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Title	**802.16m MAC PDU Structure**
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Re:	MAC: Data Plane

Abstract	This contribution propose 16m MAC PDU Header and Subheader formats.

Purpose	Discuss and adopt

802.16m MAC PDU Structure

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1   Introduction

This contribution proposes new formats for MAC header/subheaders for 802.16m. The MAC header/subheaders defined by IEEE 802.16e-2005 has the following issues:

- Long MAC Header (6 bytes) cause large MAC overhead

- Non-scalable design makes adding signaling subheader cumbersome when new features are introduced

- Multiple formats of MAC Signaling Headers without payload

- No optimization for MAC PDU with small packet size.

In addition, new MAC addressing scheme was introduced in IEEE 80216m-08_003r4 SDD document. The new MAC address scheme is defined as (STID,FID) per MAC connection, where STID is the station ID for MS and FID is the connection ID unique to one MS. This allows new design of MAC header/subheaders to reduce overhead.

2   Proposed Solution

The design principles for the new MAC header/subheaders are the following:

- Shorten generic MAC header to reduce overhead

- Allow flexible expansion of subheaders

- Unify signaling MAC header design

- Optimize design for service types with small MAC PDU size, i.e. VoIP and signal MAC header/messages.

2.1   MAC PDU

The format of MAC PDU remains the same as defined in IEEE 802.16e-2005, where subheaders can also be included as part of payload.
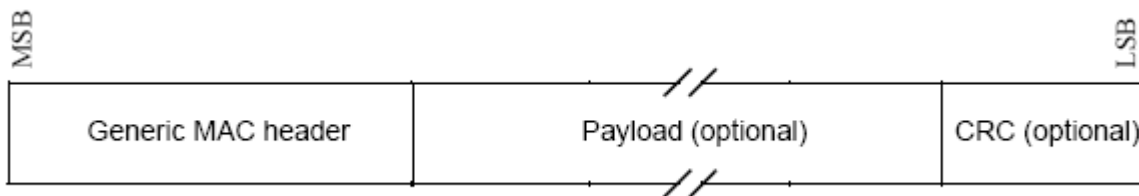

Figure 1. MAC PDU

2.2   MAC Header format

MAC header is redefined with the following changes:
- Only contains FID; STID can be included in resource allocation signaling (MAP IE) or by other

methods.

- CI and EC bits are removed from MAC header; CRC inclusion and Data encryption should be enabled at connection setup and should be consistent for all MPDU carried over that connection.
- EKS field is reduced from 2 bits to 1 bit, instead of providing an index to TEK, it provides a TEK change indication. Hence, when the sender of the MAC PDU changes its TEK, it will toggle the EKS bit in all of its MAC PDUs.
- TYPE field for subheader is replaced with an indication bit (SI), which indicates the inclusion of subheaders. Removing TYPE field not only allows size reduction of MAC Header, it also allows the more flexible growth of subheader types.
- HCS is reduced from 8 bits to 5 bits. A shorter HCS offers weaker error detection, the probability of missing a burst error bigger than n bits (where n is the size of HCS) increase from 2^{-8} to 2^{-5}. However, the size of new MAC header is also reduced from 5 bytes to 2 bytes, the conflict ratio is also reduced from $1/2\,^{\wedge}40$ to $1/2^{\wedge}16$.

Three types of MAC headers are defined in this proposal:

- Generic MAC Header (for data traffic): for MAC PDU with length longer or equal to 128 bytes
- Compressed MAC Header (for data traffic): for MAC PDU with length smaller than 128 bytes and with CRC enabled or HARQ enabled.
- Signaling MAC Header (for MAC signaling traffic, including signaling message)

Generic MAC Header

- GMH is for all data MPDU. However, it is more suitable for larger MAC PDUs since the header size is larger.
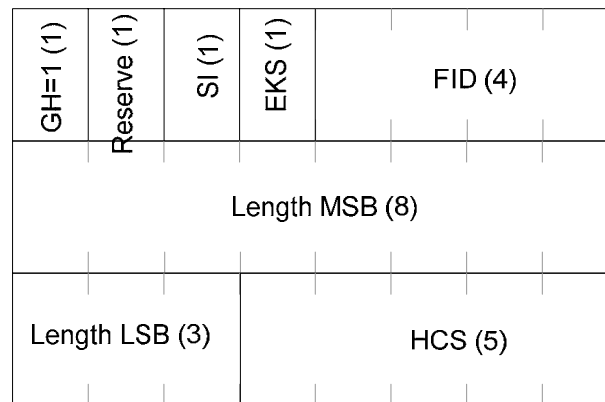- GH is the indication bit for Generic MAC Header, GH=1 for this header format

GH=1 (1)	Reserve (1)	SI (1)	EKS (1)	FID (4)
Length MSB (8)				
Length LSB (3)		HCS (5)		

Figure 2. Generic MAC Header

Compressed MAC Header

- CMH is aimed to optimize for small data MPDU (for application like VoIP). For smaller MPDU, the size of header is more critical since the MAC overhead is much larger for smaller packet caused by MAC header.
- HCS is removed from CMH, hence, CMH only can be used for connections with CRC or HARQ enabled.
- Length field is reduced to 7 bits
- Since CMH is the same size as signaling MAC header, an indication for signaling subheader (SH) is
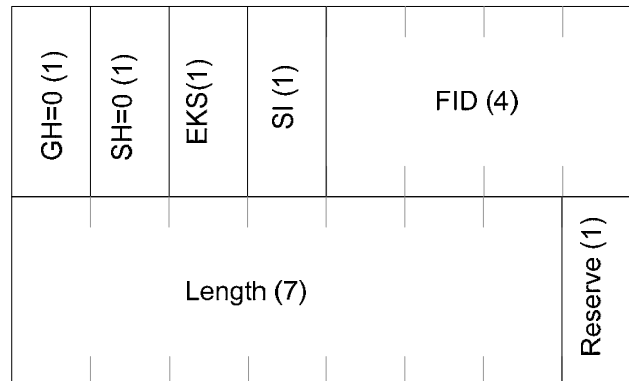
also included, where SH=0

Figure 3. Compressed MAC Header

Signaling MAC Header
- SMH is used for MPDU carrying MAC signaling messages or only signaling subheaders
- Unlike specified in IEEE 802.16e, SMH does not carry any control information, rather, it can carry header only signaling by including subheaders and no data payload.
- Unlike CMH, the HCS is included with SMH
- Since SMH is used to convey MAC control signaling, hence only will be carried over MAC management connection, a Reduced FID is used. Reduced FID is a one bit field, which sets to 0 for basic connection and sets to 1 for primary management connection.
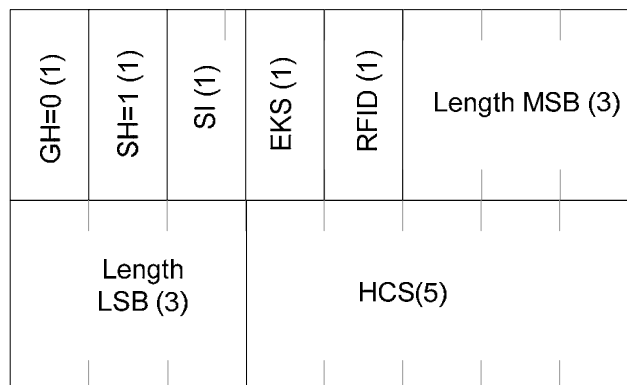

Figure 4. Signaling MAC Header

2.3   Subheader format

In IEEE 802.16e, the following subheaders are defined:
- Fragmentation
- Grant Management
- Packing subheader

- Fast Feedback
- ARQ feedback
- Extended subheader (6 DL ESF, 5 UL ESF)

Among the subheaders, Fragmentation and packing subheader are the subheaders maybe included in every MAC PDU if fragmentation and/or packing is enabled for the connection. The rest of subheaders are only included occasionally to allow piggybacking of control signaling. Hence, by including a TPYE field and ESF field in every MAC header, not only unnecessary overhead is added, but also limits the number of subheaders can be supported. The Extended subheader is a patch solution to the limitation. The new MAC header and subheader design allows a large number of subheaders while reducing the overall overhead of the system. It is as following:

- A Subheader Inclusion (SI) bit is included in MAC header. When SI is set, at least one or more subheader is present in the MPDU.
- Except for Fragmentation and Packing subheader, the rest of the subheaders follows the generic format as shown below
    - SI bit indicates at least one more subheader is included immediately following the current subheader
    - TYPE field indicates the subheader type
    - No length field included, since most subheaders are for unicast signaling, it is assumed that MS and BS has the capability information of each other. In addition, for subheader that is not carrying unicast information, the BS/MS are required to know at least the size of each type of subheader.
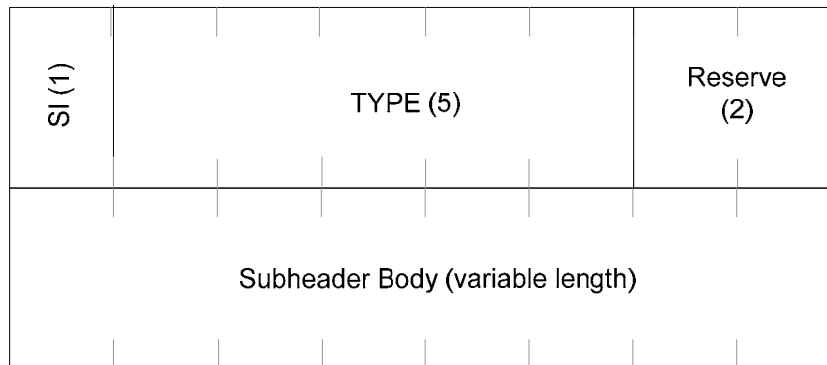

Figure 4. Subheader Format

- The inclusion of Fragmentation and Packing subheader are determined at connection set up. Hence, it's defined as following:
    - The last subheader immediately before payload should be either a Fragmentation subheader or Packing subheader when Fragmentation and/or Packing option is enabled.
    - No TYPE field included in the subheader.
    - A PH indicator to differentiate between Fragmentation subheader or Packing subheader
    - When packing subheader is included, multiple packing subheaders may be included with one precede each SDU.
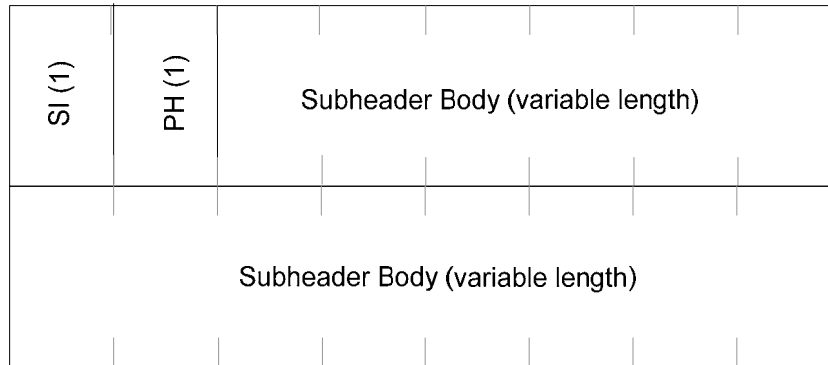
Figure 6. Fragmentation and Packing subheader format

3   Proposed Text

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10.x. MAC PDU

10.x.1 MAC Header Format

Three MAC Header formats are defined for both DL and UL. The first one is Generic MAC Header (GMH) that begins MPDU with CS data. The second one is Compressed MAC Header (CMH) that also begins MPDU with CS data. The MPDU encapsulated by CMH has a length limitation of 128 bytes while the one with GMH has a length limitation of 2048 bytes. The third type is Signaling MAC Header (SMH) that begins MPDU with management messages. The SMH also supports MPDU format with subheaders only.

A FID or a Reduced FID (for SMH) is included in MAC Header to identify the connection for each MS. STID is not included in MAC header, it might be included in resource allocation message or FFS.

10.x.1.1. Generic MAC Header

A Generic MAC Header should contain the following fields:

- Generic MAC Header indicator (GH)
- FID
- EKS bit to indicate the change of TEK at sender
- Subheader Inclusion bit (SI), which indicates the inclusion of subheaders.
- Length: length of MPDU including CRC (11 bits)
- HCS

10.x.1.2. Compressed MAC Header

A Compressed MAC Header should contain the following fields:

- Generic MAC Header indicator (GH)
- FID
- EKS bit to indicate the change of TEK at sender
- Subheader Inclusion bit (SI), which indicates the inclusion of subheaders.
- Length: length of MPDU including CRC (7 bits)
- Signaling Header Indicator

6

10.x.1.3. Signaling MAC Header

A Signaling MAC Header should contain the following fields:

- Generic MAC Header indicator (GH)
- Reduced FID (for management connections only)
- EKS bit to indicate the change of TEK at sender
- Subheader Inclusion bit (SI), which indicates the inclusion of subheaders.
- Length: length of MPDU including CRC (6 bits)
- Signaling Header Indicator
- HCS

10.x.2 MAC Subheader Format

The inclusion of subheaders is indicated by Subheader Indication (SI) bit in MAC Header. In addition, the SI bit is also included in each subheader. When SI bit in a subheader is set to 1, it is indicating there is one more subheader immediately following the current one.

Except for Fragmentation and Packing subheaders, a TYPE field is also included in each subheader. For Fragmentation and Packing subheader, no TYPE field is included. When Fragmentation subheader or Packing subheader is included, it should be included as the last subheader immediately before data payload. Multiple packing subheader also may be included, with one PSH preceding each SDU.

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