Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>
Title	Packet error rate measurements for co-channel IEEE 802.16d systems
Date Submitted	2007-07-11
Source(s)	John Sydor, Amir Ghasemi Communications Research Centre 3701 Carling Avenue Ottawa, Ontario Voice: 613-998-2388 Fax: 613-990-8369 john.sydor@crc.ca
Re:	Coexistence between IEEE 802.16h systems
Abstract	Measurement results on packet error rate of co-channel IEEE 802.16d systems
Purpose	To quantify the baseline performance of co-channel IEEE 802.16d systems in absence of any coexistence mechanisms and to aid in any ongoing co-channel interference discussions
Notice	
Release	
Patent Policy and Procedures	

Packet error rate measurements for co-channel IEEE 802.16d systems

John Sydor, Amir Ghasemi
Communications Research Centre

Introduction

In order to design and evaluate mechanisms for coexistence of 802.16 systems, it is important to quantify the effect of interference caused by their co-channel operation. While simulation enables fast and flexible proof-of-concept experimentation, it generally offers a limited accuracy due to the modeling simplifications as well as the abstraction of various PHY-layer transceiver imperfections.

As such, this contribution reports the baseline performance of co-channel IEEE 802.16-2004 systems in absence of any coexistence mechanisms using standard-compliant test equipment. The results are intended to give a general indication on the sensitivity of IEEE 802.16-2004 modulated spectra to co-channel interference from similar systems and to provide baseline results which will hopefully support proposals for coexistence techniques and frequency reuse.

Test setup

The basic setup of the test is shown in Fig. 1 where an IP traffic generator is used to generate and inject the Ethernet traffic into an 802.16 base station. The packets decoded by the 802.16 subscriber station are then passed to the traffic generator and compared with the source packets to measure the packet error rate (PER) of the RF link.

The 802.16 interference is configured and generated with an Agilent E4438C ESG vector signal generator using the Signal Studio © Software. The modulation and coding scheme (MCS) of the interference is set to QPSK 1/2 throughout the experiment.

In order to obviate the need for synchronization of the signal and interference sources, the Agilent generator is set to create a continuous interference with a 100% duty cycle. As such, the desired 802.16 signal is subject to the same interference regardless of the timing offset between the two sources.

The IEEE 802.16d equipment used for this experiment was a pre-WiMAX Vecima (VCOM) OPC3500 base station and OSR3500 Subscriber Terminal. Both units were modified to allow access to their respective RF ports.

It was decided to limit the experiment to link configurations considered in the IEEE 802.16h discussions; as such the equipment was set up to a channel plan given in Table 1.

Table 1: Test setup

Center frequency	3.5 GHz
Bandwidth	7MHz
Frame duration	10ms
DL/UL Ratio	1:1
Cyclic prefix	1/4

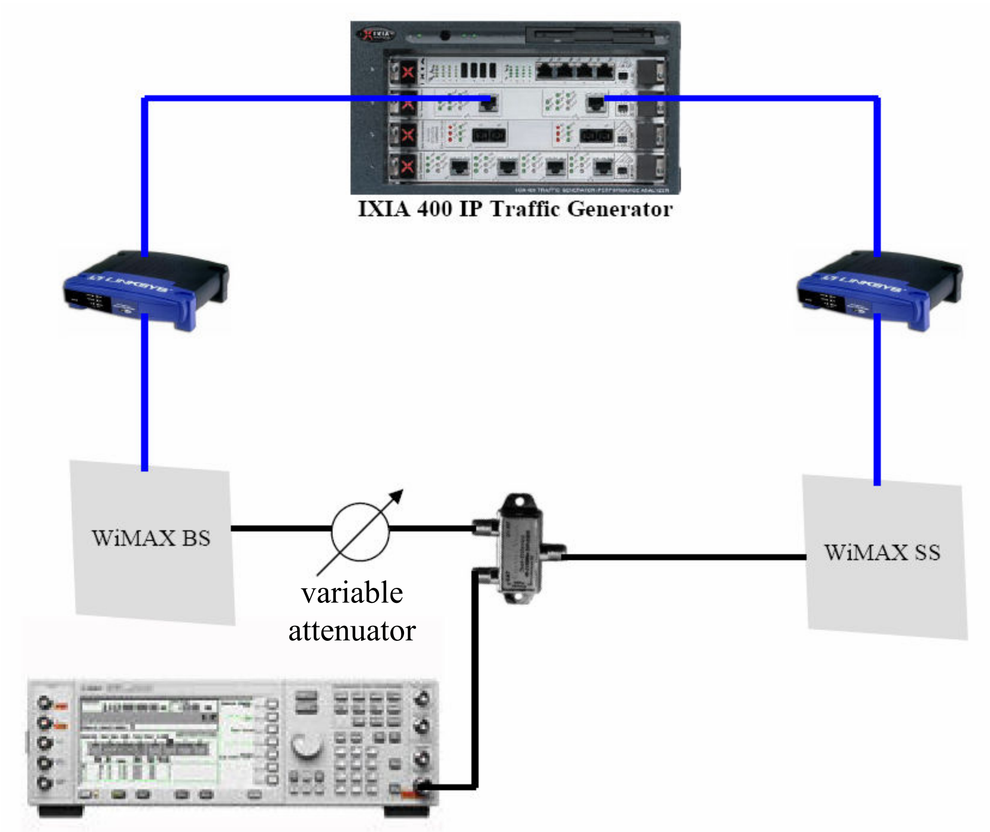

Fig. 1 Test setup

Test Results

Sensitivity of Different OFDM Modulation Schemes to CCI

The co-channel sensitivity of IEEE 802.16d modulation formats where of immediate interest in our experiments. As a secondary interest we were also interested in the sensitivity of the preamble and FCH of the downlink burst as the integrity of this part of the downlink burst has considerable bearing on the ability of the receiver to demodulate the payload.

The MCS of the signal was varied from BPSK 1/2 to 64QAM 3/4 while keeping that of the interference at QPSK 1/2. For each MCS and with a given received signal strength indicator (RSSI), the interference power was varied to obtain the PER as a function of the carrier to interference plus noise ratio (CINR). The RSSI was kept fixed throughout these measurements (see below). The PER curves obtained at RSSI of -70dBm with a fixed packet size of 256 bytes are shown in Fig. 2.

These results show the well known phenomena that increased modulation complexity has greater sensitivity to interference. A baseline comparison of these curves to that of AWGN interference alone would be useful, had we undertaken them in more detail (see below), but comparisons with theoretical works [1,2] indicate that difference between AWGN performance and co-channel interference are close to being the same. It may be cautiously correct to assume that increased CCI has the same detrimental effects as increased AWGN.

Two additional characteristics to note, especially in the context of IEEE 802.16h, is that the performance of the BPSK 1/2 curve may be roughly taken as that of the IEEE 802.16 preamble/FCH which is encoded as BPSK1/2. Secondly, even in face of relatively high CCI levels, up to rate 1/2 QPSK can be supported with a PER of ~1% at CINR of 7.5 dB.

Effect of RSSI

In the next experiment, the MCS of the signal was fixed at QPSK 3/4 and the RSSI was varied from -60dBm to -80dBm. For the given MCS and channel bandwidth, the sensitivity threshold (to AWGN) of the Vecima WiMAX receiver is about -85dBm. The results plotted in Fig. 3 indicate that the receiver's CCI performance is not as sensitive to RSSI in the -60dBm to -70dBm range as it is when the RSSI drops to -80dBm.

Why the radios and OFDM show greater sensitivity to CCI at lower RSSI levels is not immediately obvious. Part of the answer may lie with the design of the particular radio.

Comparison of AWGN and OFDM Co-Channel Interference

In the final part of the experiment, a noise generator was used in place of the Agilent signal generator. Using QPSK 3/4 and 128-byte packets for the signal, the PER of a link with a RSSI of -70dBm was measured and plotted in Fig. 4. The results show that in the region of interest (PER < 20%), a QPSK 1/2 802.16 interference source is worse compared to pure AWGN noise. These results, in addition to those shown in Figure 2, where the performance curves did not deviate significantly from those predicted by the referenced AWGN studies, seem to indicate that Co-channel interference effects due to overlapping OFDM modulation are slightly more degrading than AWGN (by about 0.5 dB in this case).

Conclusions

This work undertook an examination of IEEE 802.16 sensitivity to co-channel interference generated by similar systems. Based on the results garnered from these particular experiments, which represent a small portion of the many co-channel scenarios that can exist with IEEE 802.16 systems, it is reasonable to conclude that:

(a) The packet error rate degradation due to OFDM on OFDM co-channel interference is only slightly worse than that predicted by the AWGN interference on OFDM.

(b) OFDM systems may display increased CCI sensitivity at low RSSI levels.

(c) The IEEE 802.16-2004 specified Preambles and FCH likely have the same CCI resiliency as shown by the BPSK1/2 performance curves.

References

[1] A. Salvekar *et al.*, "BPSK modulation for IEEE 802.16 WirelessMAN OFDM," IEEE C802.16d-04/31r1, March 2004.

[2] L. Li and O. Sarca, "FEC performance with ARQ and adaptive burst profile selection," IEEE 802.16abc-01/60, November 2001.

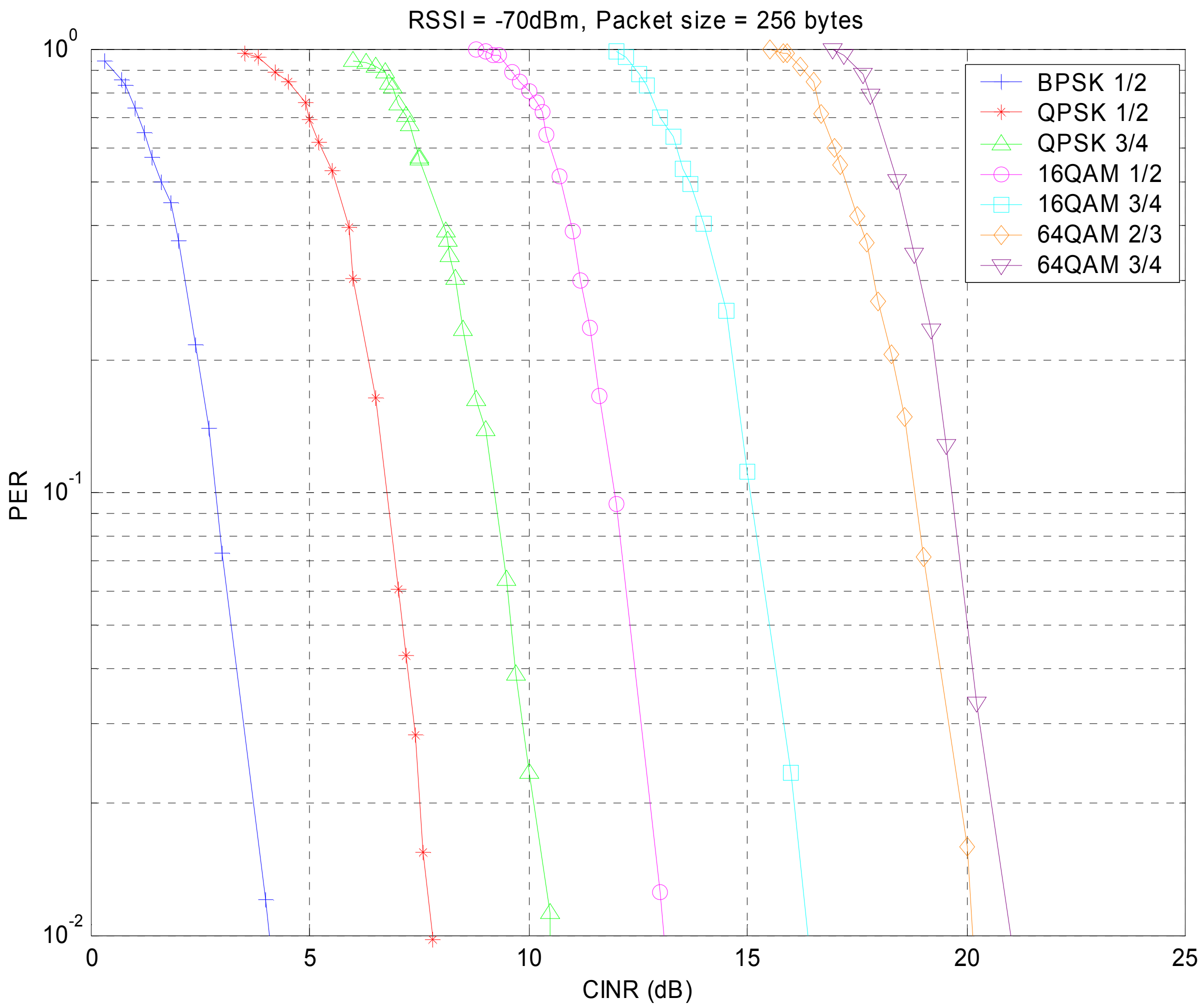

Fig. 2 PER vs. CINR (packet size = 256 bytes)

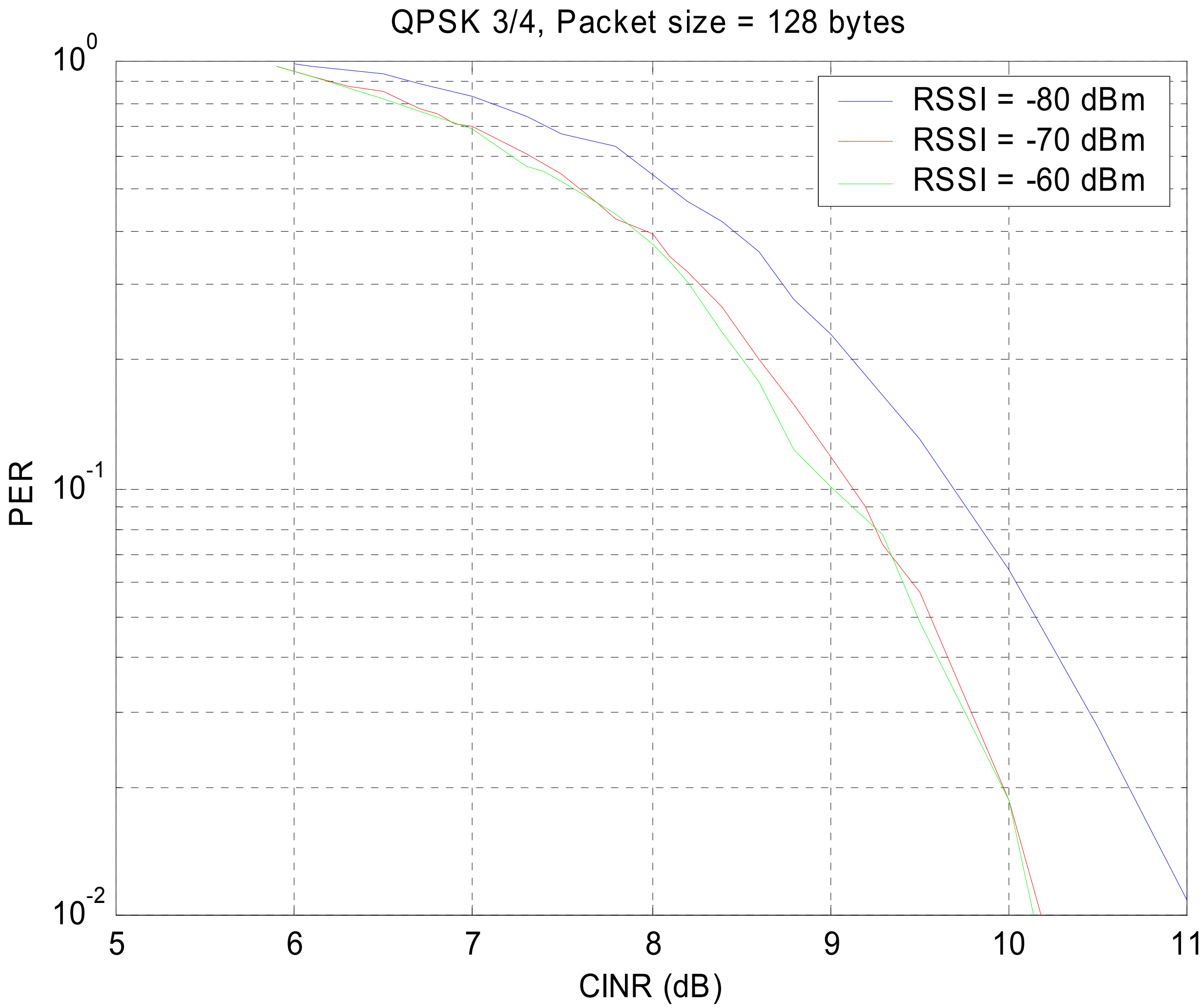

Fig. 3 PER vs. CINR (packet size = 128 bytes)

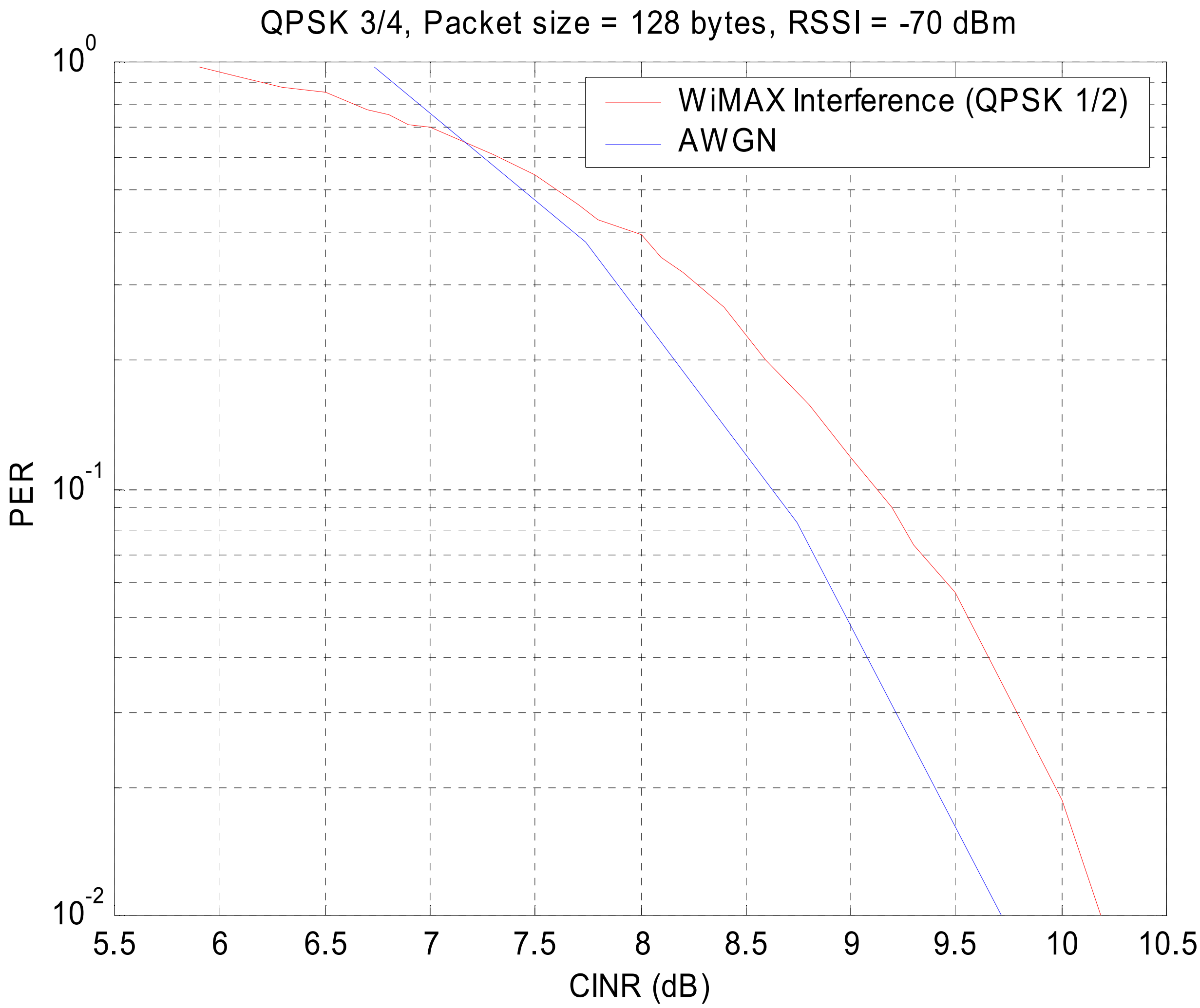

Fig. 4 PER vs. CNR (AWGN case) and CINR (802.16 interference) (packet size = 128 bytes)