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Effects Of The Cyclic Prefix In Siso And Miso Wimax Systems

Mohammed H. M. Nerma[*] and Albedeir Y. G. Othman[**]

[*]Sudan University of Science and Technology, College of Engineering, School of Electronics Engineering, Khartoum, Sudan

[**]Umdurman Islamic University, Department of Electrical and Electronic Engineering, Khartoum, Sudan

mohamed_hussien@ieee.org

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Abstract:

The cyclic prefix (CP) is actually a copy of the last portion of the data symbol appended to the front of the symbol during the guard interval (GI). By adding a CP, the channel can be made to behave as if the transmitted waveforms were from time minus infinite, and thus ensure Orthogonality, which essentially prevents one subcarrier from interfering with another (called inter-carrier interference (ICI)).This paper demonstrates the effects of the CP on the single input/single output (SISO) and multi input/single output (MISO) WiMAX systems. In this work, the effect of different values of CP is shown in term of bit error rate (BER) and signal to noise ratio (SNR). This work shows also the impact of the adaptive modulation and coding (AMC) on data transmission rate with different values of the CP. The contribution of this work is twofold; first, it shows the best value of the BER for different values of the CP using AMC. Second, shows the effect fading for different values of the CP.

Keywords*—*WiMAX; OFDM; SISO; MISO; AMC; CP; GI; ICI; ISI; SNR ;BER.

Introduction:

Cyclic prefix (CP) is often used in conjunction with modulation in order to retain sinusoids' properties in multipath channels, and time-invariant systems. Therefore, if the channel is assumed to be linear and time invariant, in practice, this cannot be achieved, as real signals are always time-limited. So, to mimic the infinite behavior, prefixing the end of the symbol to the beginning makes the linear convolution of the channel appear as though it were circular convolution, and thus, preserve this property in the part of the symbol after the CP [1]. Furthermore, the CP is used to reduce the effect of fading in the channel and improve the performance of the channel and also improve bit error rate (BER) [2]. CP acts as a buffer region where delayed information from the previous symbols can get stored. Transmission of CP reduces the data rate, the system designers will want to minimize the CP duration. Typically, CP duration is determined by the expected duration of the multipath channel in the operating environment. In the simulation model data is modulated and then CP is added to reduce the effect of fading and to give sufficient time to the receiver for storage of signal [3]. The subcarrier Orthogonality of an OFDM system can be jeopardized when passes through a multipath channel [4]. CP is used to combat inter-symbol interference (ISI) and inter-carrier interference (ICI) introduced by the multipath channel. CP is a copy of the last part of OFDM symbol which is appended to the front of transmitted OFDM symbol [5].

Materials and methods:

In this work the model of the WiMAX system (IEEE 802.16d with and without space-time block coding (STBC)) is used. The MATLAB program is used for the simulation. The simulation parameters are shown in table 1 and table 2 in the next section. The simulation mode used different values of the CP (1/4, 1/8, 1/16, and 1/32 with different type of channel fading (with and without fading) using AMC. The results were analyzed and discussed in results and discussion section. The results are analyzed and compared with that stated in [6], [7].

System Description:

In the simulation model, case 1 and case 2 represent the WiMAX system when the nonlinear amplifier is disabled, case 3 and case 4 represents the system in when the nonlinear amplifier is enabled, case 5 and case 6 4 represents the system in the presence of the nonlinear amplifier and the pre-distortion. The individual cases (1, 3 and 5) represents the system when AMC is enabled (modified 64QAM), and the cases conjugal (2, 4 and 6) was the AMC is disabled. While the ID0 Represent (1/2 BPSK), ID1 Represent (1/2QPSK), ID2 Represent (3/4 QPSK), ID3 Represent (1/2 16QAM), ID4 Represent (3/4 16QAM), ID5 Represent (2/3 64QAM), ID6 Represent (3/4 64QAM). The performance parameters for the simulated system are listed in table 1 and table 2.

Table 1: Performance parameter of the SISO-WiMAX system.

Channel bandwidth (MHz):	3.50	K factor:	0.50
Number of OFDM symbols per burst:	2.00	Maximum Doppler shift (Hz):	0.50
Cyclic prefix factor (G):	1/4	Gain vector (dB):	[0 -5 -10]
Amplifier nonlinearity & Pre-distortion :	Enable	Delay vector (s):	[0 0.4 0.9]*1e^{-6}
Low SNR thresholds for rate control (dB):	[6 : 10 : 13 : 16 : 21 : 23]	Fading mode:	Frequency selective fading
Models a multipath Rician fading channel with :	AWGN	RateID without STBC	0 - 6

Table 2: Performance parameter of the MISO-WiMAX system.

Channel bandwidth (MHz):	3.50	K factor:	0.50
Number of OFDM symbols per burst:	2.00	Maximum Doppler shift (Hz):	0.50
Cyclic prefix factor (G):	1/4	Gain vector (dB):	[0 -5 -10]
Amplifier nonlinearity & Pre-distortion :	Enable	Delay vector (s):	[0 0.4 0.9]*1e^{-6}
Low SNR thresholds for rate control (dB):	[6 : 10 : 13 : 16 : 21 : 23]	Fading mode:	Frequency selective fading
Models a multipath Rician fading channel with :	AWGN	Rate ID without STBC	0 - 6

Results and discussion:

This section shows the results of throughput, SNR and BER when using SISO/MISO WiMAX system with and without fading. First, the throughput performance for different cases in the presence of the fading for SISO WiMAX system is shown in table 3 and figure 1. From these results we note that the CP impact on individual cases significantly due to the repeated change in AMC, the results shows that the CP and Bits suit inverse proportion i.e. increase the CP decreases the bits.

Table 3: The throughput of SISO-WiMAX system with fading.

	Bits					
CP	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
1/4	102600	11592	102600	11592	102600	11592
1/8	114640	12880	114640	12880	114640	12880
1/16	121520	13616	121520	13616	121520	13616
1/32	124960	13984	124960	13984	124960	13984

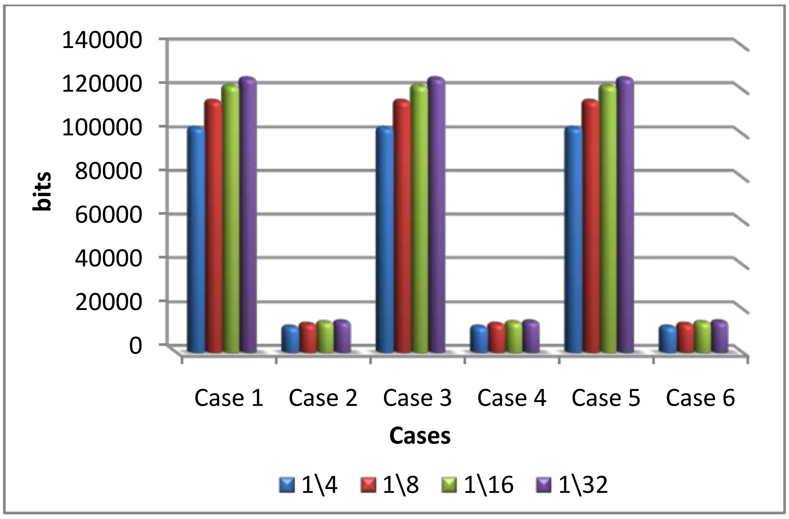

Figure 1: The effect of the CP on the data transmission rate of SISO-WiMAX system with fading.

Table 4: The throughput of SISO-WIMAX system without fading.

	Bits					
CP	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
1/4	100296	96840	100296	96264	100296	97416
1/8	112144	103312	111376	105808	112144	103312
1/16	119024	111728	117872	99248	118832	113264
1/32	122656	112480	121312	108640	122656	112480

Table 4 and figure 2 shows the results in the fading channel. Compared these results with the results of the system without fading (table 3 and figure 1); it found that the system without fading has a high transmission rates of data than the one without fading.
Second, the BER performance of SISO WiMAX system for different cases is shown in table 5 and figure 3 – 9. (Note all the values in the table 5 are an arithmetic average). These results show the effect of using different modulation techniques with different values of the CP. Figure 3 shows the results when using ID0 (1/2 BPSK), CP = 1/8 gives the best value of BER where CP = 1/32 gives the worst value of the BER. Figure 4 shows the results when using ID1 (1/2 QPSK), CP = 1/8 gives the best value of BER where CP = 1/16 gives the worst value of the BER. Figure 5 shows the results when using ID2 (3/4 QPSK), CP = 1/8 gives the best value of BER where CP = 1/16 gives the worst value of the BER. Figure 6 shows the results when using ID3 (1/2 16QAM), CP = 1/32 gives the best value of BER where CP = 1/16 gives the worst value of the BER. Figure 7 shows the results when using ID4 (3/4 16QAM), CP = 1/16 gives the best value of BER where CP = 1/4 gives the worst value of the BER. Figure 8 shows the results when using ID5 (2/3 64QAM), CP = 1/16 gives the best value of BER where CP = 1/4 gives the worst value of the BER. Figure 9 shows the results when using ID6 (3/4 64QAM), CP = 1/16 gives the best value of BER where CP = 1/32 gives the worst value of the BER.

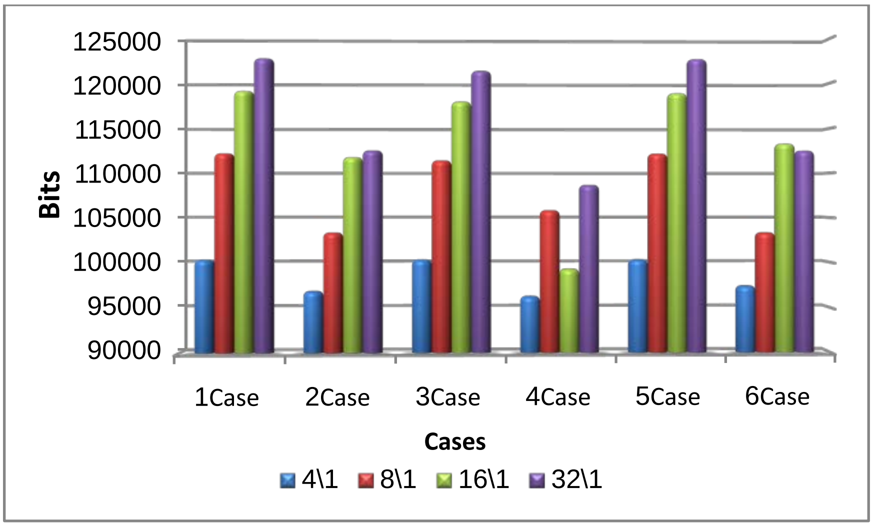

Figure 2: The effect of the CP on the data transmission rate of SISO-WiMAX system without fading.

Table 5: The effect of the CP on the average BER using AMC in SISO WiMAX system.

CP	SNR							Bits
	ID0	ID1	ID2	ID3	ID4	ID5	ID6	
	BER							
1/4	0.02669	0.08644	0.11424	0.15706	0.18865	0.23998	0.26585	0.154130
1/8	0.02523	0.08425	0.1129	0.15673	0.18844	0.23884	0.26555	0.153133
1/16	0.02718	0.08685	0.11459	0.15830	0.18633	0.23680	0.26520	0.153608
1/32	0.02878	0.08568	0.11289	0.15589	0.18704	0.23902	0.26594	0.153606

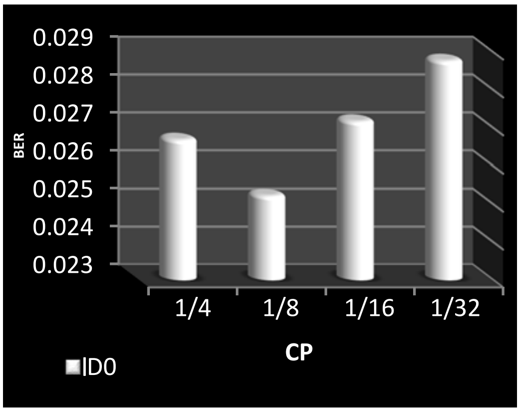

Figure 3: The BER when using ID0 (1/2 BPSK).

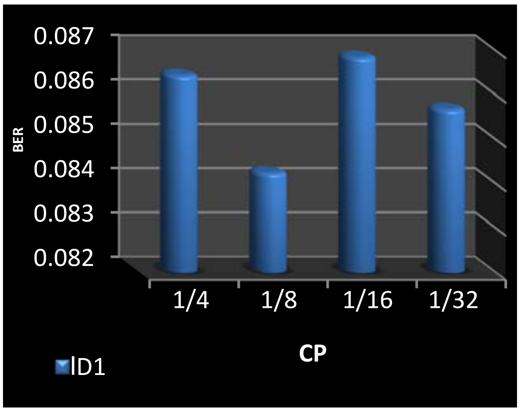

Figure 4: The BER when using ID1 (1/2QPSK).

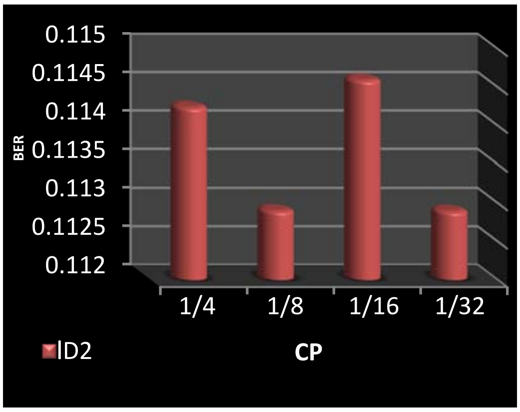

Figure 5: The BER when using ID2 (3/4 QPSK).

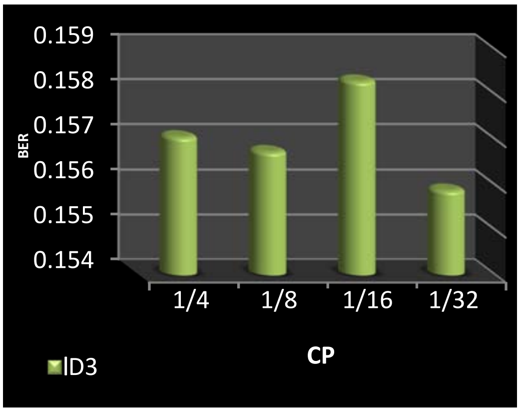

Figure 6: The BER when using ID3 (1/2 16QAM).

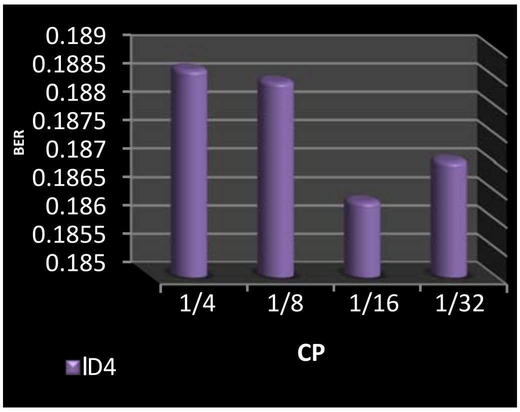

Figure 7: The BER when using ID4 (3/4 16QAM).

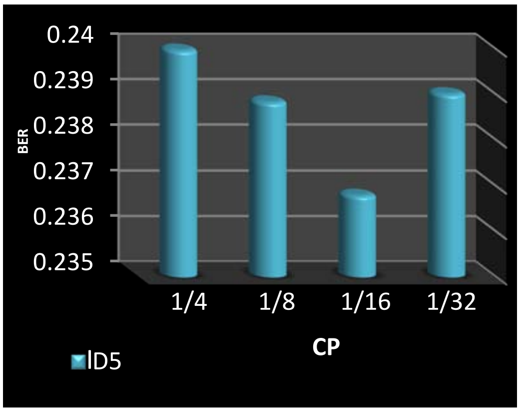

Figure 8: The BER when using ID5 (2/3 64QAM).

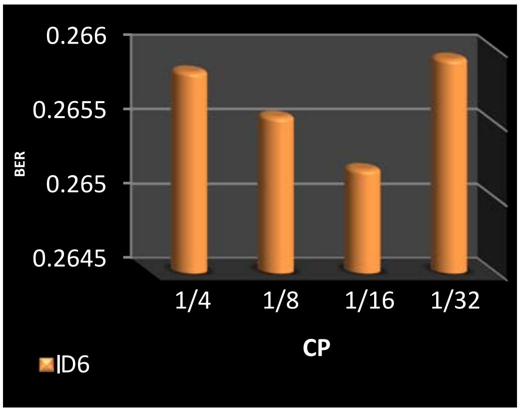

Figure 9: The BER when using ID6 (3/4 64QAM).

Third, this section presented various BER vs. SNR for various values of the CP. Figure 10, 11, 12, and 13 displays the performance of BER using 1/4, 1/8, 1/16 and 1/32 of the CP respectively. The results shows that the CP does not affect the BER, but clearly affect the data transmission rate (see the same table 5). These results rapprochement results obtained in [8], [9], [10] when using MIMO-WiMAX system.

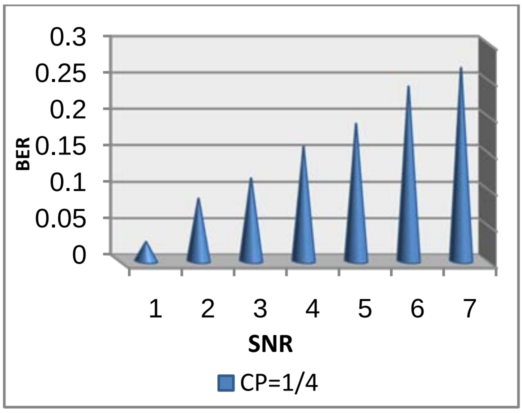

Figure 10: The BER when using CP=1/4.

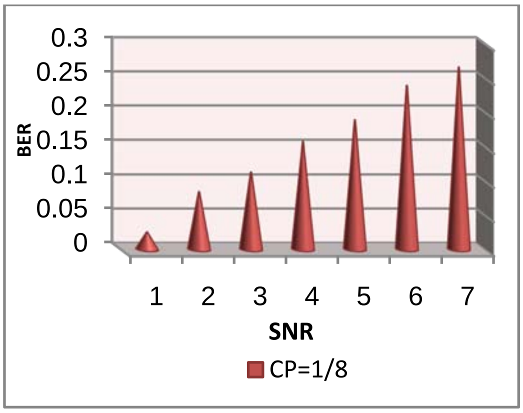

Figure 11: The BER when using CP=1/8.

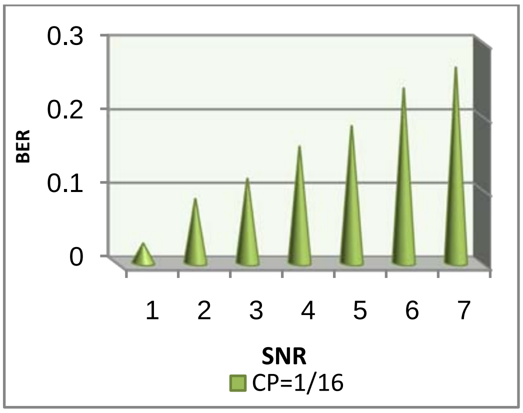

Figure 12: The BER when using CP=1/16.

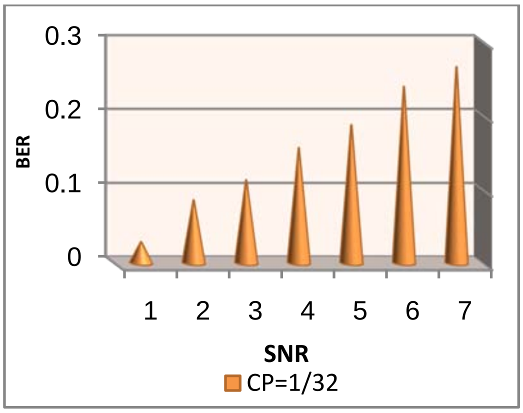

Figure 13: The BER when using CP=1/32.

Fourth, the BER performance of MISO WiMAX system for different cases is shown in table 6 and figure 14 – 20. (Note all the values in the table 6 are an arithmetic average). These results show the effect of using different modulation techniques with different values of the CP. Figure 14 shows the results when using ID0 (1/2 BPSK), CP = 1/8 gives the best value of BER where CP = 1/16 gives the worst value of the BER. Figure 15 shows the results when using ID1 (1/2 QPSK), CP = 1/6 gives the best value of BER where CP = 1/32 gives the worst value of the BER. Figure 16 shows the results when using ID2 (3/4 QPSK), CP = 1/16 gives the best value of BER where CP = 1/4 gives the worst value of the BER.

Table 6: The effect of the CP on the average BER using AMC in MISO WiMAX system.

CP	SNR							Bits
	ID0	ID1	ID2	ID3	ID4	ID5	ID6	
	BER							
1\4	0.04077	0.09512	0.11688	0.16345	0.19445	0.25307	0.292675	0.16521
1\8	0.04090	0.09472	0.11572	0.16117	0.19265	0.25201	0.291606	0.16411
1\16	0.04226	0.09369	0.11194	0.16022	0.19202	0.25124	0.292964	0.16348
1\32	0.04107	0.09544	0.11608	0.16029	0.19365	0.25820	0.307207	0.16742

Figure 17 shows the results when using ID3 (1/2 16QAM), CP = 1/16 gives the best value of BER where CP = 1/4 gives the worst value of the BER. Figure 18 shows the results when using ID4 (3/4 16QAM), CP = 1/16 gives the best value of BER where CP = 1/4 gives the worst value of the BER. Figure 19 shows the results when using ID5 (2/3 64QAM), CP = 1/16 gives the best value of BER where CP = 1/32 gives the worst value of the BER. Figure 20 shows the results when using ID6 (3/4 64QAM), CP = 1/8 gives the best value of BER where CP = 1/32 gives the worst value of the BER.

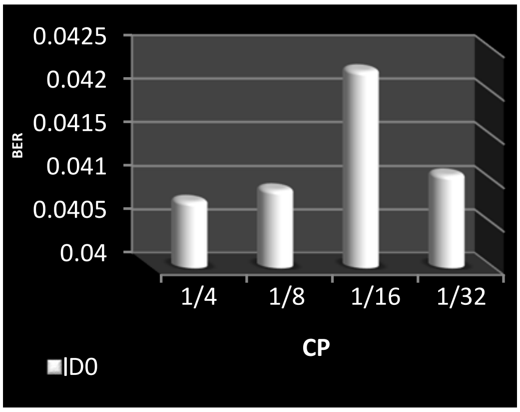

Figure 14: The BER when using ID0 (1/2 BPSK).

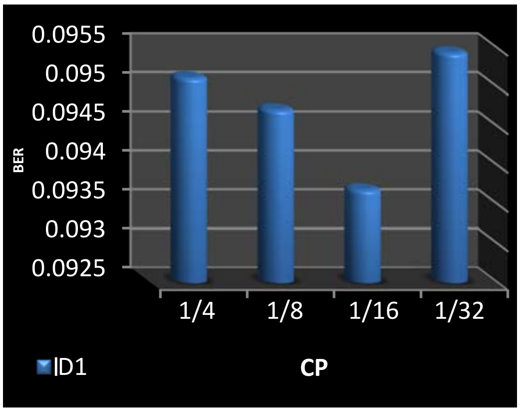

Figure 15: The BER when using ID1 (1/2 QPSK).

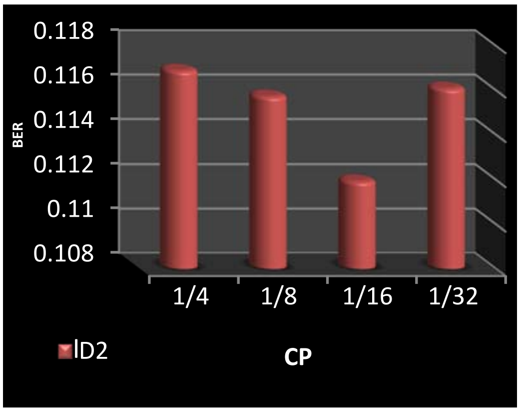

Figure 16: The BER when using ID2 (3/4 QPSK).

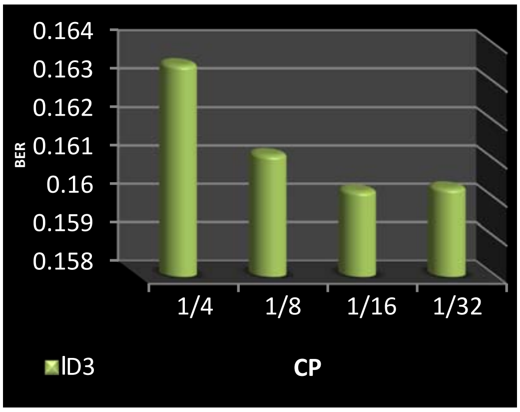

Figure 17: The BER when using ID3 (1/2 16QAM).

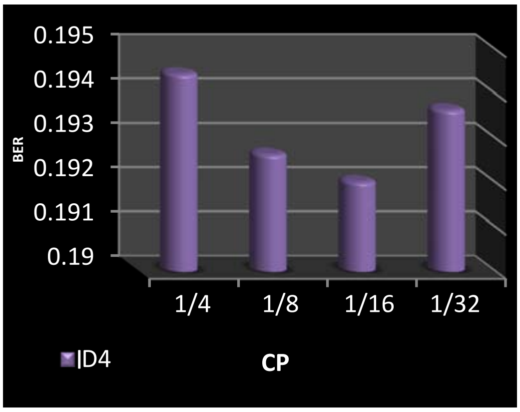

Figure 18: The BER when using ID4 (3/4 16QAM).

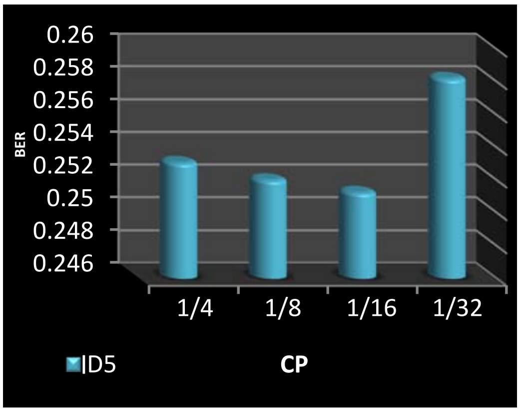

Figure 19: The BER when using ID5 (2/3 64QAM).

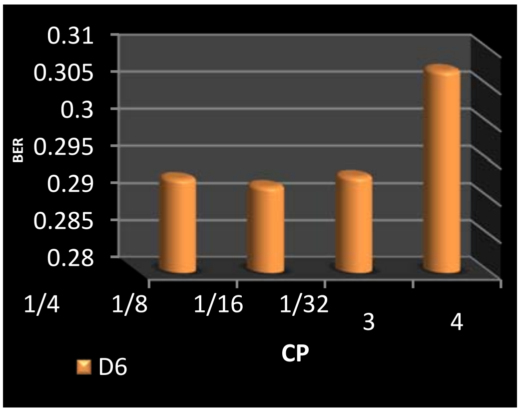

Figure 20: The BER when using ID6 (3/4 64QAM).

Fifth, this section presented various BER vs. SNR for various values of the CP. Figure 21, 22, 23, and 24 displays the performance of BER using 1/4, 1/8, 1/16 and 1/32 of the CP respectively. Again the results shows that the CP does not affect the BER, but clearly affect the data transmission rate (see the same table 3). These results rapprochement results obtained in [9], [10] when using MIMO-WiMAX system.

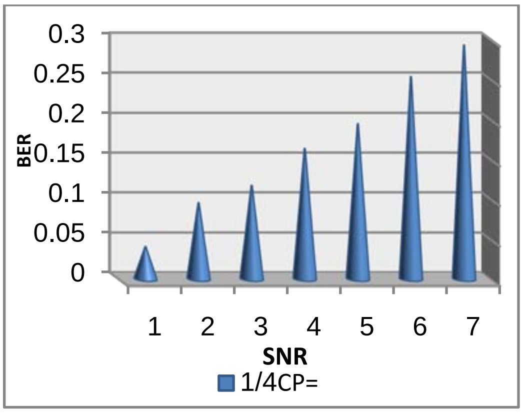

Figure 21: The BER when using CP=1/4.

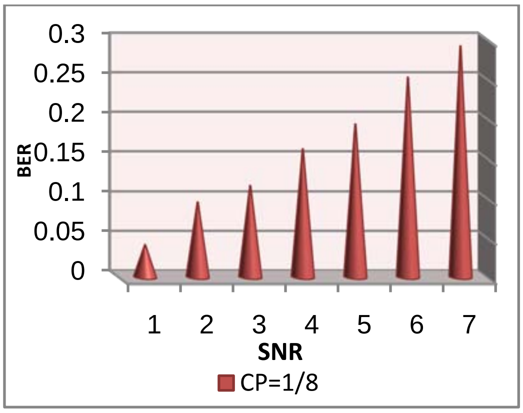

Figure 22: The BER when using CP=1/8.

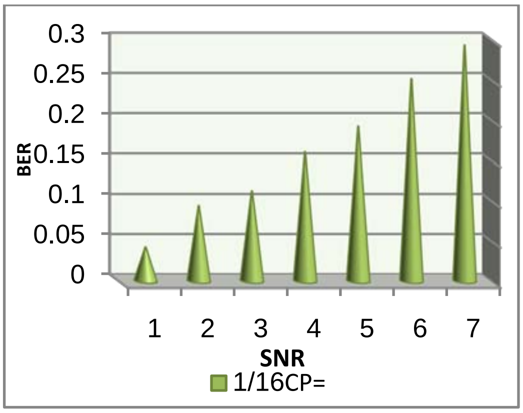

Figure 23: The BER when using CP=1/16.

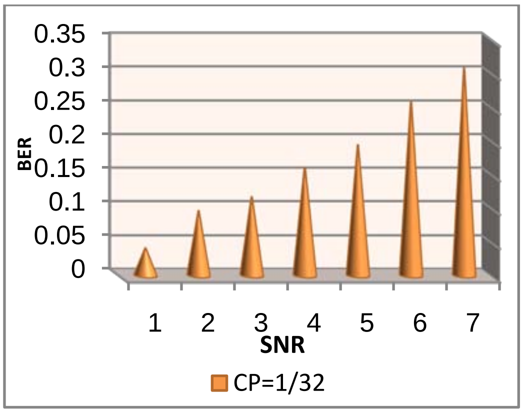

Figure 24: The BER when using CP=1/32.

Finally, this section shows the results of the CP on the data rate using AMC. Table 7 and figure 25 shows the average total Bits per IDs for each CP separately. The results shows an enormous increasing in the throughput when decreasing the CP, we can deduce that the AMC in case of transmission from one ID to another in ascending sequence regularly top Throughput will be higher CP settles then.

Table 7: The effect of the CP on the data transmission rate.

CP	SUM
1/4	54380.57
1/8	60660.57
1/16	63734.86
1/32	66043.43

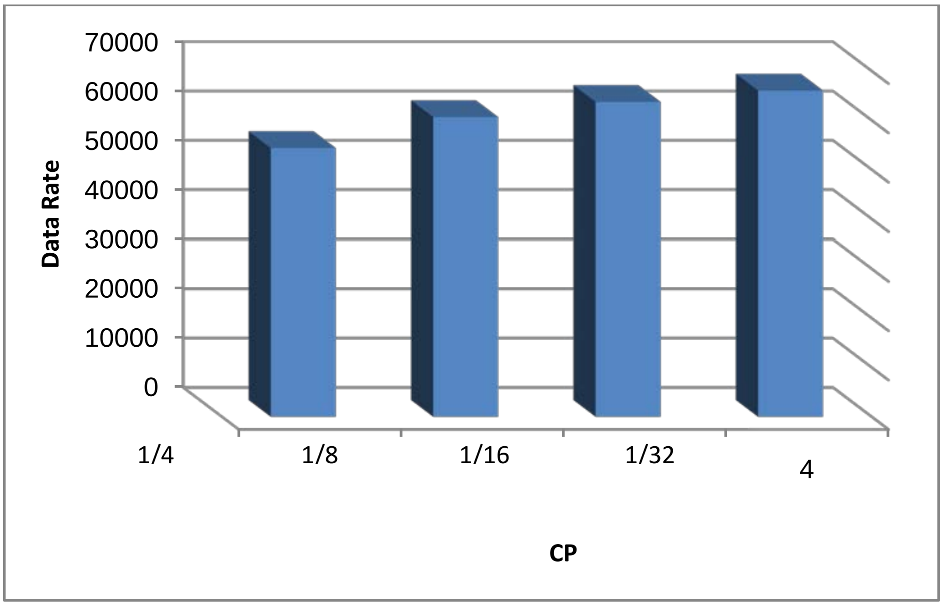

Figure 25: The effect of the CP on the data transmission rate when using AMC.

Conclusion:

In this paper the effect of the CP in SISO/MISO WiMAX systems with and without fading is shown in term of the throughput, SNR and BER using AMC. The results show that the CP limits the speed of transmission. As the distance increases signal strength and the SNR are decreases, so it required switching from higher modulation level to lower modulation level. At the low values of SNR, fading is more and signal strength is going low as the distance increases. To defeat this problem higher value of CP need to be chosen. Large value of the CP means large time gap between two frames which mean extra time to receive signal from multipath signals. Although the large values of the CP reduces data rate however, it increases coverage up to large distance. Thus chosen the appropriate value of the CP gives the desired distance that need to cover by the signal. The contribution of this work is that it shows the best value of the BER for different values of the CP using AMC. Moreover, the paper shows the effect fading for different values of the CP.

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Biographies:

Albedeir Yaseen Gafer Othman (albedeir1985@yahoo.com) received his MS.C. degree in communication engineering from Sudan University of Science and Technology, Sudan in 2012. His Many of patents in the field of communications and remote control, he have scientific papers in the field of communications, His research is focused on Wireless Communication and Optical Fiber in communication. Currently he is working for in Omdurman Islamic University, Khartoum, Sudan. He is Director of management in technology development organization (TDO), and One of the most important founders.

Mohamed Hussien Mohamed Nerma (mohamed_hussien@ieee.org) received his Ph.D. degree in communication engineering from Universiti Teknologi PETRONAS, Malaysia in 2010. He is a reviewer and invited reviewer of different international journals and conferences and he is also an active member in all assessment and accreditation activities. His research is focused on Wireless Communication, OFDM (WiMAX, WiFi, DVB-T, and LTE), Cognitive radio, OFDM and FPGA, Wavelet Based OFDM Systems, and Optical Fiber Transceivers. Currently he is working for Sudan University of Science and Engineering, Khartoum, Sudan. He is senior member of IEEE.