Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**128 and 256 FFT Sizes for OFDMA PHY**
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Re:	Working Group Review of P802.16e/D2
Abstract	
Purpose	To propose enhancements to the OFDMA PHY in P802.16e/D2 draft for better performance in narrow channel bandwidths.
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Scalable OFDMA PHY Expansion

1 Introduction

In this contribution we propose enhancements to the WirelessMAN OFDMA PHY, so that it can perform more optimally in narrow channel bandwidths of smaller than 5 MHz while keeping the sub-carrier spacing fixed in line with the concept of Scalable OFDMA option in P802.16e/D2. The following are some of the parameters that are required to meet the requirements from service providers. The contribution covers expansion of Scalable FFT size set to include 256 and 128 for DL FUSC and PUSC sub-channelization and UL sub-channelization formats.

2 Bandwidth

For service providers who would like to deploy a high speed public cellular network, the system bandwidths are limited to 1.25, 2.5, 5, and 10 MHz for licensed bands and 10 and 20MHz for unlicensed bands.

3 Sampling Frequency

According to the allowed bandwidth, the sampling frequency needs to be the same as specified in P80216-REVd_D4.

4 FFT Size and CP duration

In order to support full coverage and full mobility with low overhead for CP insertion for smaller bandwidths, the option for FFT sizes of 128 and 256 should be also included, i.e., 128-FFT for 1.25 MHz BW and 256-FFT for 2.5 MHz BW to be added to the existing set of options, that is 512-FFT for 5 MHz, 1024-FFT for 10 MHz BW, and 2048-FFT for 20 MHz BW. Although the CP duration can be as large as ¼ of an OFDMA symbol duration, but by choosing CP value of 1/8, the maximum multipath delay of 12.8 us can be supported while the corresponding overhead is limited to 10% for all bandwidth configurations.

5 Frame Length

Frame length is from 2msec to 20msec with identical frame structure for various channel bandwidths in licensed and licensed exempt operation.

6 Proposed Text Changes

[Apply the following changes to Tables 272a and 272c]

Table 272a— 2048-FFT OFDMA downlink carrier allocations

Parameter	Value	Comments
Number of DC Subcarriers	1	Index 1024
Number of Guard Subcarriers, Left	172	
Number of Guard Subcarriers, Right	173	
Number of Used Subcarriers (Nused)	1703	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Pilots		
VariableSet #0	24	0,72,144,216,288,360,432,504,576,648,720, 792,864,936,1008,1080,1152,1224,1296,1368, 1440,1512,1584,1656
ConstantSet #0	4	39,645,1017,1407
VariableSet #1	24	36,108,180,252,324,396,468,540,612,684,756, 828,900,972,1044,1116,1188,1260,1332,1404, 1476,1548,1620,1692
ConstantSet #1	4	261,651,1143,1419
VariableSet #2	2~~3~~4	48,120,192,264,336,408,480,552,624,696,768,840, 912,984,1056,1128,1200,1272,1344,1416, 1488,1560,1632
ConstantSet #2	4	330,726,1155,1461
VariableSet #3	24	12,84,156,228,300,372,444,516,588,660,732, 804,876,948,1020,1092,1164,1236,1308,1380, 1452,1524,1596,1668
ConstantSet #3	4	342,849,1158,1530
VariableSet #4	24	24,96,168,240,312,384,456,528,600,672,744,816, 888,960,1032,1104,1176,1248,1320,1392,1464, 1536,1608,1680
ConstantSet #4	4	351,855,1185,1545

VariableSet #5	23	60,132,204,276,348,420,492,564,636,,708,780,852, 924,996,1068,1140,1212,1284,1356,1428,1500, 1572,1644
ConstantSet #5	4	522,918,1206,1701
Number of data subcarriers	1536	
Number of data subcarriers per subchannel	48	
Number of Subchannels	32	
PermutationBase		3, 18, 2, 8, 16, 10, 11, 15, 26, 22, 6, 9, 27, 20, 25, 1, 29, 7, 21, 5, 28, 31, 23, 17, 4, 24, 0, 13, 12, 19, 14, 30

Table 272c— 512-FFT OFDMA downlink carrier allocations

Parameter	Value	Comments
Number of DC Subcarriers	1	Index 256
Number of Guard Subcarriers, Left	43	
Number of Guard Subcarriers, Right	43	
Number of Used Subcarriers (Nused)	426	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Pilots		
VariableSet #0	6	0,72,144,216,288,360
ConstantSet #0	1	39
VariableSet #1	6	36,108,180,252,324,396
ConstantSet #1	1	261
VariableSet #2	6	48,120,192,264,336,408
ConstantSet #2	1	330
VariableSet #3	6	12,84,156,228,300,372
ConstantSet #3	1	342
VariableSet #4	6	24,96,168,240,312,384
ConstantSet #4	1	351
VariableSet #5	~~5~~6	60,132,204,276,348
ConstantSet #5	1	420
Number of data subcarriers	384	
Number of data subcarriers per subchannel	48	
Number of Subchannels	8	
PermutationBase		7,4,0,2,1,5,3,6

[Add the following tables in section 8.4.6.1.2 after Table 272c and rename Tables 272d-f to 272f-h]

Table 272d— 256-FFT OFDMA downlink carrier allocations

Parameter	Value	Comments
Number of DC Subcarriers	1	Index 128
Number of Guard Subcarriers, Left	22	
Number of Guard Subcarriers, Right	22	
Number of Used Subcarriers (Nused)	212	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Pilots		
VariableSet #0	3	0,72, 144
VariableSet #1	3	36,108,180
VariableSet #2	3	24,96,168
VariableSet #3	3	60,132, 204
ConstantSet #0	1	12
ConstantSet #1	1	39
ConstantSet #2	1	48
ConstantSet #3	1	84

ConstantSet #4	1	120
ConstantSet #5	1	156
ConstantSet #6	1	192
Number of data subcarriers	192	
Number of data subcarriers per subchannel	48	
Number of Subchannels	4	
PermutationBase		0,2,1,3

Table 272e— 128-FFT OFDMA downlink carrier allocations

Parameter	Value	Comments
Number of DC Subcarriers	1	Index 64
Number of Guard Subcarriers, Left	10	
Number of Guard Subcarriers, Right	11	
Number of Used Subcarriers (Nused)	107	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Pilots		
VariableSet #0	2	0,72
VariableSet #1	2	24,96
ConstantSet #0	1	12
ConstantSet #1	1	36
ConstantSet #2	1	39
ConstantSet #3	1	48
ConstantSet #4	1	60
ConstantSet #5	1	84
Number of data subcarriers	96	
Number of data subcarriers per subchannel	48	
Number of Subchannels	2	
PermutationBase		0,1

[Add the following tables in section 8.4.6.1.2 after renamed Table 272h as suggested above]

Table 272i— 256-FFT OFDMA downlink carrier allocations - PUSC

Parameter	Value	Comments
Number of DC Subcarriers	1	index 128
Number of Guard Subcarriers, Left	23	
Number of Guard Subcarriers, Right	24	
Number of Used Subcarriers (Nused) including all possible allocated pilots and the DC carrier.	209	Number of all subcarriers used within a symbol
renumbering sequence	12, 13, 9, 5, 15, 6, 4, 2, 7, 10, 16, 3, 14, 8, 1, 11, 0	used to renumber clusters before allocation to subchannels:
Number of carriers per cluster	13	Number of all subcarriers used within a symbol, (12 data and 1 pilot subcarrier)
Number of clusters	16	
Number of carries per subchannel	48	
Number of subchannels	8	
PermutationBase4 (for 4 subchannels)	3,4, 2, 1	Four groups of four

		subchannels each

Table 272j— 128-FFT OFDMA downlink carrier allocations - PUSC

Parameter	Value	Comments
Number of DC Subcarriers	1	index 64
Number of Guard Subcarriers, Left	11	
Number of Guard Subcarriers, Right	12	
Number of Used Subcarriers (Nused) including all possible allocated pilots and the DC carrier.	105	Number of all subcarriers used within a symbol
renumbering sequence	5, 6, 4, 2, 7, 3, 8, 1	used to renumber clusters before allocation to subchannels:
Number of carriers per cluster	13	Number of all subcarriers used within a symbol, (12 data and 1 pilot subcarrier)
Number of clusters	8	
Number of carries per subchannel	48	
Number of subchannels	4	
PermutationBase2 (for 2 subchannels)	0, 1	Two groups of two subchannels each

[Add the following tables after Table 247b]

Table 247c—256-FFT OFDMA uplink subcarrier allocations

Parameter	Value	Comments
Number of DC Subcarriers	1	index 128
Number of Guard Subcarriers, Left	31	
Number of Guard Subcarriers, Right	32	
Number of Used Subcarriers (Nused) including all possible allocated pilots and the DC carrier.	193	Number of all subcarriers used within a symbol
PermutationBase0	2,4,0,5,3,6,7,1	used to allocate tiles to subchannels
Number of carriers per tile	4	Number of all subcarriers used within a tile
Number of tiles	48	
Number of tiles per subchannel	6	
Number of subchannels	8	

Table 247d—128-FFT OFDMA uplink subcarrier allocations

Parameter	Value	Comments
Number of DC Subcarriers	1	index 64
Number of Guard Subcarriers, Left	15	
Number of Guard Subcarriers, Right	16	
Number of Used Subcarriers (Nused) including all possible allocated pilots and the DC carrier.	97	Number of all subcarriers used within a symbol
PermutationBase0	2,0,3,1	used to allocate tiles to subchannels
Number of carriers per tile	4	Number of all subcarriers used within a tile

Number of tiles	30	
Number of tiles per subchannel	6	
Number of subchannels	4	

References

[1] IEEE P802.16-REVe/D2-2004 Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Band.