Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>	
Title	**Proposal for IEEE 802.16m OFDMA numerology**	
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Re:	IEEE802.16m-07/047, "Call for Contributions on Project 802.16m System Description Document (SDD)"	
Abstract	Proposal for IEEE802.16m OFDMA numerology.	
Purpose	Discuss and accept the proposal into the 16m SDD baseline document.	
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Considerations on IEEE 802.16m OFDMA Numerology

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Introduction

This contribution proposes a set of OFDMA numerology for 16m, which is the base of OFDMA technology implementation. We suggest this set of OFDMA numerology is described as a part of 802.16m frame structure in IEEE 802.16m SDD baseline document and IEEE 802.16m amendment.

Problem Description

As we all know, IEEE 802.16m SRD requires that IEEE 802.16m shall meet the IMT-Advanced requirements. And all enhancements included as part of IEEE 802.16m should promote the concept of continued evolution, allowing IEEE 802.16 to maintain competitive performance as technology advances beyond 802.16m.

On the other hand, IEEE 802.16m SRD requires that IEEE 802.16m shall provide continuing support and interoperability for WirelessMAN-OFDMA Reference System which is defined as system compliant with the capabilities set specified by WiMAX Forum Mobile System Profile Release 1.0. For example, based on the backward compatibility requirements, 802.16m BS shall support 802.16m and legacy MSs when both are operating on the same RF carrier.

But actually there are a lot of problems existing in current legacy system design. Some of them have an unfavorable impact of system implementation, network deployment and equipment cost. So the inheritance of legacy system's drawbacks shall be prevented when we design 802.16m system.

OFDMA numerology is the base of OFDM technology and directly affects the frame structure design which is one of the basic elements of the Physical Layer. Now we will describe some problems caused by OFDMA numerology which is used by legacy system and their effect on current legacy system. The following table describes the basic OFDMA numerology defined by current legacy system.

Table 1 – basic OFDMA numerology defined by current legacy system

Channel Bandwidth (MHz)	5	10	20	3.5	7	8.75
Sampling Frequency (MHz)	5.6	11.2	22.4	4	8	10
FFT Size	512	1024	2048	512	1024	1024
Subcarrier Spacing (kHz)	10.94	10.94	10.94	7.8	7.8	9.76
Useful Symbol Time (us)	91.4	91.4	91.4	128.2	128.2	102.46
CP (us)	11.42	11.42	11.42	16.025	16.025	12.81

Subcarrier Spacing

The legacy systems with 5/10/20MHz, 3.5/7MHz and 8.75MHz have different subcarrier spacing values which are based on different base sampling frequencies. Such incompatible sampling frequency sets make the system implementation complex and raise the equipment cost due to the separate frequency source per sampling

frequency set.

CP
On the one hand, as specified by Mobile WiMAX System Profile, only one type of CP exists in current legacy system, which is 1/8 of useful symbol time. Current legacy system does not support different CP length for different BS in the network, but only one effective CP value is used for all the BSs. Actually there are no mechanisms to allow BS to change or configure the CP duration in current legacy system. It is not suitable to use only one type of CP length for indifferent usage scenarios. For example, in the scenario with severe multipath (i.e. larger delay spread), longer CP should be used to eliminate the ISI and ICI. But simple scenario with fewer multipath only requires short CP in order to reduce overhead and transmission power.
On the other hand, the CP length defined by current legacy system is a fraction of useful symbol time. But actually the CP duration is not dependent on the useful symbol time, especially in current legacy system where the useful symbol time changes between different sampling frequency sets.

Number of used subcarriers
For one given FFT size of legacy system, the values of the number of used subcarriers are different due to different permutation mode, even for same channel bandwidth. The following table lists the number of used subcarriers and bandwidth efficiency for different permutation modes. Here 10MHz channel bandwidth is used as an example while counting the corresponding bandwidth efficiency.

Table 2 – Number of used subcarriers defined by current legacy system

		Permutation mode	Number of used subcarrier	Bandwidth efficiency (Channel bandwidth: 10MHz)
FFT size -1024	DL	PUSC	841	92%
		FUSC	851	93.1%
		Optional PUSC	865	94.63%
		AMC	865	94.63%
	UL	PUSC	841	92%
		Optional PUSC	865	94.63%
		AMC	865	94.63%

All the above problems caused by legacy OFDMA numerology shall be prevented in 802.16m frame structure design.

Suggested Solution

Based on the above description and suggested criteria, we propose the following OFDMA numerology for IEEE 802.16m.

Subcarrier spacing
We propose 12.5KHz subcarrier spacing which is applied for all the channel bandwidth, e.g. 5/10/20MHz, 3.5/7/14MHz and also 8.75MHz. A 12.5KHz subcarrer spacing has a property of good trade-off of mobility and frequency efficiency with CP overhead. The sampling frequency of different channel bandwidth will be based on this subcarrier spacing and appropriate FFT size. It means that all the channel bandwidth will have the same base sampling frequency.

CP
We propose three types of CP length based on 12.5KHz subcarrier spacing, which are used for different radio

scenarios. These three types of CP are short CP with 2.5us duration, normal CP with 9.375us duration, and long CP with 16.875us duration.

Number of used subcarriers
We propose the number of used subcarriers independent of permutation mode. For all the types of permutation modes, with the same bandwidth, the number of used subcarriers is same.

Parameter		Unit	Parameter Values				
Channel Bandwidth		MHz	5	7	10	14	20
Sub-carrier Spacing		KHz	12.5				
Sampling Frequency		Mhz	6.4	12.8	12.8	25.6	25.6
FFT size			512	1024	1024	2048	2048
Number of used sub-carriers			401	561	801	1121	1601
CP Length	Short CP	μs	2.5	2.5	2.5	2.5	2.5
	Normal CP	μs	9.375	9.375	9.375	9.375	9.375
	Long CP	μs	16.875	16.875	16.875	16.875	16.875

With consideration of legacy system support, we propose TDM mode to be used for DL and UL.

Specific Text

To add the following specific text into the corresponding chapter of SDD document.

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11. Physical layer

11.1 Frame structure

11.1.1 Primitive parameters

The following primitive parameters characterize the OFDMA symbol:

- BW: The nominal channel bandwidth.
- Nused: The number of used subcarriers, which includes the DC subcarrier.
- Subcarrier spacing △f: 12.5KHz is applied to all the channel bandwidth.
- T_{CP}: The duration of CP. The following values shall be supported: 2.5us, 9.375us, and 16.875 us.

11.1.2 Derived parameters

The following parameters are defined in terms of the primitive parameters.

- N_{FFT}: FFT size
- Sampling frequency: $Fs = \triangle f * N_{FFT}$
- Useful symbol duration: $Tu = 1/\triangle f$
- OFDMA symbol duration: $Ts = Tu + T_{CP}$
- Sampling time : Tu/N_{FFT}

Parameter		Unit	Parameter Values				
Channel Bandwidth (BW)		MHz	5	7	10	14	20
Sub-carrier Spacing (△f)		KHz	12.5				
Sampling Frequency (Fs)		Mhz	6.4	12.8	12.8	25.6	25.6
FFT size			512	1024	1024	2048	2048
Number of Used sub-carriers (Nused)			401	561	801	1121	1601
CP Length (T_{CP})	Short CP	μs	2.5	2.5	2.5	2.5	2.5
	Normal CP	μs	9.375	9.375	9.375	9.375	9.375
	Long CP	μs	16.875	16.875	16.875	16.875	16.875

TDM shall be used in DL and UL of IEEE 802.16m frame to support legacy system.

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Reference

[1] IEEE802.16m-07/002r4, IEEE802.16m system requirements
[2] IEEE Std 802.16e-2005 and IEEE Std 802.16-2004/Cor1-2005 (Amendment and Corrigendum to IEEE Std 802.16-2004)
[3] WiMAX Forum Mobile System Profile Release 1.0 Approved Specification