent from a legitimate user.
    - Rogue SS could make false uplink bandwidth requests and waste precious uplink bandwidth.
    - Rogue MS could send BR header on behalf of other MS with bandwidth request of “ZERO” byte, which leads to Denial of Service attack.
  - Aggregate Bandwidth Request contains 19 bits
    - It’s not often for an MS to request for 512k bytes in one bandwidth request.
    - If more bandwidth is needed, a piggyback BR could be used.
    - Is 19 bit selected in .16e just for the purpose of byte alignment?
  - BR is in the unit of bytes
    - BS allocate resource in the unit of radio block in .16m. Thus it makes sense for MS to request for bandwidth in the unit of radio block.
  - Incremental BR is sent together with other signaling
    - How often does an MS sends BR and other signaling together?
    - If not, only aggregate BR is used and other signaling headers are sent by itself.

Proposed Bandwidth Request Header Format



- Hdr Type: Header Type (1 for BR and other signaling header)
- Sig Hdr Type: Signaling Header Type (0 for BR and 1 for other signaling header)
- Counter LSB: the LSBs of counter
- BR: bandwidth requested in the unit of resource block
- STId: Station identifier of the MS
  - Not present if the BR request is sent using the resource dedicate to the MS.
- Flow identifier: Flow identifier of the connection requesting for b/w
- A-HCS: Authenticated HCS (refer to contribution C80216m-08/

Proposed text changes for 802.16m SDD (1)

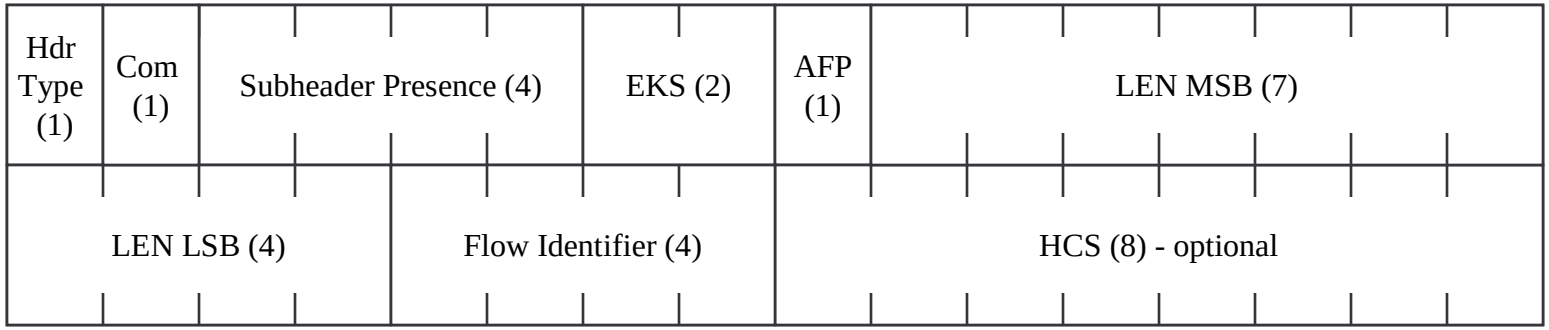
- Section 10.x: MAC PDU design
- Section 10.x.1: MAC PDU Services and Functions
  - Each MAC PDU contains a MAC header, optional payload and optional CRC.
  - MAC header could either be standalone header containing signalling information without payload or proceed payload containing MAC management messages or user data. It only contains information that cannot be derived from DL control and signalling information or service flow information.
  - Compressed header formats are used for connections such as multicast/broadcast and connections with persistent allocation. Station identifier carried in DL control and signalling information is used to determine header format used in the MAC PDU.

Proposed text changes for 802.16m SDD (2)

- Multiple MAC PDUs from different MSs could be concatenated into a single transmission. One MAC SDU or MAC management message could be fragmented into one or more MAC PDUs. Multiple MAC SDUs or MAC management messages from the same MS could be packed into one MAC PDU.
- MAC PDU or MAC header could be protected using one type of error detection mechanism.
  - If PHY level error detection (e.g., HARQ) is enabled for the connection, no other error detection is applied to the MAC PDU and MAC header.
  - If no PHY level error detection is enabled, but CRC is enabled for the connection, no other error detection is applied for MAC header.
  - Otherwise, error detection on MAC header is applied.
- Multiple piggyback bandwidth requests for different connections may be included in one subheader.

Proposed text changes for 802.16m SDD (3)

- Section 10.x.2: MAC Header
- Section 10.x.2.1 Generic MAC Header



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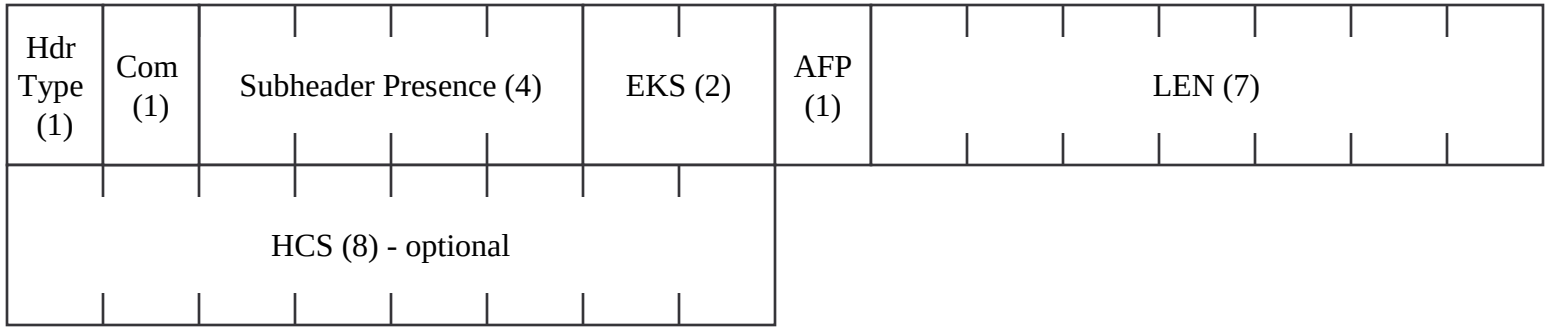
- EKS: Encryption key sequence
- AFP: Indication of presence of ARQ feedback payload
- Flow identifier: Flow identifier of the connection
- LEN: the length of the MAC PDU including MAC header and CRC if present
- HCS: header check sequence (only present when neither HARQ nor CRC is enabled for the connection)

Proposed text changes for 802.16m SDD (4)

- Section 10.x.2.2 Compressed MAC Header



- Hdr Type: Header Type (0 - GMH, 1 - signaling header)
- Com: Indicate the GMH format (0 - normal GMH, 1- compressed GMH)
- Subheader Presence: Indicate presence of subheaders in the payload
- EKS: Encryption key sequence
- AFP: Indication of presence of ARQ feedback payload
- LEN: the length of the MAC PDU including MAC header and CRC if present
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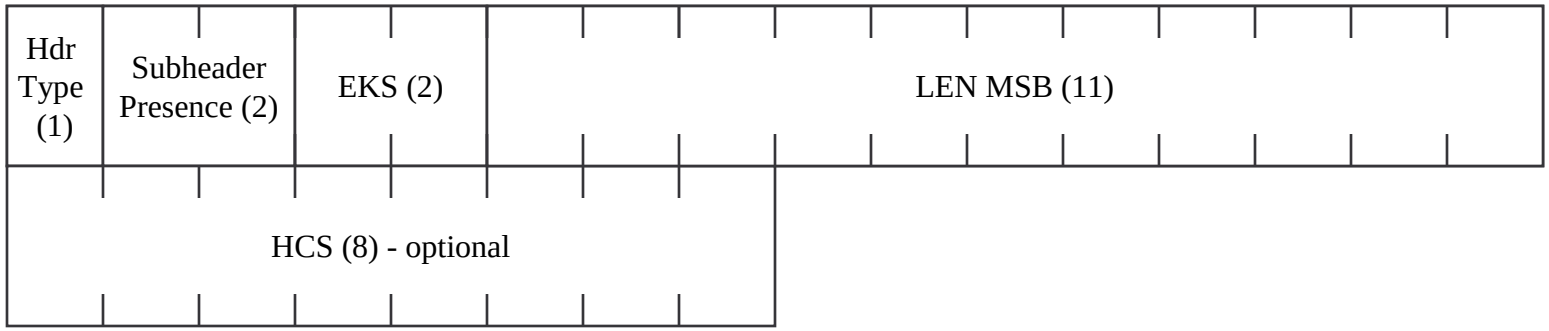
Proposed text changes for 802.16m SDD (5)

- Section 10.x.2.3 Multicast/Broadcast MAC Header



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  - 00: no subheader is present
  - 01: presence of fragment subheader
  - 10: presence of packing subheader
  - 11: reserved
- EKS: Encryption key sequence
- LEN: the length of the MAC PDU including MAC header and CRC if present
- HCS: header check sequence (only present when neither HARQ nor CRC is enabled for the connection)

Proposed text changes for 802.16m SDD (5)

- Section 10.x.2.4 Subheader
- Section 10.x.2.4.x Grant Management Subheader

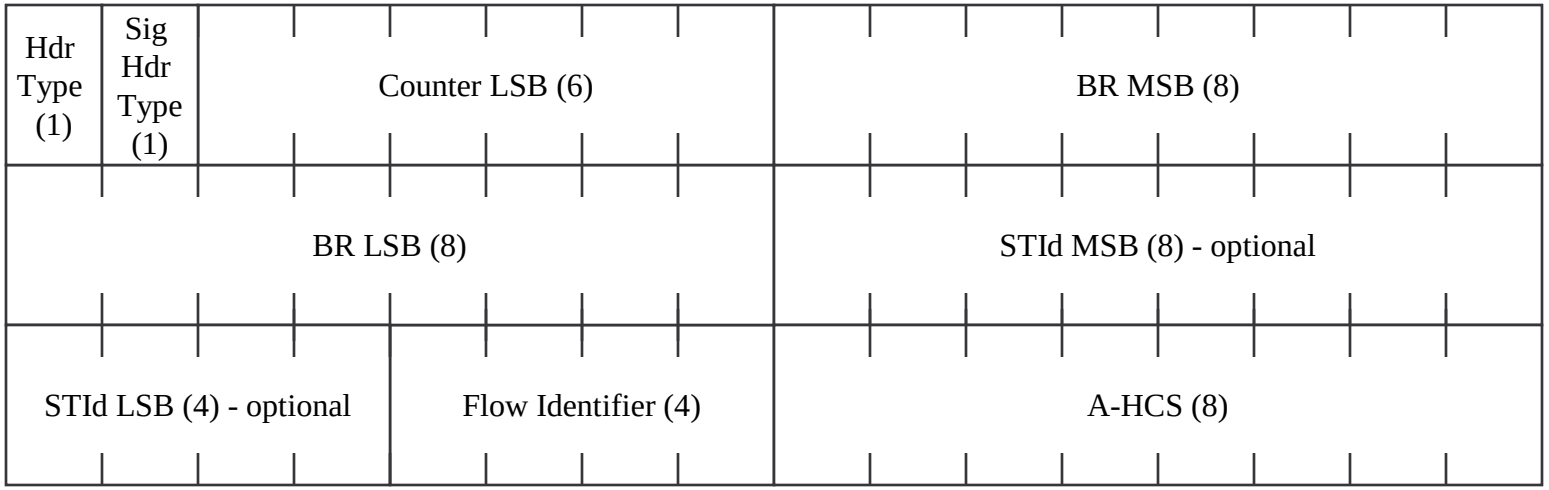
  {insert the table in slide #13}
- Section 10.x.2.4.y Extended Packing Subheader

  {insert the table in slide #14}
- Section 10.x.2.5 Extended Subheader

  {insert the table in slide #16}

Proposed text changes for 802.16m SDD (6)

- Section 10.x.2.5 Signaling MAC Header
- Section 10.x.2.5.1 Bandwidth Request Header



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- Flow identifier: Flow identifier of the connection requesting for b/w
- A-HCS: Authenticated HCS