Throughput Enhancement and Performance Improvement of the OFDM Based WLAN System

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Summary
This paper presents two models of WLAN-OFDM, which offer a new decision policy in the adaptive modulation (AM) technique of choosing the order of modulation schemes to map the data onto the carriers. Numerous modes will be tested in this paper. The common concept in these proposed models is using the high order modulation schemes together with the low order ones at low SNR values. In model (1), the percentage of using the different modulation schemes will be controlled by the SER value only. So the SER performance of the high order modulation schemes such as 128, 256QAM will be improved. However in model (2), decision policy of choosing the modulation scheme will be made based on the SNR value, but the percentage of the usage will be controlled by the SER value. In both models the appropriate choosing of the clipping ratio (CR) is very important to define the percentage of using a certain order of modulation scheme. The throughput of the two tested models will be enhanced dramatically at all SNR values, and a good improvement in the PAPR will be achieved.

Key words:
PAPR, clipping ratio, Adaptive modulation, IEEE 802.11g-OFDM, SER.

1. Introduction

Wireless Local Area Network (WLAN) technology is rapidly a critical component of computer networks and is growing even now. This growth comes from the fact that IEEE802.11 standardized its WLAN specification. Thus IEEE802.11 WLAN has become very popular as an open solution for providing mobility as well as essential network services [1]. (WLAN) are becoming part of omnipresent communication infrastructures. WLANs are being applied in hotels, airports, cafes. Different types of terminals are already or planed to be equipped with WLAN such as laptops, PDAs, and mobile phones. In the next generation WLAN standard, increasing the link throughput reliably to support a number of novel multi-media applications is a key point of standard development [3]. The standard was designed to provide wireless connectivity and efficient data transfer for users who are either stationary or are moving with limited velocity. The first amendment to the standard,
IEEE802.11b, used Direct-Sequence Spread Spectrum (DSSS) modulation for transmitting data [4]. Later amendments (specifically IEEE802.11a and 802.11g) make use of OFDM, a modulation method which offers several important benefits. The IEEE802.11 WLAN standard, called Legacy standard, was approved and the corresponding standard specification was published in 1997. After the finalization of Legacy standard, several standard amendments were released and even currently other amendments have been discussed in working groups in IEEE802.11. Currently Orthogonal Frequency Division Multiplexing (OFDM) is the chosen technology for enhanced and future high data rate WLAN systems. OFDM is a key technology to mitigate the multi-path effect of the wireless channel. It has been already used in DVB–T, IEEE802.11a and IEEE802.11g [2]. OFDM is known as a wireless communication system which is robust in the environment of multi-path and keeps high transmission speed. This is because transmission data is separately conveyed using multiple low rate data sequences mapped to multiple subcarriers. Moreover, since each subcarrier overlaps with neighbor subcarriers, bandwidth is efficiently utilized. Each subcarrier can be detached from neighbor ones because subcarriers are orthogonally overlapped with neighbors. However, one of the limitations of using OFDM is the high peak-to-average power ratio (PAPR) of the transmitted signal. A large PAPR leads to disadvantages such as increased complexity of the analog to digital converter (A/D) and reduced efficiency of the radio frequency (RF) amplifier. If power amplifiers are not operated with large linear-power back-offs, it is impossible to keep the out-of-band power below imposed limits. This leads to very inefficient amplification, expensive transmitters and causing inter-modulation among the subcarriers and undesired out-of-band radiation. The PAPR reduction techniques are therefore of great importance for OFDM systems. Partial transmit sequences (PTS)[5], selected mapping (SLM) [6],

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active constellation extension (ACE) [7], Golay sequences and Reed-Muller codes (GRC) [8], clipping signal scheme [9][10][11][12], selective scrambling (SLS)[13] and windowing signal scheme were recently proposed to reduce PAPR. The side information (SI) must be transmitted to the receiver when using PTS, SLM and SLS methods, and then the channel efficiency drops a little. The complexity of using GRC method is too high to employ at real-time practice, and it is only efficacious when the subcarrier number equals to several special values as well. The ACE scheme wastes the precious power, especially when the mobile's power is very limited. The clipping signal scheme is relatively simpler than others. And the performance of the clipping scheme is superior to that of the windowing signal scheme in OFDM systems, because the windowing technique distorts all signals, but the clipping technique distorts small portion signal where the peak power exceeds the max-permitted power. This paper will focus on the clipping signal technique. Networks using adaptive modulation and coding (AMC) can increase or decrease modulation efficiency by selecting an appropriate modulation and coding level or mode. AMC allows a link to be adapted such that the throughput is maximized for channel conditions. In wireless communication systems, random fluctuations prevent the continuous use of highly bandwidth-efficient modulation, and therefore Adaptive Modulation and Coding (AMC) has become a standard approach in recently developed wireless standards. The idea behind AMC is to dynamically adapt the modulation and coding scheme to the channel conditions so as to achieve the highest spectral efficiency at all times [14].

The remainder of this paper is organized as follows. Section II presents the basic the simulation model, next, numerical results, plots of complementary cumulative distribution function (CCDF), PSD, throughput, and plots of SER, are presented in section III. Finally, Section IV presents the major conclusions.

2. Simulation Model

This paper tries to improve the overall performance of IEEE802.11g which is an amendment of Legacy standard, 802.11a and 802.11b, using OFDM in 2.4 GHz frequency band [14]. To achieve this mission this paper suggests two models with numerous modes to use the clipping technique to control the adaptive modulation. The proposed adaptive modulation (AM) to be used in this simulation is totally different form the conventional AM. Table I shows the values of parameters were used in this simulation model. The OFDM signal will be clipped hardly when using low order modulation scheme in model (1) to give chance to the high order modulation schemes to be used at low SNR values. The appropriate choosing of clipping ratio is very important to keep the SER at acceptance value. The first task to consider in FFT implementation is that the OFDM spectrum is centered on f_c. One simple way to achieve the centering is to use a 2N-IFFT [15].

TABLE I
SIMULATION PARAMETERS

Parameters	Values
Modulation scheme (Mapping scheme)	4QAM, 16QAM, 64QAM, 128QAM, 256QAM,
Channel bandwidth (MHz)	20 MHz
FFT Size (NFFT)	64
Number of data subcarriers	48
Useful symbol duration T_U	4 µs
Carrier spacing 1/ T_U	312..5 KHz
Carrier frequency f_c	2.4 GHz
Guard Time	800 ns
Channel coding	none
Channel model	AWGN

As suggested in [15], zeros were added to the OFDM signal to achieve over-sampling. The transmitted baseband OFDM signal can be expressed as:

$$x(t) = \sum_{n=0}^{N-1} y_n e^{j2\pi f_n t} \quad 0 \le t \le NT \qquad (1)$$

When using the clipping scheme, the phase information of the signal is completely transmitted, and the amplitude of the signal is clipped if the power of the signal exceeds the max-permitted power. Because of the limited transmitting power, the PAPR must be reduced to a proper value, which is operated easy and satisfy systems requirement. Then, the real valued bandpass samples, x, were clipped at amplitude A as follows:

$$y = \begin{cases} -A, & \text{if } x < -A \\ x, & \text{if } -A \le x \le A \\ A, & \text{if } x > A \end{cases} \qquad (2)$$

The variation of the envelope of a multi-carrier signal can be defined by the peak to average power ratio (PAPR) which is given by:

$$PAPR = \frac{\mathrm{Max}\left\{|x(t)|^2\right\}}{\mathrm{E}\left\{|x(t)^2|\right\}} \quad (3)$$

At the transmitter side, the clipping method reduces the amplitude dynamics, and thus the PAPR of the signal that has to be amplified. This result is presented in Complementary Cumulative Distribution Function (CCDF) a term which is defined as follows:

$$CCDF\left(PAPR(x)\right) = \mathrm{Prob}\left(PAPR(x) > PAPR0\right) \quad (4)$$

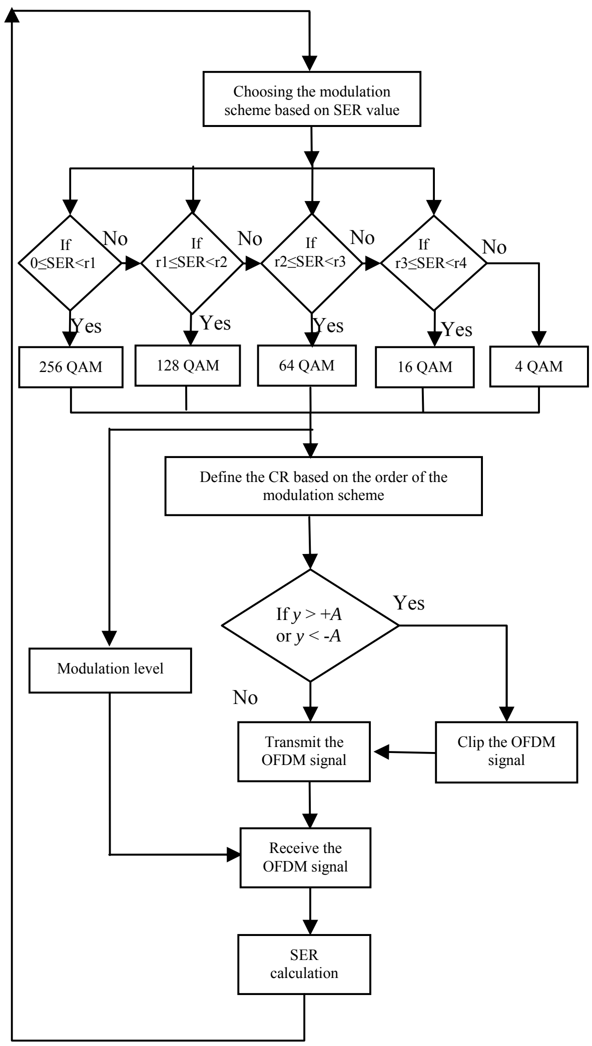

Fig.1. The proposed model (1)

The function CCDF can be interpreted as the probability that the PAPR of an OFDM signal exceeds some clip level PAPR0. Unfortunately, clipping generates a spectral regrowth (the so called spectral shoulders) on the spectrum of output signal, widening its frequency support. Thus, parasitic frequencies appear in the adjacent channels. Filtering after clipping is therefore compulsory to limit this spectral regrowth and, finally, to assure a good system performance.

A cyclic prefix (CP) is then appended to minimize interblock interference and aid the frequency domain equalizer at the receiver. Digital-to-analog (D/A) conversion and analog filtering are performed. The clipping process is characterized by the clipping ratio (CR), defined as the ratio between the clipping threshold and the root-mean square (rms) level of the OFDM signal. However, Clipping is a nonlinear process that leads to distortion. Without filtering, clipping causes out-of-band radiation. Digital filtering is present to control out-of-band radiation.

$$\mathrm{CR} = \frac{\mathrm{CL}}{\mathrm{rms\ level}} \quad (5)$$

Where CL is the Clipping Level and CR is the clipping ratio.

The CR in this simulation has different values depends on the modulation order used for data mapping. For the low order modulation scheme such as 4QAM, and 16QAM, hard CR is used (CR=0.2, 0.5 and 0.7). Clipping the OFDM signal before amplification is a simple and typical method for the PAPR reduction [12]. The SNR thresholds for conventional AM technique are set according to a SER=10^{-5}. The thresholds are summarized in table II. Based on theses thresholds the decision about the individual modulation level is made. In the simulation the thresholds which are used in the new form AM of the two proposed models will be compared to theses thresholds in the table II.

TABLE II
THRESHOLDS FOR CONVENTIONAL AM

Modulation Mode	SNR threshold (dB)
BPSK	8
4QAM	12
16QAM	18
64QAM	22
128QAM	30
256QAM	40

3. Results and Discussion

This simulation was implemented in MATLAB. Simulation results were obtained in WLAN-OFDM system with a total of 100 OFDM frames, each frame consists of 128 OFDM symbol with a total of 64 subcarriers. Three modes were tested in Model (1) with five, four, and three modulation schemes. In model (2), two modes were tested with five and four modulation schemes.

TABLE III
THE PROPOSED MODELS AND MODES

Model	Proposed Modes	Modulation schemes used in IEEE802g proposed modes	Note
Model (1)	Mode A	4+16+64+128+256-QAM	AM is SER controlled
	Mode B	4+16+64-+256-QAM	
	Mode C	4+16+64-QAM	
Model (2)	Mode D	4+16+64+128+256-QAM	AM is SER and SNR controlled
	Mode E	4+16+64+256-QAM	

A. The proposed Model (1)

The proposed AM in model (1) and model (2) are controlled by the clipping ratio (CR). But the proposed AM in model (1) is based on the SER value only as shown in figure 1. This model has the ability to improve the performance of the SER of the high order modulation scheme such as 256, 128 and 64QAM through permitting these schemes to be used to map the data onto the subcarriers together with the low order modulation schemes such as 16, and 4QAM at low SNR values. As mentioned before this paper tries to improve the overall performance of the WLAN-OFDM system, so it is important to reduce the PAPR of the OFDM. The two proposed models (1) and (2) introduce the clipping technique to solve this problem and combine it to work together with AM to improve the performance of the WLAN system. As shown in figure 2 and table IV the obtained reduction in PAPR in mode A at the probability of 10^{-3} is 3.02 dB, and 1.6 dB compared to the conventional WLAN-OFDM with 256, and 4QAM respectively.

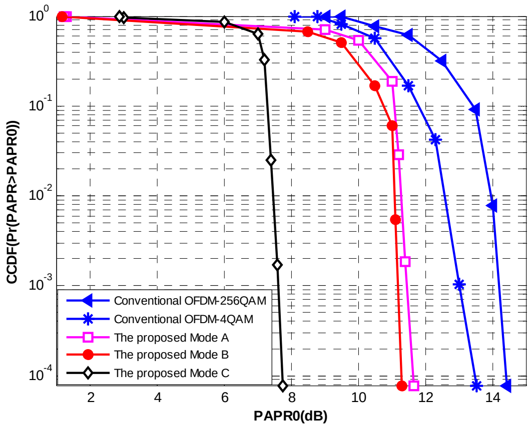

Fig.2. CCDF of PAPR for conventional IEEE802.11g-OFDM with 256-QAM, 4QAM and the proposed modes: A, B, and C

The best improvement in the PAPR at the probability of 10^{-3} was achieved with the proposed C, which was on the order of 5.97 dB compared to the conventional WLAN-OFDM with 64QAM and on the order of 5.3 dB compared to the conventional IEEE802.11g -OFDM with 4QAM as shown in Table IV. Table V and VI shows the percentage of the symbols in mode A and B which mapped at different SNR values using high order modulation schemes.

TABLE IV
THE OBTAINED REDUCTION IN PAPR AT PROBABILITY OF 10^{-3}

mode	PAPR reduction compared to the normal OFDM with:		
	256QAM (dB)	64QAM (dB)	4QAM (dB)
Mode A	3.02	—	1.6
Mode B	3.22	—	1.8
Mode C	—	5.97	5.3

TABLE V
THE PERCENTAGE OF TRANSMITTED SYMBOLS IN MODE A THAT WERE MAPPED USING FIVE ORDERS OF MODULATION SCHEMES AT DIFFERENT SNR VALUES

SNR (dB)	Symbols percentage that were mapped using:		
	64-QAM	128-QAM	256-QAM
2	21%	12%	18%
8	13%	12%	41%
12	22%	8%	58%
18	0%	12%	88%
20	0%	1%	99%
23	0%	0%	100%

TABLE VI
THE PERCENTAGE OF TRANSMITTED SYMBOLS IN MODE B THAT WERE MAPPED USING FOUR ORDERS OF MODULATION SCHEMES AT DIFFERENT SNR VALUES

SNR (dB)	Symbols percentage that were mapped using:		
	16-QAM	64-QAM	256-QAM
2	25 %	19 %	18 %
8	19 %	30 %	34 %
12	13 %	26 %	61 %
18	0 %	11 %	89 %
20	0 %	2 %	98 %
23	0 %	0 %	100 %

The performance of SER of theses two modes is clearly improved by mapping the input data using five modulation schemes with different percentage. At low SNR values the majority of the input data were mapped using high modulation schemes and as the SNR value is increased, the percentage of the data which were mapped using the highest order modulation scheme 256QAM is also increased.

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From figure 3, it is easy to note that the performance of SER of the tested modes in model (1) is better than the performance of the SER of the conventional WLAN-OFDM system with 64QAM, 128, and 256QAM.

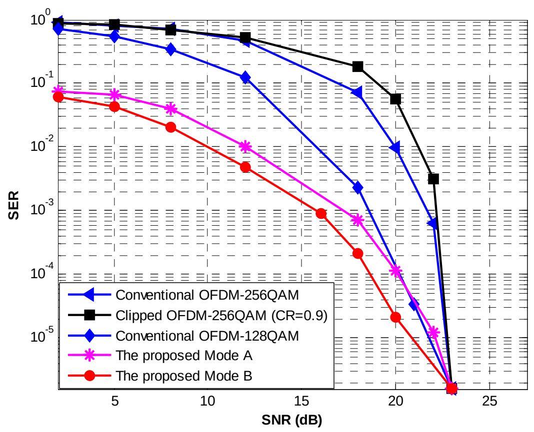

Fig.3. SER performance of the conventional, clipped IEEE802.11g-OFDM with 256QAM, 128QAM and the proposed modes A and B

In mode A at 10^{-2} SER level, the improvement in the SNR is 8 dB, and 3.8 dB compared to the conventional IEEE802.11g-OFDM with 256QAM, and 128QAM respectively. But the improvement is 4.5 dB, and 1.3 at 10^{-3}. Also in mode B the improvement in SNR is 10 dB, and 5.8 dB compared to the conventional IEEE802.11g-OFDM with 256, and 128QAM respectively. At 10^{-3} it is 6 dB, and 2.8 dB. Figure 4 also shows the ability of the proposed mode C to improve the performance of the SER of the WLAN-OFDM system. At 10^{-2}, and 10^{-3} SER level, the improvement in the SNR of the proposed mode over the conventional IEEE802.11g -OFDM with 64QAM is 1 dB, and 0.8 dB respectively.

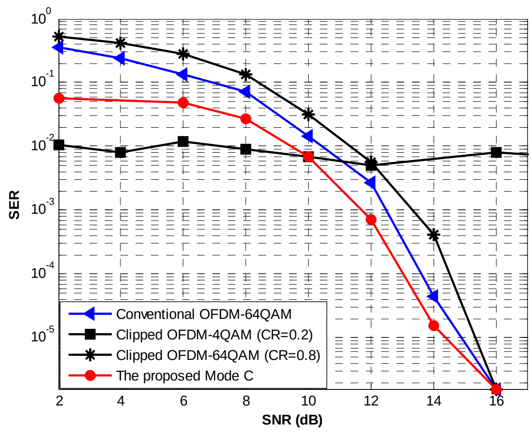

Fig.4. SER performance of the conventional, clipped IEEE802.11g-OFDM with 64QAM, 4QAM and the proposed mode C

The advantage of AM which used in the tested modes A, and B can be seen obviously in figure 5. The bit rate in the proposed AM is not a constant as also in the conventional AM, but it is clear the enhancement in the bit rate of the proposed modes especially at low SNR values. This enhancement in the throughput comes from using the high order modulation schemes together with the low order modulation schemes at low SNR values.

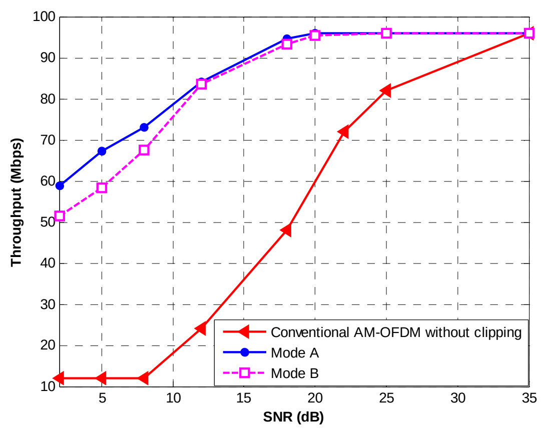

Fig.5. Throughput of the conventional AM-IEEE802.11g-OFDM system and the two proposed modes A, and B

Table VII proves the ability of the proposed modes A, and B to enhance the data rate especially at low SNR values. it is obvious the reduction in the required time to send a data with a size of 1 Gbps. The comparison here in made between the conventional AM and the new form of Am which was used in mode A and B. this comparison is based on the SNR thresholds.

TABLE VII
COMPARISON BETWEEN THE REQUIRED TRANSMISSION TIME OF THE CONVENTIONAL OFDM AND THE PROPOSED MODES A, B, AND C AT DIFFERENT SNR VALUES

Data size	Transmission time when using:				SNR value (dB)
	Mode A (sec)	Mode B (sec)	Mode C (sec)	Conventional (sec)	
1Gbps	17.01	19.20	20.53	83.33	2
	13.71	14.83	16.15	41.67	8
	11.91	11.97	14.52	41.67	12
	10.58	10.71	13.89	20.83	18
	10.43	10.47	—	13.89	20
	10.43	10.42	—	10.42	23

B. The proposed Model (2)

Two modes D, and E were tested in this model. In these modes the AM decision will be made based on the SER and SNR values. In other word at some certain values of SNR, the decision of AM can be made based on the value of the SER. If the SER value is very small (smaller than target value which is defined based on the CR used in the tested mode), the input data will be mapped using two modulation schemes with maintain the SER value under the target value, and in the same time enhance the data rate at that SNR value. Also as in model (1), the clipping technique will be used to reduce the PAPR in model (2). But in model (2), there will be two defined values of the CR. In brief this model uses the CR to control the decision of the AM, in other word based on the value of the CR (hard or soft), AM will choose the appropriate values of SNR to use two modulation schemes to map the input data and the percentage of this using will based on the SER value.

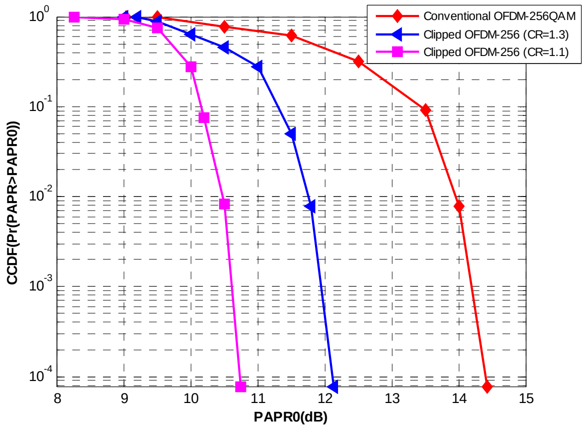

Fig.6. CCDF of PAPR for conventional IEEE802.11g-OFDM-256QAM and the clipped IEEE802.11g-OFDM-256QAM at hard and soft CR values

Figures 6, 7, and 8 shows the improvement in the PAPR at two different values of CR (hard CR and soft CR) for each modulation schemes used in the tested modes D and E. Figure 6 shows PAPR as a function of the clipping ratio. The PAPR of the unclipped IEEE802.11g-OFDM-256QAM signal is 14.2 dB. When using soft CR (CR=1.3), the PAPR at the probability of 10^{-3} is only 11.8 dB. This means that for large CR the OFDM signal is unclipped, but as CR→0, the peak and average power converge, thus PAPR→0 dB.

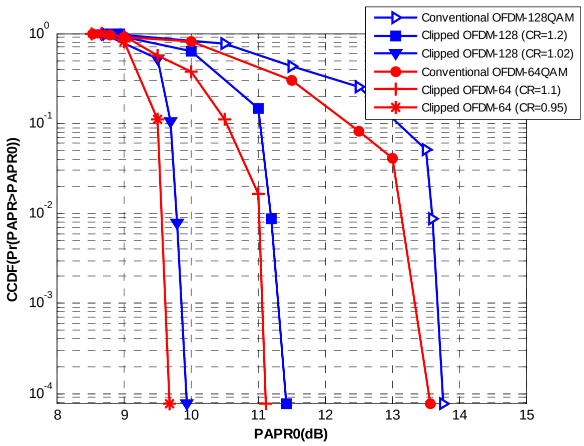

Fig.7. CCDF of PAPR for conventional (IEEE802.11g-OFDM-128,64QAM), and the clipped (OFDM-128,64QAM) at hard and soft CR values

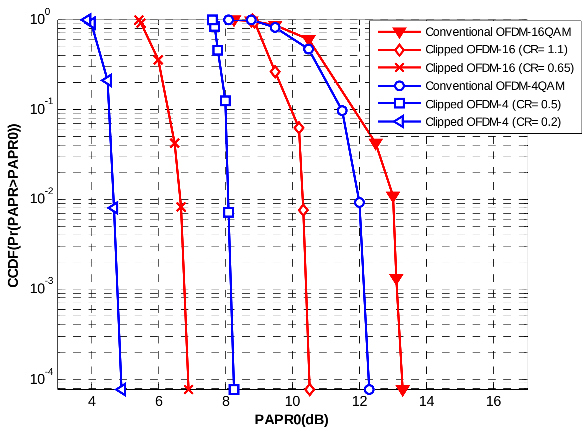

Fig.8. CCDF of PAPR for conventional (IEEE802.11g-OFDM-16,4QAM), and the clipped (OFDM-16,4QAM) at hard and soft CR values

The best reduction in PAPR was achieved with OFDM-4QAM with hard CR value at probability of 10^{-3} which is 7.37 dB as shown in table VIII.

Table IX and X shows in details the distribution of all the modulation schemes which were used in modes D and E to map the data onto the carriers to produce the OFDM symbols.

TABLE VIII
THE OBTAINED REDUCTION IN PAPR AT PROBABILITY OF 10^{-3}

Mode	CR	PAPR reduction compared to the normal OFDM with:				
		256 QAM (dB)	128 QAM (dB)	64 QAM (dB)	16 QAM (dB)	4 QAM (dB)
Mode D	hard	3.67	—	3.89	6.39	7.37
	Soft	2.28	—	2.45	2.77	4.01
Mode E	hard	3.67	3.79	3.89	6.39	7.37
	soft	2.28	2.34	2.45	2.77	4.01

TABLE IX
THE PERCENTAGE OF TRANSMITTED SYMBOLS IN MODE D THAT WERE MAPPED USING FIVE ORDERS OF MODULATION SCHEMES AT DIFFERENT SNR VALUES

SNR	The used Modulation schemes M-QAM		Percentage of the Modulated Symbols using this scheme (Soft CR)		Percentage of the Modulated Symbols using this scheme (Hard CR)		Note
2-5	4		100		100		AM is based on the SER and SNR values and controlled by the clipping ratio (CR)
6	4	16	10	90	25	75	
7	4	16	2	98	18	82	
8-10	16		100		100		
11	16	64	25	75	29	71	
12	16	64	10	90	19	81	
13-15	64		100		100		
16	64	128	9	91	21	79	
17-19	128		100		100		
20	128	256	5	95	12	88	
21	128	256	2	98	7	93	
>22	256		100		100		

TABLE X
THE PERCENTAGE OF TRANSMITTED SYMBOLS IN MODE E THAT WERE MAPPED USING FIVE ORDERS OF MODULATION SCHEMES AT DIFFERENT SNR VALUES

SNR	The used Modulation schemes M-QAM		Percentage of the Modulated Symbols using this scheme (Soft CR)		Percentage of the Modulated Symbols using this scheme (Hard CR)		Note
2 -5	4		100		100		AM is based on the SER and SNR values and controlled by the clipping ratio (CR)
6	4	16	7	93	29	71	
7	4	16	2	98	16	84	
8-12	16		100		100		
13	16	64	4	96	6	94	
14-19	64		100		100		
20	64	256	4	96	8	92	
21	64	256	1	99	4	96	
>22	256		100		100		

It is obvious to note the new proposed policy to make the decision in AM to keep the SER under certain value even using the clipping technique to reduce the PAPR. At some SNR value, the data will be mapped using two modulation schemes and the majority of the data were mapped using the higher order modulation schemes to enhance the data rate at that SNR value. This percentage of the transmitted symbol will be controlled by the CR value and the decision was based on the calculated SER of previous transmission. The SER performance of the tested mode D with hard CR can be shown in figure 9. The curve is kept under 10^{-3} even all the OFDM symbols are clipped hardly. There are some increment in the SER, because of using the high order modulation schemes was used at low SNR value to enhance the data rate at that SNR value. But the performance of SER of the tested mode D with soft CR is kept under 10^{-4} at low SNR values with some increment between 12 and 18 dB, because of using the high order schemes 64 and 128QAM at that SNR value which are below the thresholds value of these schemes. Of course, this increment is caused by the clipping technique.

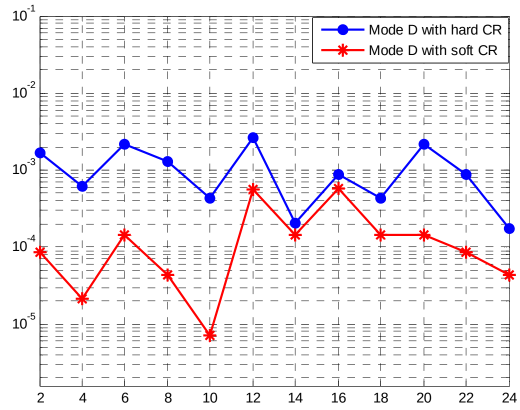

Fig.9. SER performance of Mode D with hard and soft CR

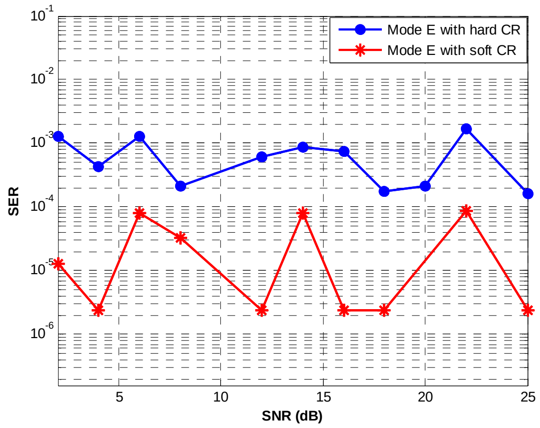

Fig.10. SER performance of Mode E with hard and soft CR

Figure 10 shows the SER performance of the tested mode E, it is easy to note the advantage of this mode over the mode D; this is because of don not using 128QAM to map the data in mode E. Also the performance of SER in mode D with soft CR is better than the performance of SER with hard CR. It is totally kept under the target SER value which is 10^{-4}. Despite this mode using clipping technique soft CR, but it shows its ability to offer SER performance same as the performance of the conventional IEEE802.11g-OFDM as shown in figure11.

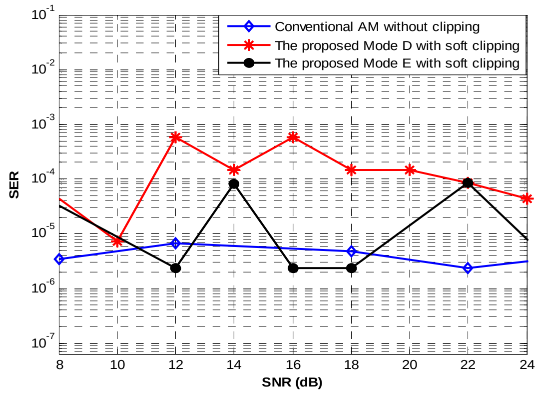

Fig.11. SER performance of the conventional IEEE802.11g-OFDM and the tested Modes D&E with soft CR

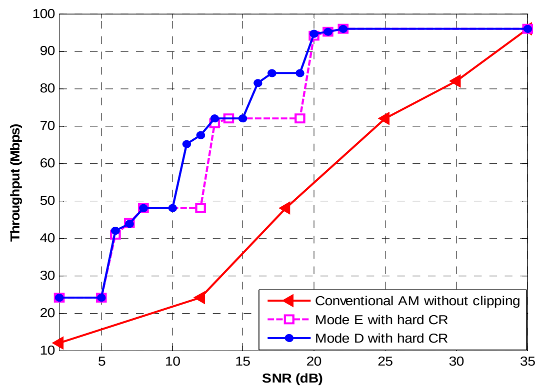

Fig.12. Throughput of the conventional IEEE802.11g-OFDM-AM and the two tested modes E, and D with hard CR

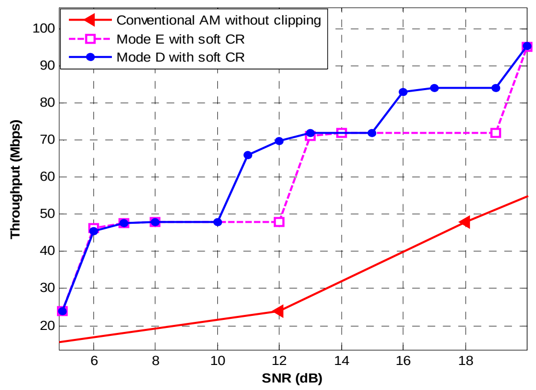

Fig.13. Throughput of the conventional IEEE802.11g- OFDM-AM and the two tested modes E, and D with soft CR

Despite the tested modes D and E in model (2) were applying the clipping technique with hard and soft CR, but they offer a good enhancement in the data rate over all SNR values as shown in Figures 12 and 13. The best enhancement in the throughput was achieved in the tested mode D with soft CR. Table XI and XII proves the drawn results in figures 12 and 13.

TABLE XI
COMPARISON BETWEEN THE REQUIRED TRANSMISSION TIME OF THE CONVENTIONAL OFDM AND THE PROPOSED MODE D AT DIFFERENT SNR VALUES

Data size	Transmission time when using:			SNR value (dB)
	Mode D (soft CR) (sec)	Mode D (hard CR) (sec)	Conventional OFDM (sec)	
1Gbps	41.67	41.67	83.33	2-5
	21.93	23.81	83.33	6
	21.04	22.89	83.33	7
	20.83	20.83	41.67	8-10
	15.15	15.38	41.67	11
	14.37	14.83	41.67	12
	13.89	13.89	20.83	13-15
	12.06	12.27	20.83	16
	11.91	11.91	13.89	17-19
	10.48	10.58	11.91	20
	10.44	10.51	11.91	21
	10.42	10.42	10.42	>22

TABLE XII
COMPARISON BETWEEN THE REQUIRED TRANSMISSION TIME OF THE NORMAL OFDM AND THE PROPOSED MODE E AT DIFFERENT SNR VALUES

Data size	Transmission time when using:			SNR value (dB)
	Mode D (soft CR) (sec)	Mode D (hard CR) (sec)	normal (sec)	
1Gbps	41.67	41.67	83.33	2-5
	21.59	24.37	41.67	6
	21.04	22.64	41.67	7
	20.83	20.83	41.67	8-12
	14.08	14.17	20.83	13
	13.89	13.89	20.83	14-19
	10.52	10.63	13.89	20
	10.44	10.52	13.89	21
	10.42	10.42	10.42	>22

It is clear to note from table XI and XII that the time required to send 1 Gbps using the proposed modes D and E with hard and soft CR is less than the time required to send the same data using the conventional WLAN-IEEE802.11g-OFDM with the conventional AM. The best saving in the transfer time was also achieved in the tested mode D with soft CR.

Clipping is a nonlinear process and may cause significant in-band distortion, which degrades the SER performance, and out-of-band noise, which reduces the spectral efficiency.

Filtering after clipping can reduce the spectral splatter but may also cause some peak regrowth.

Figure 14 and 15 show the effects of clipping and filtering on the performance of a conventional IEEE802.11g-OFDM-256QAM system.

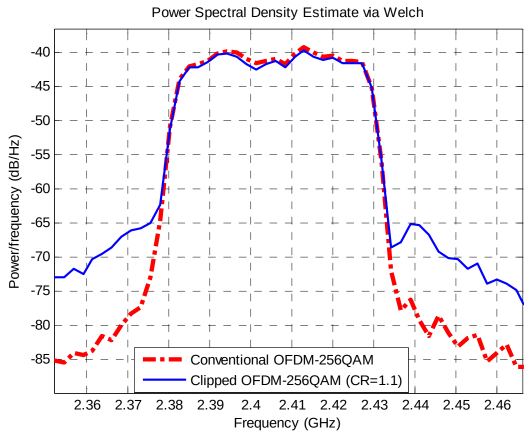

Fig.14. The power spectral density of the conventional IEEE802.11g-OFDM and clipped IEEE802.11g-OFDM signal with 256-QAM

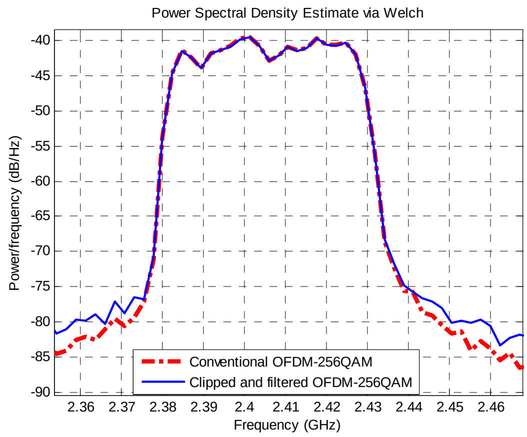

Fig.15. The power spectral density of the conventional IEEE802.11g-OFDM and clipped-filtered IEEE802.11g-OFDM signal with 256-QAM

In the conventional IEEE802.11g-OFDM-256QAM system the out-of-band noise emission power is only 10 dB lower than the signal power. But With hard clipping ratio CR= 1.1 and after applying the filtering, it is easy to note that the spectral sidelobes after filtering are now at least 4 dB lower than the signal mainlobe.

4. Conclusion

Two models of IEEE802.11g-OFDM were proposed in this paper. Theses models offer new decision policy in AM which is based on the SER in model (1) and based on SER and SNR in model (2). But in both models the CR was used as the controller of the percentage of using the modulation schemes at different SNR values. This new policy has the ability to give the priority to the high order modulation schemes to map the data onto the carriers, but without degrade the SER performance. The three tested modes in model (1) show their ability to improve the SER performance of IEEE802.11g-OFDM compare to the SER performance of the high order schemes such as 64, 128, and 256QAM. The tested modes in model (2) also offer a good SER performance compare to the conventional AM. Both models can provide a good reduction in the PAPR, but the modes which using soft CR show their ability to enhance the data rate at all SNR values. The analysis and numerical results show that the proposed models can provide improved performance in SER, reduce PAPR, and enhance the throughput of IEEE802.11g-OFDM system.

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