Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	Extended Cyclic Prefix for High-Mobility Support of IEEE 802.16m Frame Structure
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Re:	IEEE 802.16m-07/047 – Call for Contributions on Project 802.16m System Description Document (SDD), shoot for " Frame Structure with special attention to legacy support" topic.
Abstract	This contribution proposes a mechanism to improve system performance in high mobility environments with high-mobility zones in the new 802.16m frame structure.
Purpose	For 802.16m discussion and adoption
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Extended Cyclic Prefix for High-Mobility Support of IEEE 802.16m Frame Structure

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Introduction

The 802.16m system requirements [1] describes the system performance demand for high speed environments However, the WirelessMAN-OFDMA Reference system can support limited link performance under moderate to high speed scenarios. This contribution proposes new cyclic prefix (CP) options used by the new data zone in the 802.16m frame structure as shown in [2]. Based on the larger CP length, the inter-subcarrier interference (ICI) can be significantly reduced with low-complexity interference cancellation techniques. This will improve data reception in high-mobility applications.

Frame Structure with High-Mobility Support

In the proposed frame structures for high mobility environments for IEEE 802.16m, a new DL/UL data zone is appended at the end of conventional DL/UL zones as shown in Figure 1 [2]. The proposed frame structure is compatible with the legacy system and is configured to increase the system performance under high-mobility applications with the advanced mode Greenfield DL/UL zones. It is well known that the system link error rate deteriorates dramatically in the WirelessMAN-OFDMA Reference system for high levels of modulation and coding schemes when the user velocity is very high (e.g. 300 km/hr). In this case the ICI resulting from neighboring data subcarriers dominates AWGN, thus complicated techniques performed subcarrier-by-subcarrier for ICI mitigation are usually required to decrease the interference. However, the ICI can be significantly decreased in time domain with much less complexity and then the system can operate under much higher speed environments than expected for the WirelessMAN-OFDMA Reference system. This goal is achieved through the use of sample repetition of the cyclic prefix portion in each OFDMA symbol. The burden of complexity and power for the receiver design can be also greatly relieved without degrading the system performance.

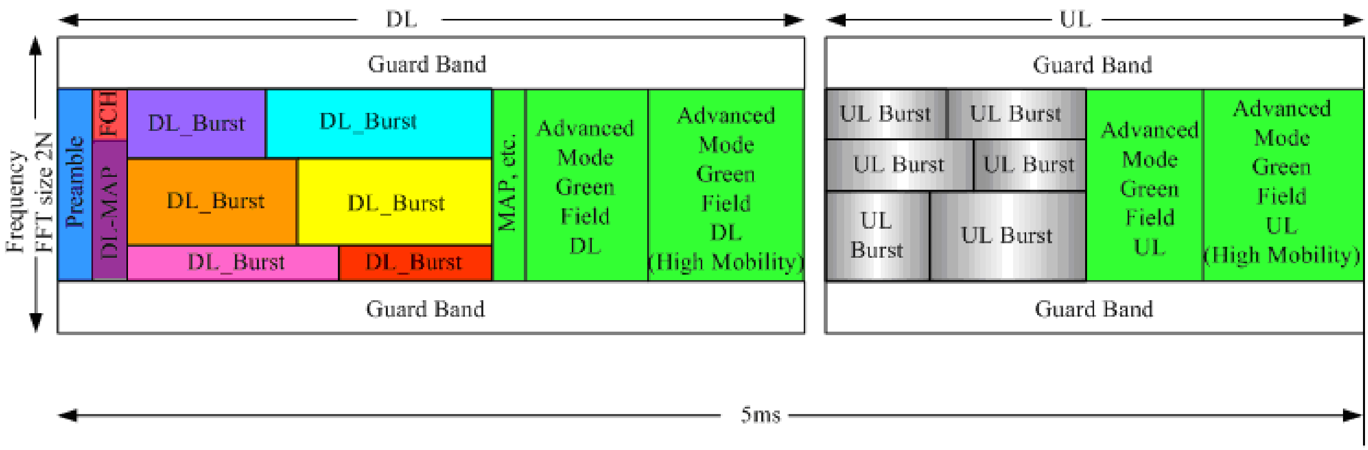

Figure 1. OFDMA frame structure for IEEE 802.16m with high-mobility support

ICI Cancellation Using Cyclic Prefix

Conventional ICI cancellation techniques rely on complicated MMSE or multistage interference cancellation approaches to estimate and mitigate the interference. In the WirelessMAN-OFDMA Reference system, it can be shown that the system can operate and maintain data transmission under very high mobility scenarios (e.g., 300 km/hr or above) with QPSK modulation only. This will greatly complicate the receiver design and the power consumption will become very critical for the mobile units. We suggest using larger CP length than that defined in the WirelessMAN-OFDMA Reference system such that a robust and simple ICI cancellation approach can be employed in the receiver. We learned from careful analysis that a great amount of the ICI can be expressed as the channel differential value scaled by some constant, and this value can be also reproduced by the repetitive samples of the samples on the CP and the OFDM symbol. The reproduction and subtraction of the ICI require only complex subtraction and constant multiplication. Also note that the estimation accuracy increases along with the available CP size. The sustainable user mobility can be extended significantly with little system complexity.

Simulation Results

We show the uncoded BER comparisons with various CP lengths for 16 QAM and 64 QAM, respectively for the PUSC permutation zone. The channel bandwidth is 10 MHz and the FFT size is 1024 points. The modified ITU Vehicular-A channel model [3] is employed as the multipath channel. The channel state information (CSI) is assumed ideal without channel estimation error. As we can see in Figures 2 and 3, when the user velocity is set at 300 km/hr (denoted by VA300), the system performance is dominated by the ICI and exhibits error floors for the SNR range larger than 15dB without ICI cancellation techniques. On the other hand, the proposed approach can improve the performance by at least 8 dB with different CP lengths of 512 points (1/2 FFT size), and 768 points (3/4 FFT size). Finally, when a CP length with 100% FFT size (1024 samples) is available, we can achieve the ICI-free performance even at SNR= 40 dB. Note that the proposed approach with CP lengths of 768 and 1024 outperforms the static scenario with CP=128 samples at most SNR ranges. This is due to the effect of energy combining of repetitive samples from the CP. Figure 4 illustrates the coded BER comparisons for various CP lengths with 16 QAM and 64 QAM using the convolutional coding of code rate 1/2. It can be observed that the performance with the proposed approach under 300 km/hr even outperforms the static case without ICI. The suggested approach can provide at least 3 dB improvement at the BER of 10^{-5} when the CP size of 100% FFT is used.

Proposed Text

-- Start of the proposed text --

xxx. Frame Structure

xxx.y Advanced Mode Greenfield Zone with high mobility

xxx.y.z Cyclic Prefix size

In order to improve system performance under high-mobility scenarios with the advanced mode zones, more choices on the CP size should be considered in these zones and should at least include one of the following options

(a) 1/2 FFT size

(b) 3/4 FFT size

(c) FFT size

--- End of the proposed text --

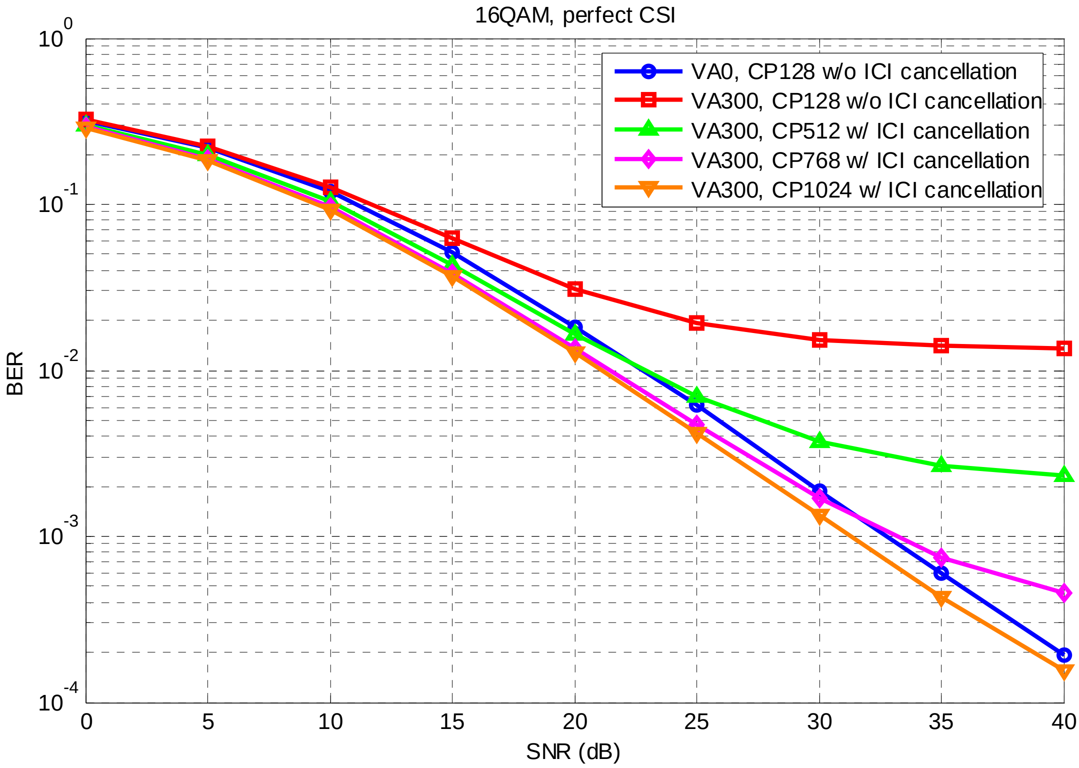

Figure 2. Performance comparison with various CP lengths for 16 QAM

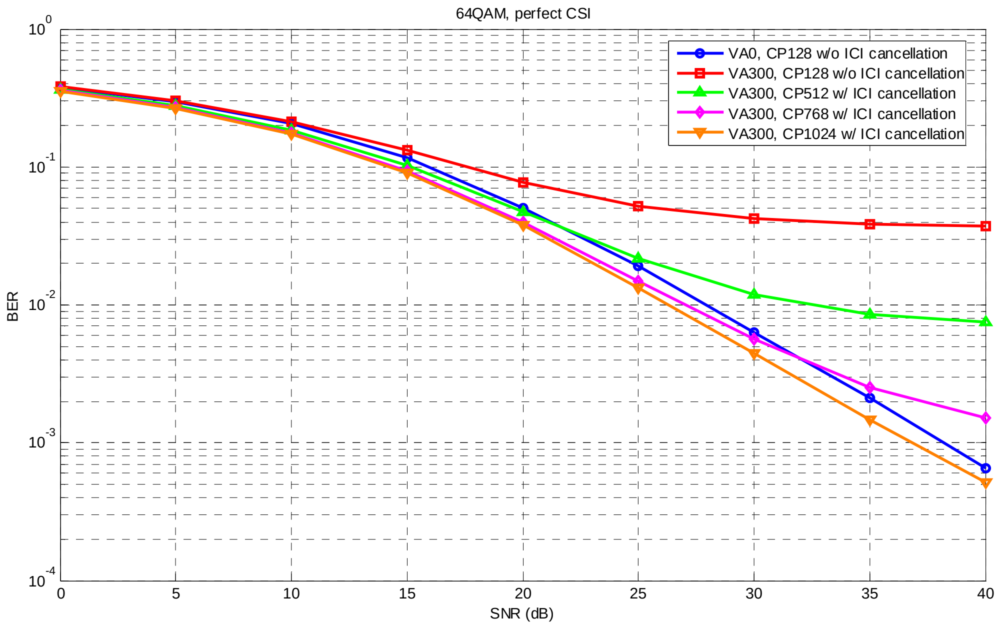

Figure 3. Performance comparison with various CP lengths for 64 QAM

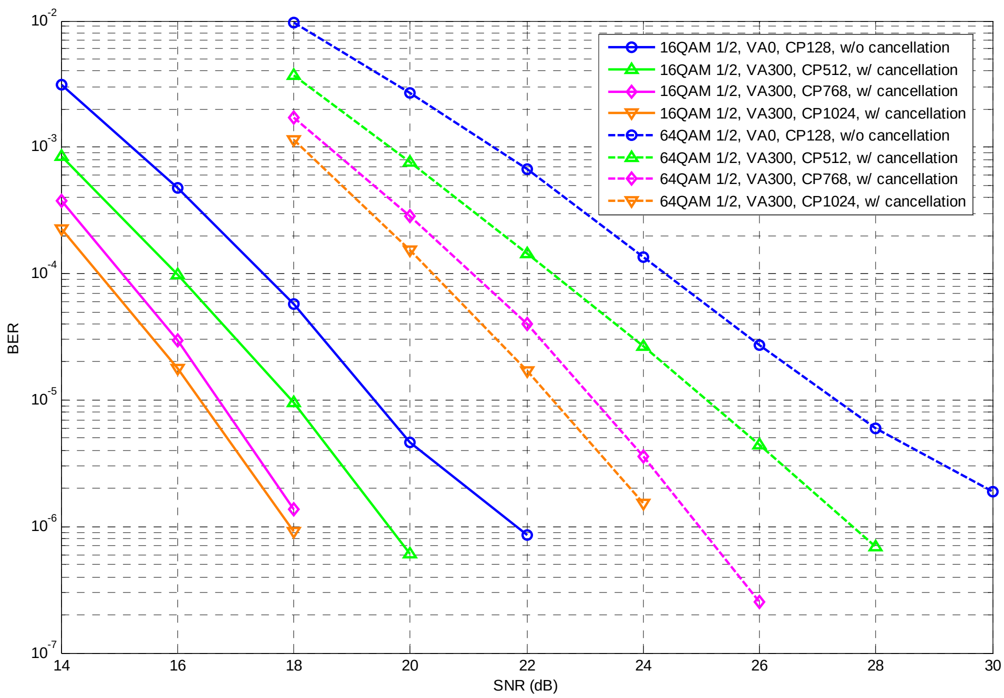

Figure 4. Performance comparison with various CP lengths for CC-1/2 16QAM and 64 QAM.

References

[1] M. Cudak, “802.16m System Requirements, ” IEEE 802.16m-07/002r4

[2] R.-J. Chen, *et al*, “OFDMA Frame Structures with Scalable Bandwidth and High-Mobility Support for IEEE 802.16m, ” IEEE 802.16m-07/295r1.

.[3] R. Srinivasan, *et al*, “Draft IEEE 802.16m Evaluation Methodology”, IEEE 802.16m-07/037r2.