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| Project | **IEEE 802.16 Broadband Wireless Access Working Group <**<http://ieee802.org/16>**>** |
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| Purpose | For comment prior to session #106 |
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IEEE 802.16s

Draft System Description Document

Sept 15, 2016

## Introduction

Proposals will be adopted into this document, and should follow the structure of the two sections below. References to the clauses amended in the base standard are desirable.

PAR Scope ( From 802.16-16-0038-00-000s):

This project specifies WirelessMAN-OFDMA TDD operation in exclusively-licensed spectrum with channel bandwidth from 100 kHz up to 1.25 MHz, including 1 MHz explicitly. The amendment will target operation in the 700 MHz band but will also support operation in other VHF/UHF bands. The project amends Clause 12 of IEEE Std 802.16, adding a new system profile and *amending other clauses as required to support the narrower channel widths*. The range and data rate supported by the added profile are commensurate with those of the base standard, as scaled by the reduced channel bandwidth.

The italicized phrase is the reasoning behind the section for MAC changes related to improving efficiency, which is necessary to meet SRD requirements in narrower channel bandwidths.

## Table of System Description Parameters

The following table defines the key parameters defining the PHY operation affecting channel bandwidth.

Based on the SRD, Band AMC is assumed, and TDD is assumed.

|  |
| --- |
| Nominal Channel Bandwidth |
| Sampling frequency (MHz) |
| FFT size |
| Subcarrier spacing (kHz) |
| Subcarrier Allocation Scheme in downlink and in uplink (permutation) |
| Number of Subchannels in downlink and in uplink |
| Actual Bandwidth (centered on nominal channel) for full channel |
| Actual Bandwidth (centered on nominal channel) per subchannel with AMC  |
| Preamble Scheme  |
| Cyclic Prefix |
| CDMA Codes |
| Frame Size (ms) |
| Duplexing Mode (assumed TDD) |
| Forward Error Correction |

## Parameter Ranges

Nominal Channel Bandwidth 1 MHz, 500 KHz, 250 KHz, 125 KHz, 100 KHz

Sampling frequency (MHz) 1.12 MHz, 1.14 MHz, 1.152 MHz (for 1 MHz and 500 KHz
(sampling ratios of 28/25 to 57/50 to 144/125)

 Scales to 50% for 250 and 125 KHz, and 40% for 100 KHz

FFT size 128

Subcarrier spacing (kHz) 8.75 KHz, 4.375 KHz, 3.5 KHz (based on channel width)

Subcarrier Allocation Scheme in downlink and in uplink (permutation) Band AMC 2x3 and 1x6

Number of Subchannels in downlink and in uplink 3, 6, or 12 (based on channel width, in full channel)

Actual Bandwidth (centered on nominal channel) for full channel (derived: sampling clock \* (109/128) \* % subchannels used)

Preamble Scheme Standard 128 FFT, or modified to fit into effective BW

Cyclic Prefix 1/8 or 1/16

CDMA Codes Standard 128 FFT, or modified to fit into effective BW

Frame Size (ms) 5, 10, 12.5, 20, 25, 40mS, 50mS

Slot definition in downlink and in uplink Implied by permutation: 1 sub-channel by 3 or 6 symbols

Duplexing Mode assumed TDD

Forward Error Correction Optional CTC

UL / DL Ratio Range Defined in symbols, but supporting a range 10:1 to 1:10. To be defined per frame duration and per channel size.

## System-level Design Aspects

* The amendment will support exclusive operation using Band AMC operation. The amendment must remove mandatory requirement for PUSC in Zone 1.
* Adjustment of sampling clock may be used as a mechanism to adjust channel occupancy to better meet regulatory requirements in various regions. (TBC)
* Disassociate preamble ID from sector ID (TBC)
* Provide information for auto-configuration of remotes, through a combination of periodic system information as well as scanning by the remotes.

## Performance Analysis (derived from SRD 802.16-16-0044)

### PHY Layer modifications

Quantifying the PHY Layer Throughput Benefits[[1]](#footnote-1)

**Summary of throughput enhancements for specific feature modifications, compared to 802.16-2012**

| **Baseline: 1 MHz channel BW, 128 FFT with PUSC in DL and optional UL PUSC, with 28/25 sampling factor, and 5 ms frame size** |
| --- |
| **Feature or Attribute** | **Change or Modification** | **Notes** | **Throughput Impact****Relative to baseline** |
| Permutation | PUSC to Band AMC | Mobility is a low priority & other PUSC ‘benefits’ less significant with smaller channel BWs | +33.3% |
| Frame Size | 2x Increase from 5 ms to 10 ms | Tradeoff with 2x increased latency | +24.1% |
| Further increases to 15 ms, 20 ms, & 25 ms | Subsequent increases will incur considerable additional latency | An additional gain of; +5.5%, +3.3%, +1.4% respectively |
| Cyclic Prefix | Reduce from 1/8 to 1/16 | Symbol OH is reduced from >11% to <6% | +11.5% |
| Sampling Factor | 28/25 to 57/50 to 144/125 | Adds 1 data symbol for each step increase from 28/25 | +3.85% and +3.70% respectively |

The following table shows MAC overhead for the channel sizes and frame sizes shown above. This is without any MAC overhead reduction – the messages are per IEEE 802.16-2012.

This table illustrates the problem with MAC overhead in the IEEE 802.16-2012 standard. The section below on MAC modifications will present options for reducing overhead.

Table - Overhead for channels BW and frame duration (without MAC changes)

|  |  |
| --- | --- |
| Channel Size (KHz), % BW | Percentage overhead per Frame Duration (mS) |
|  | 5 | 10 | 12.5 | 20 | 25 | 50 |
|  |  |  |  |  |  |  |
| 1000, 100% | 26.24% | 12.23% | 9.39% | 6.94% | 5.15% | 2.30% |
| 1000, 33% | 62.89% | 30.45% | 23.96% | 16.04% | 12.44% | 5.95% |
| 500, 100% | 44.68% | 21.34% | 16.67% | 11.49% | 8.79% | 4.13% |
| 500, 33% | 117.54% | 57.77% | 45.81% | 29.71% | 23.36% | 11.41% |
| 250, 100% | 81.11% | 39.55% | 34.16% | 22.42% | 17.54% | 7.70% |
| 250, 33% | 226.82% | 112.41% | 92.44% | 58.85% | 46.68% | 22.34% |
| 125, 100% | 153,93% | 83.25% | 63.29% | 40.63% | 35.00% | 17.96% |
| 125, 33% | 445.36% | 228.96% | 179.86% | 113.48% | 93.30% | 47.11% |
| 100, 100% | 204.91% | 97.81% | 83.68% | 53.37% | 40.84% | 19.42% |
| 100, 33% | 569.20% | 279.66% | 229.39% | 144.44% | 113.70% | 55.85% |

The channel size column includes options for full channel use, and sub channel use (33%) for each channel BW.

The color highlighting identifies the values that are below 15% (Green) and above 15% (Orange)

This table assumes 2 concurrent DL FEC codes present in a single DL Subframe, and assumes 2 bursts maximum in an UL subframe. It does take into account the overhead of the DL MAP, UL MAP, preamble and gaps. This does not include the MAC frame header overhead. This table assumes a Cyclic Prefix of 1/16.

The following figures illustrate the relationship between throughput, latency, and frame size

**Figure 2 Left:** *Shows UL + DL PHY throughput for 5, 10, 15, 20, and 25 ms frame sizes,* **Right:** *Shows minimal frame dependent UL latency for unsolicited grant service for same 5 frame sizes[[2]](#footnote-2)*

<To be developed: table showing channel BW, frame sizes, and number of symbols available in UL/DL and possible UL/DL ratios (or consider defining ratio in terms of UL/DL symbols rather than %). This table is intended to illustrate the resulting limits on the UL / DL ratio at higher overhead values>

## MAC Layer Modifications (for efficiency)

### MAC Optimization Principles

MAP related changes:

See potential changes to MAP in document [16-16-0051-00-000s-proposed-mac-changes](https://mentor.ieee.org/802.16/dcn/16/16-16-0051-00-000s-proposed-mac-changes.xlsx).

Notes for further discussion:

* Consider removing MAP fields that have fixed values. Keep in mind the possible benefits of certain information for use in provisioning parameters to the remote. (I.E. removing certain information would require more provisioning configuration, and could possibly result in remotes requiring manual reconfiguration if system parameters changed)
* Consider reducing the length of certain fields.
* Consider increasing periodicity of certain MAC messages. Certain messages could be sent every N frames, depending on their rate of change.
* Consider relaxing requirement on rectangular bursts. Could bursts be allocated based on filling slots sequentially?
* Is encryption for MAP needed? Encryption Control DL-MAP always non encrypted hence dropped.
* It is probably not desirable to reduce bits for CID, as it would reduce capability to support larger numbers of SS per sector. (TBD – what is the best number of bits for CID?)

Other MAC Changes:

Optimization for reducing MAC PDU Overhead in case of short PDUs.

Rely on concatenation to combine short PDUs. Today, it is only possible to concatenate packets from the same connection (CID). To Consider: Can packets from different connections be concatenated on the UL?

To Consider: Optimization for improved handling of TCP ACK? Is ACK spoofing in scope in terms of efficiency improvement?

To Consider: Are there any optimizations for reducing overhead for Bandwidth Request messages?

To be confirmed: we believe there are no changes necessary to support reduction in MAC messages used for mobility given the application in a nomadic environment. These messages are configurable using existing mechanisms.

To Consider: Is there any MAC layer optimization that could make the handling of DNP3 protocol more efficient?

To consider: Are there any additional MAC optimizations needed related to improving support for VLANs?

<To Be Inserted: Similar table to Table 1 including proposed MAC overhead after applying adopted reduction methods>

1. 16-16-0047-01-000s-benefits-of-specific-phy-layer-parameters-to-support-1mhz-channels [↑](#footnote-ref-1)
2. From: 16-16-0047-01-000s-benefits-of-specific-phy-layer-parameters-to-support-1mhz-channels [↑](#footnote-ref-2)