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| Title | **Guidelines for Overhead Evaluation of IEEE 802.16s Proposals** | |
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| Abstract | Describes criteria for evaluating overhead of 802.16s proposal | |
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Guidelines for Overhead Evaluation of

IEEE 802.16s Proposals

## General

1. The IEEE 802.16 air interface protocol overhead consists of the following overhead components:
   1. PHY layer overhead
   2. Per-frame overhead
   3. MAC layer overhead

These overhead components are discussed in details in this document.

1. Overhead reduction and high frequency utilization is essential to maintain broadband experience in the relatively narrow channels for which the IEEE 802.16s amendment is designed.

## PHY Layer Overhead

1. Guard band:
   1. As an unused portion of the available band, the guard bands can be viewed a PHY overhead component. Minimization of this overhead is done by maximizing the sampling clock to fit the active subcarriers within the available band subject to the applicable FCC spectrum mask (e.g., FCC Part 27 for the Upper 700 MHz A Block). The related overhead component is the ratio between the un-used channel bandwidth and the total channel bandwidth. In some cases, e.g., PUSC, the bandwidth used in downlink and uplink or in different phases of communication is different in which case, the overhead changes from phase to phase.

Example:

* + 1. Preamble, the rest of the DLSF, ULSF and CDMA codes all consume the same bandwidth
    2. Channel bandwidth = 1 MHz
    3. Used bandwidth = 945 KHz
    4. Unused Channel bandwidth Overhead = 55 /1000 = 5.5%

1. Subcarrier overhead:

This is due to the pilots and the DC subcarriers.

Subcarrier overhead = (# of pilots per OFDMA symbol +1)/(total # of subcarriers – guard subcarriers)

Note: the number of pilot subcarriers may be different in uplink and downlink and may also change between consecutive symbols (e.g., in the case of UL PUSC).

Example: 128 FFT with AMC 3X2:

Total # of subcarriers = 128

Total # of active subcarriers = 108

Total # of data subcarriers = 96

Pilot overhead = 12/108 = 11%

1. CP overhead:

The Cyclic Prefix overhead is equal to the CP value. The most common CP value used is 1/8 but, depending on deployment scenario, a lower CP (e.g., 1/16 or 1/32) may be used to reduce overhead.

1. Modulation and coding:

A stronger Forward Error Correction code has more overhead than a weaker one but it enables a higher modulation scheme. It makes therefore more sense to measure the bandwidth utilization for each FEC code by means of the number of bytes per slot where the slot is the minimal allocation granularity of the MAC layer and is defined in each permutation. The number of bytes per slot vary between 6 bytes for QPSK ½ to 30 bytes per slot for 64QAM 5/6.

## Per-Frame Overhead

1. General:

The per-frame overhead includes the preamble, FCH, the DL-MAP and the UL-MAP all of which are carried in every DLSF. As such, the per-frame percentage overhead increases as the frame capacity is reduced, i.e., as the frame duration is smaller and as the number of sub-channels is lower. The per-frame overhead components are broadcast messages which need to be received by all remotes in the sector. As such, a robust modulation and coding schemes (typically QPSK ½) is used.

1. Preamble:

The preamble is one symbol long.

1. DL MAP:

The standard DL MAP has an IEEE 802.16 MAC PDU structure. As such, it has a 10 bytes PDU overhead which consists of GMAC header and CRC. The standard offers a non-compressed and a compressed DL MAP structures as described in tables 1 and 2 below.

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| **Table 1: Non Compressed DL MAP Structure** | | | |
| **S.NO** | **Features** | **As per Standard**  **in bits** | **As per proposal** |
| DL-MAP | | | |
| 1 | DL-MAP MAC Management Message ID | 8 |  |
| 2 | Frame Duration Code | 8 |  |
| 3 | Frame Number | 24 |  |
| 4 | DCD Count | 8 |  |
| 5 | BSID | 48 |  |
| 6 | Number Of OFDMA symbols | 8 |  |
| DL-MAP IE- If DIUC = 15 CID Switch IE | | | |
| 1 | DIUC | 4 |  |
| 2 | Extended DIUC | 4 |  |
| 3 | Length | 4 |  |
| DL-MAP IE - If DIUC between 0 to 12 | | | |
| 1 | DIUC | 4 |  |
| 2 | N\_CID (Number of CIDs) | 8 |  |
| 3 | CIDs (array of CIDs) | 16 |  |
| 4 | Symbol Offset (Number of slots) | 8 |  |
| 5 | Subchannel Offset | 6 |  |
| 6 | No of Symbols | 7 |  |
| 7 | No of Sub-channels | 6 |  |
| 8 | Boosting | 3 |  |
| 9 | Repetition | 2 |  |
| GMAC Header & CRC | | | |
| 1 | HT | 1 |  |
| 2 | EC | 1 |  |
| 3 | Type | 6 |  |
| 4 | ESF | 1 |  |
| 5 | CI | 1 |  |
| 6 | EKS | 2 |  |
| 7 | Rsv | 1 |  |
| 8 | LEN | 11 |  |
| 9 | CID | 16 |  |
| 10 | HCS | 8 |  |
| 11 | CRC | 32 |  |

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| **Table 2: Compressed DL MAP Structure** | | | |
| **S.NO** | **Features** | **As per Standard**  **in bits** | **As per proposal** |
| DL-MAP | | | |
| 1 | Compressed MAP Indicator | 3 |  |
| 2 | ULMAP appended | 1 |  |
| 3 | FDD partition change flag | 1 |  |
| 4 | MAP message length | 11 |  |
| 5 | PHY synchronization field | 32 |  |
| 6. | DCD count | 8 |  |
| 7. | Operator ID | 8 |  |
| 8 | Sector ID | 8 |  |
| 9 | Number Of OFDMA symbols | 8 |  |
| 10 | DL IE Count | 8 |  |
| DL-MAP IE- If DIUC = 15 CID Switch IE | | | |
| 1 | DIUC | 4 |  |
| 2 | Extended DIUC | 4 |  |
| 3 | Length | 4 |  |
| DL-MAP IE - If DIUC between 0 to 12 | | | |
| 1 | DIUC | 4 |  |
| 2 | N\_CID (Number of CIDs) | 8 |  |
| 3 | CIDs (array of CIDs) | 16 |  |
| 4 | Symbol Offset (Number of slots) | 8 |  |
| 5 | Subchannel Offset | 6 |  |
| 6 | No of Symbols | 7 |  |
| 7 | No of Sub-channels | 6 |  |
| 8 | Boosting | 3 |  |
| 9 | Repetition | 2 |  |
| GMAC header and CRC | | | |
| 1 | HT | 1 |  |
| 2 | EC | 1 |  |
| 3 | Type | 6 |  |
| 4 | ESF | 1 |  |
| 5 | CI | 1 |  |
| 6 | EKS | 2 |  |
| 7 | Rsv | 1 |  |
| 8 | LEN | 11 |  |
| 9 | CID | 16 |  |
| 10 | HCS | 8 |  |
| 11 | CRC | 32 |  |

1. The UL MAP:

The standard UL MAP has an IEEE 802.16 MAC PDU structure. As such, it has a 10 bytes PDU overhead which consists of GMAC header and CRC. The standard offers a non-compressed and a compressed UL MAP structures as described in tables 3 and 4 below.

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| **Table 3: Non Compressed UL MAP Structure** | | | |
| **S.NO** | **Features** | **As per Standard**  **in bits** | **As per proposal** |
|  | | | |
| 1 | ULMAP MMM | 8 |  |
| 2 | FDD Partition flag | 1 |  |
| 3 | Reserved | 7 |  |
| 4 | UCD Count | 8 |  |
| 5 | Allocation Start Time | 32 |  |
| 6 | Number Of OFDMA symbols | 8 |  |
| ULMAP IE (common to all burst type) | | | |
| 1 | CID | 16 |  |
| 2 | UIUC | 4 |  |
| If UIUC = 12 IR IE / UIUC = 10 PR IE | | | |
| 1 | OFDMA Symbol Offset | 8 |  |
| 2 | Sub-channel Offset | 7 |  |
| 3 | No of Symbols | 7 |  |
| 4 | No of Sub-channels | 7 |  |
| 5 | Ranging Method | 2 |  |
| 6 | Ranging Indicator | 1 |  |

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| If UIUC = 13 PAPR IE | | | | | | |
| 1 | OFDMA symbol offset | | 8 |  | | |
| 2 | Sub-channel offset | | 7 |  | | |
| 3 | No. OFDMA symbols | | 7 |  | | |
| 4 | No. sub-channels/SZ Shift Value | | 7 |  | | |
| 5 | PAPR Reduction/Safety Zone | | 1 |  | | |
| 6 | Sounding Zone | | 1 |  | | |
| 7 | *Reserved* | | 1 |  | | |
| If UIUC = 1 to 8 DATA BURST IE | | | | | | |
| 1 | Duration (# of slots) | | 10 |  | | |
| 2 | Repetition coding indication | | 2 |  | | |
| If UIUC = 14 CDMA-ALLOC-IE | | | | | | |
| 1 | Duration | | 6 |  | | |
| 2 | UIUC | | 4 |  | | |
| 3 | Repetition Coding Indication | | 2 |  | | |
| 4 | Frame Number Index | | 4 |  | | |
| 5 | Ranging Code | | 8 |  | | |
| 6 | Ranging Symbol | | 8 |  | | |
| 7 | Ranging sub channel | | 7 |  | | |
| 8 | BW request mandatory | | 1 |  | | |
| If UIUC = 15 Extended UIUC for power control (We have changed UIUC =9) | | | | | | |
| 1 | Extended UIUC | | 4 | |  | | |
| 2 | Length | | 4 | |  | | |
| 3 | Power Control | | 8 | |  | | |
| 4 | Power Measurement Frame | | 8 | |  | | |
| GMAC header and CRC | | | | | | | | |
| 1 | | HT | 1 | | |  | | |
| 2 | | EC | 1 | | |  | | |
| 3 | | Type | 6 | | |  | | |
| 4 | | ESF | 1 | | |  | | |
| 5 | | CI | 1 | | |  | | |
| 6 | | EKS | 2 | | |  | | |
| 7 | | Rsv | 1 | | |  | | |
| 8 | | LEN | 11 | | |  | | |
| 9 | | CID | 16 | | |  | | |
| 10 | | HCS | 8 | | |  | | |
| 11 | | CRC | 32 | | |  | | |

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| **Table 4: Compressed UL MAP Structure** | | | | | | | |
| **S.NO** | **Features** | | | **As per Standard**  **in bits** | **As per proposal** | |
| UL-MAP | | | | | | | |
| 1 | | UCD Count | 8 | | |  | |
| 2 | | Allocation Start Time | 32 | | |  | |
| 3 | | Number Of OFDMA symbols | 8 | | |  | |
| ULMAP IE (common to all burst type) | | | | | | | |
| 1 | | CID | 16 | | |  | |
| 2 | | UIUC | 4 | | |  | |
| If UIUC = 12 IR IE / UIUC = 10 PR IE | | | | | | | |
| 1 | | OFDMA Symbol Offset | 8 | | |  | |
| 2 | | Sub-channel Offset | 7 | | |  | |
| 3 | | No of Symbols | 7 | | |  | |
| 4 | | No of Sub-channels | 7 | | |  | |
| 5 | | Ranging Method | 2 | | |  | |
| 6 | | Ranging Indicator | 1 | | |  | |
| If UIUC = 13 PAPR IE | | | | | | | |
| 1 | | OFDMA symbol offset | 8 | | |  | |
| 2 | | Sub-channel offset | 7 | | |  | |
| 3 | | No. OFDMA symbols | 7 | | |  | |
| 4 | | No. sub-channels/SZ Shift Value | 7 | | |  | |
| 5 | | PAPR Reduction/Safety Zone | 1 | | |  | |
| 6 | | Sounding Zone | 1 | | |  | |
| 7 | | *Reserved* | 1 | | |  | |
| If UIUC = 1 to 8 DATA BURST IE | | | | | | | |
| 1 | | Duration | 10 | | |  | |
| 2 | | Repetition coding indication | 2 | | |  | |
| If UIUC = 14 CDMA-ALLOC-IE | | | | | | | |
| 1 | | Duration | 6 | | |  | |
| 2 | | UIUC | 4 | | |  | |
| 3 | | Repetition Coding Indication | 2 | | |  | |
| 4 | | Frame Number Index | 4 | | |  | |
| 5 | | Ranging Code | 8 | | |  | |
| 6 | | Ranging Symbol | 8 | | |  | |
| 7 | | Ranging sub channel | 7 | | |  | |
| 8 | | BW request mandatory | 1 | | |  | |
| If UIUC = 15 Extended UIUC for power control (We have changed UIUC =9) | | | | | | | |
| 1 | | Extended UIUC | 4 | | |  | |
| 2 | | Length | 4 | | |  | |
| 3 | | Power Control | 8 | | |  | |
| 4 | | Power Measurement Frame | 8 | | |  | |

## MAC PDU Overhead

## 

1. General

The MAC PDU overhead is due to the IEEEE 802.16 GMAC header and CRC which is added in the process of encapsulating the SDU into an IEEE 802.16 PDU. The basic standard GMAC header is 10 bytes long. It becomes a significant overhead component in the following scenarios:

* 1. When the traffic has significant percentage of small SDUs
  2. When the capacity of the DLSF/ULSF is small resulting in fragmentation of long SDUs into small fragments

1. PDU overhead for small SDUs:
   1. In addition to the GMAC header overhead, IP SDUs have substantial additional percentage overhead including 14 bytes Ethernet header + 20 bytes IP header + UDP/TCP header + possible higher layer headers. A large portion of these headers can be compressed using Packet Header Suppression (PHS) which leads to even shorter compressed SDUs. Example:
      1. SDU size = 64 byte
      2. Compressed SDU size = 36 bytes (In the general case, at least 28 bytes can be suppressed).
      3. Standard MAC PDU size: 10 bytes
      4. MAC PDU overhead = 10/46 = 22%

1. Fragmentation due to limited capacity of the DLSF/ULSF:

Fragmentation should be minimized by configuring the frame duration, the number of sub-channels in the downlink and in the uplink direction (while considering the downlink and uplink FEC codes), for sufficient DLSF and ULSF capacity to carry the bulk of the traffic un-fragmented. As in the case of per-frame overhead, this emphasizes the need to support extended frame sizes as the channel bandwidth/# of sub-channels is reduced.