QCIF IMAGES PERFORMANCE ANALYSIS OVER ADAPTATIVE MODEM

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***Abstract*—**This article proposes, modulation study with multi-levels QoS analysis, which can be used to perform physical layer functions for new generation systems. The 3G wireless systems, the wireless LANs, and the wireless MAN have included different modulation schemes as a means to provide a higher data rate. Based on the perceived Signal-to-Noise Ratio (SNR) of the immediately previous frame in the frame exchange process, provisioning of service delivery are dynamically varied by selecting links that can use higher bandwidth modulation schemes. In this paper, we considered different images classes and different modems schemes to provide a study of the physical-layer link speed effect on high-layer network performance based on different QoS parameters that depend in class and type of multimedia traffic. In our work, we have considered basics modulation techniques used in mobile and wireless systems. Based on this analysis an adaptive modulation scheme for SDR is proposed to pick the constellation size that offers the best reconstructed image quality for each average SNR. Simulation results of image transmissions confirm the effectiveness of our proposed adaptive modulation scheme.

***Keywords*—** modulation, QoS, QCIF image, transmission, AWGN, performance, SNR

I. INTRODUCTION

In telecommunications, quality of service is considered as a fundamental reference for all network planification phases. The principle qualities of service aspects are the following [1][2]:

Transmission quality[3], which concern transmitted information fidelity. Information emitted from the sender over telecommunication systems must arrive to the receiver without errors, alteration and loss. The quality global criterion depends on the service types such as legibility in telephone communications[4], fidelity and purity in musical transmission, quality and conformity in images transmission and rate and errors probability in data transmission. In technical level, particular criterions must be principally considered such as the total attenuation of the liaison, propagation time, bandwidth, the comportment with distortions, perturbations influences with noise and diaphony [5][6].

Commutation quality that concerns the communications routing among the network. The principle commutation quality criterions are the networks congestion probability, the information's loss probability and the connections establishment average time [7].

Fiability is an important aspect of quality of service. It specifies the system aptitude to satisfy functionalities exigencies during specified time. Fiability is specified and ee evaluated with the following criterions, which are faults tolerance, system reparability, faults detections, localization and isolation [8][9].

The software defined radio (SDR) is a technology, which facilitates implementation of some functional modules in a radio system such as modulation, demodulation, signal generation, and coding and link-layer protocols in software. SDR helps in building reconfigurable software radio systems where parameters dynamic selection for each of the above-mentioned functional modules is possible. An ideal use for this flexible architecture is in the area of wireless networks, where a node may adapt to its environment and user objectives. Instead of dedicated hardware designed to carry out a rigid set of objectives, software implementations of hardware devices are entirely flexible regarding their functionality. Used in a packet-switched wireless network, software radio systems can perform multimode modulation and demodulation offering greater control over spectrum usage and minimizing the need for dedicated hardware. At the physical level, flexible transceiver architectures enables greater maximization of channel capacity.

For example, SDR can be used to download coefficients for a filter block or equation of a generation polynomial for a coding block or modulation induce. Since those coefficients determine the performance, a desired system can be obtained at run time by downloading the external parameters using the air interface.

Automatic selection of the correct modulation scheme is a major advantage in a wireless network. As the channel capacity varies, switching between modulation schemes enables the baud rate to be increased or decreased in order to maximize the channel capacity usage and reduce the bit error rate.

In this paper we evaluate image transmission quality and compare the performances of linear modulation schemes, i.e., Quadrature Amplitude Modulation and Phase Shift Keying of the order of 4, 8, 16, 32 and 64. Based on this performances analysis an adaptive modulation scheme for SDR can be suggested.

This paper is structured in five sections. The first section is the introduction, which describes the principle aspects of quality of service and SDR concept. Section 2 shows the analytical and simulation results of images transmission over

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the AWGN channels. Section 3 illustrates quality analysis of specific modem for wireless network. Section 4 illustrates the modulations schemes effects on the images transmissions quality. Finally the conclusions of this paper are given in section 5.

II. Quality analysis of images transmission over AWGN channel

A. *Characteristics of AWGN channels*

The channel of binary input and additive white gaussien noise (AWGN) which is illustrated in fig.1, it's a reference model in the channel coding and modulation techniques study [10][11]. It is used in order to modelise transmission real channels in direct visibility.

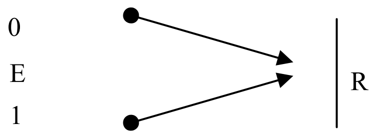


Fig.1: AWGN channel

The input of gauss channel is modelised by discrete aleatory variable, the continuous aleatory variable R, which is represented by (1), modeling its output:

$$R=E+B \quad (1)$$

Where B is an uncertain gaussienne variable with a null average and a variance σ^2 that represents the noise power. The successive realizations b of the aleatory variable B are non-correlated, the B probability density is given by (2) [9]:

$$P_B(b)=\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(b)^2}{2\sigma^2}} \quad (2)$$

The noise corresponds to the undesirable signals captured by the receiver. Those signals disrupt the good useful signal reception. We can reduce the transmission noise effects, for example by using a detection element that takes a decision on the samples received in the channel output. Then, the AWGN channel turns into BSC (Binary Symmetrical channel) channel, which is illustrated by fig. 2.

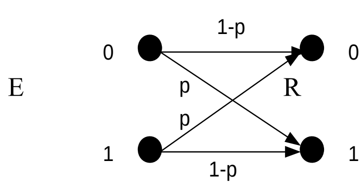


Fig.2: BSC channel

The symmetrical Binary channel use alphabets of binary input and output. This channel is characterized by its error probability p, that is the same when the symbol emitted is 0 or 1 gave out, so the channel doesn't make the difference between a bit equals to '1' or equal to '0' for this reason the channel is characterized as symmetrical. It is stationary, and the successive symbols are affected with mutually independent errors [17]. We have used this channel shown in fig.3 to analyze image transmission quality.

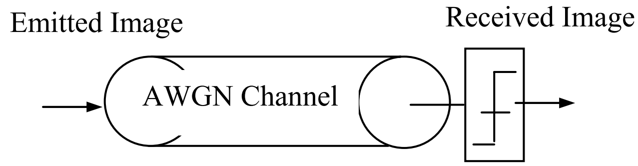


Fig.3: Transmission scheme over AWGN channel

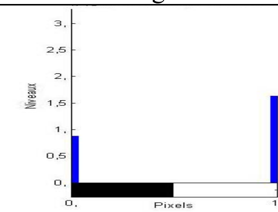
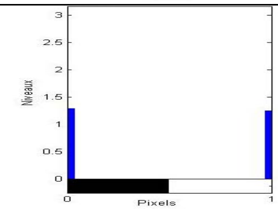
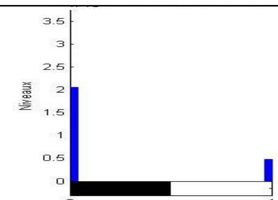
When the noise level is low, the decision element eliminates its effect in the output. However, when the noise level is high, the signal is drowned in this noise and it is not possible to avoid the transmission errors [12][13].

A signal transmitted on a mobile radio channel is scattered, reflected and refracted by objects in the radio environment [14].

B. Image transmission over AWGN channel

From several images, we have chosen LENA, FORMAN and NEWS images. LENA image presents a balanced histogram between black and white pixels, FORMAN image is clearer than LENA image and the NEWS image is darker than LENA image. Table I illustrates these QCIF binary images and their histograms.

TABLE I
LENA, FORMAN AND NEWS IMAGES HISTOGRAMS

	QCIF Image	Histogram
Forman		
Lena		
News		

The QCIF images transmission simulations results through the AWGN channel which are illustrated by fig.4 (a, b and c), show that although the histograms of the LENA, FORMAN and NEWS image (binary, gray level and color) are different, their transmission scheme behavior are similar, their bit errors number are similar, the erroneous pixels number and the PSNR are invariable from image to another image. When we change the image type (binary, gray, color), the bit error number and the erroneous pixels for image color are more important then those for gray image and binary image. This difference leads to the image size.

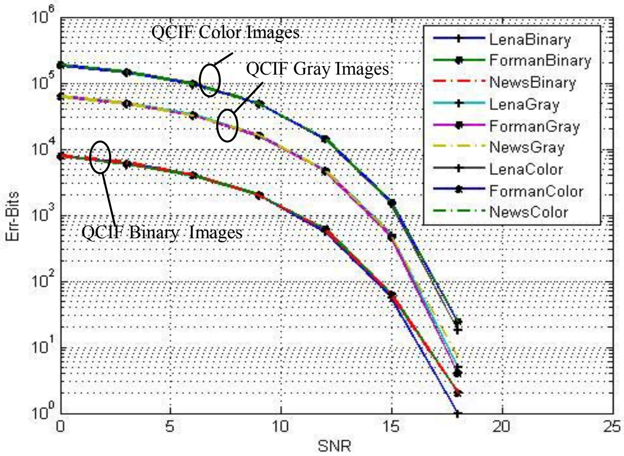


Fig. 4.a Bits errors of different QCIF Images

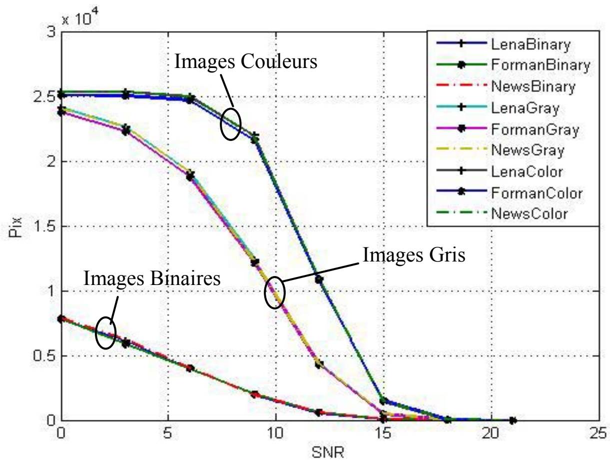


Fig. 4.b Pixels errors of different QCIF Images

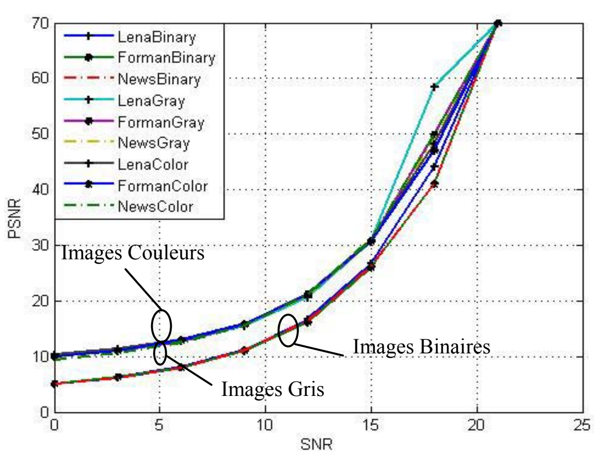


Fig.4.c PSNR of different QCIF Images

III. Quality analysis of specific modem for wireless network

A wide variety of modulation techniques are used in wireless networking. The selection of the best digital modulation technique for a specific application is driven by a number of criteria, the most important being [15] :

- Spectral efficiency : achieving the desired data rate within the available spectral bandwidth.
- Bit error rate (BER) performance: achieving the required error rate given the specific factors causing performance degradation in the particular application (interference, multipath fading, etc.).
- Power efficiency: particularly important in mobile applications where battery life is an important user acceptance factor.
- Modulation schemes with higher spectral efficiency require higher signal strength for error-free detection.
- Implementation complexity: which translates directly into the cost of hardware to apply a particular technique. Some aspects of modulation complexity can be implemented in software, which has less impact on end-user costs.

In table II we have regrouped the most modulation techniques used in new generation of wireless networks.

TABLE II
MODULATIONS APPLICATIONS DOMAINES

Modulation	Systems
MSK, GMSK	GSM
BPSK	GPS, spatial telemetry, cable modems
QPSK DQPSK	UMTS, Satellite, CDMA, NADC, TETRA, PHS, PDC, LMDS, DVB-S, cable modems, TFTS
QPSK	CDMA, satellite, DECT, paging, RAM mobile data, AMPS, CT2, ERMES, public safety
8PSK	EGPRS, Satellite, telemetry
16 QAM	Hyper frequency digital link, modems, DVB-C, DVB-T
32 QAM	DVB-T
64 QAM	DVB-C, modems, wireless networks
256 QAM	Modems, DVB-C, Numeric Video

Standards such as HSDPA, WiFi and WiMax operate using a large number of modulations and coding modes [10]. Each mode offers a BER versus Signal to Noise Ratio (SNR) performance.

Simulations are used to derive Bit Error Rate values for a range of modulation efficiency. Simulations used in this section were developed using the Matlab Communications Toolbox. The communications library form this software package was adapted to create a number of different modulation schemes that were investigated.

The BER performance in AWGN environment of modulations schemes of principle mobiles networks standards are simulated and the results are shown in fig.5. GSM use the MSK modulation, EGPRS use the PSK-8 modulation and UMTS use the QPSK modulation. For a BER equal to 10-4, UMTS modem can give 6dB as gain than the EGPRS modem and 9dB as gain than the GSM modem.

The BER performance of wireless network modulation schemes are compared and the simulation results are illustrated in fig.6. WiFi operates with different modem schemes such as BPSK, QPSK, QAM16 and QAM 64. For a BER equal to 10-4, QPSK modulation can give 8,5 db as gain than QAM16 and QAM64.

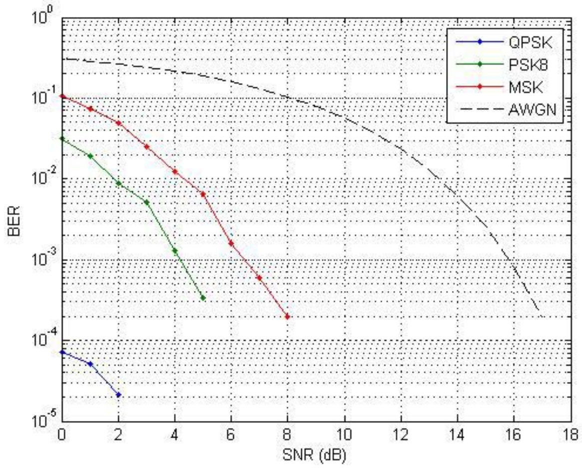


Fig.5 : BER performance of GSM, EGPRS and UMTS modems

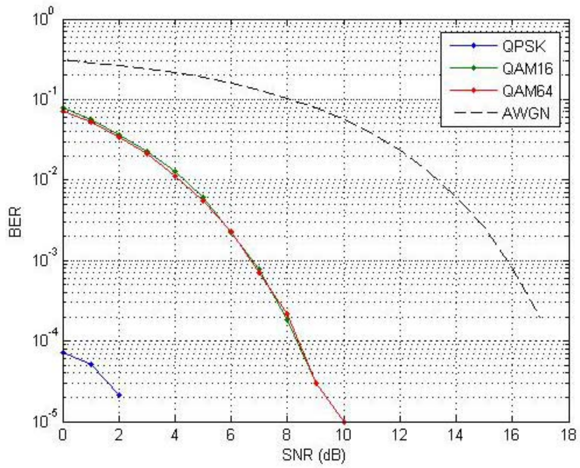


Fig.6 : BER performance of WiFi modems

The BER performance of DVB-C and DVB-S modems schemes are simulated and results are given in fig.7. The DVB-C uses QAM16, QAM32, QAM64, QAM128 et QAM256 modems. Based on simulation results, it is observed that for SNR<8db the BER of different modems are quite similar. The DVB-S uses QPSK, PSK8, QAM16, APSK16 and APSK 32.

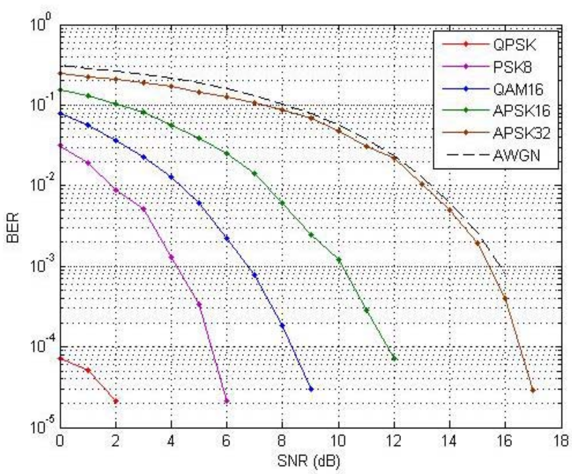


Fig.7.a : BER performance of DVB-S.

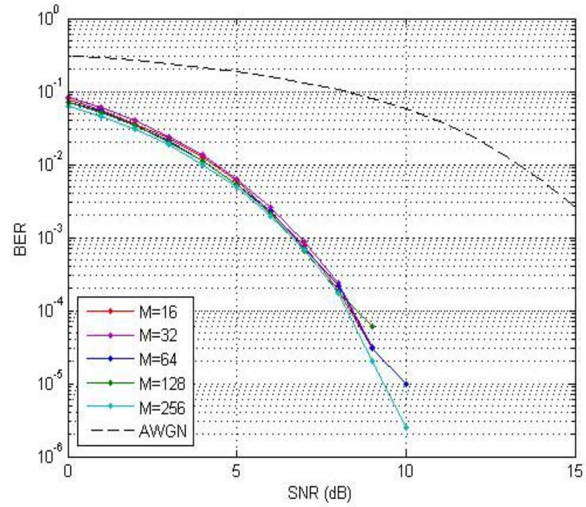


Fig.7.b : BER performance of DVB-C.

To put in evidence the performances of the modems used in the studied systems, we characterized the transmission quality of the binary QCIF image received by these modems by the measure of the BER and the PSNR in worst case (SNR=0 db). The simulation results are illustrated in tables 3 and 4.

In table III, we observes that the qualities of the images gotten by the QAM-16 and QAM-64 modems are quite similar. The quality is improved with the QPSK modem, whereas the image received by the BPSK modem is without errors.

In table IV, we observes the quality of the image gotten by the UMTS modem that is better than the one gotten by the EGPRS modem that is even better that the one gotten by the GSM modem .

The value of PSNR is a number that reflects the quality of the transmitted image or video sequence with respect to the original sequence. High PSNR values indicate a strong correlation with the original sequence and hence the transmitted image is deemed to be of good quality.

The formulas used to calculate PSNR for binary or gray image are shown below in (3) and (4) [16].

$$MSE=\frac{\sum_{x=0,y=0}^{W,H}\left[O(x,y)-R(x,y)\right]^2}{W*H} \quad (3)$$

$$PSNR=20\log_{10}\left(\frac{\max(S(i))-\min(S(i))}{\sqrt{MSE}}\right) \quad (4)$$

In (3), O denotes the original image and R denotes the received. The images are W×H dimensional, and the MSE is calculated as the squared difference between all corresponding pixels, divided by the total number of pixels in the image. All the images used the experimental work of this paper are of QCIF dimensions, so W is 176 and H is 144. PSNR is derived by setting the MSE to the maximum value of pixel, which is equal to (max (S(i)). PSNR is a log based metric and it is measured in decibels (dB).

The formula used to calculate PSNR color image is shown below in (5)

$$PSNR = 20\log_{10}\left(\frac{\max(S(i)) - \min(S(i))}{\sqrt{MSE_{RGB}}}\right) \text{ and}$$

$$MSE_{RGB} = \frac{MSE_R + MSE_G + MSE_B}{3} \qquad (5)$$

TABLE III
IMAGE QUALITY PERFORMANCE OF THE WIFI MODEMS

	QCIF binary image	Errors Bits number	PSNR(db)
BPSK		0	∞
QPSK		2	41.0285
QAM 16		1140	13.4697
QAM 64		889	14.5497

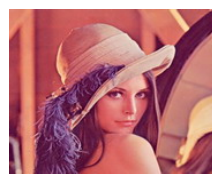
TABLE IV
IMAGE QUALITY PERFORMANCE OF THE GSM, EGPRS AND UMTS MODEMS

	QCIF binary image	Errors Bits number	PSNR(db)
MSK (GSM)		2816	9.5424
8PSK EGPRS)		935	14.3306
QPSK(UMTS)		2	41.0285

IV. IMAGES TRANSMISSION QUALITY ANALYSIS OVER DIFFERENT MODULATION SCHEMES

To evaluate the impact of the channel on the image quality and, we need to compare the received (possibly distorted) image with the actually emitted image. In table V we have evaluated LENA QCIF image transmission quality by illustrating emitted and received images. This analysis is done for three images types (binary, gray level and colored) with QAM-64 modulation used for worst case.

TABLE V
IMAGES TRANSMISSION QUALITY OVER QAM-64 MODEM WITH SNR=0 DB

	Emitted Image	Received Image
		
Gray		
Color		

In QAM-64 modulation, we have used symbol with six bits, so in table VI we have regrouped the number of errors bits, number of errors pixels and the quality of the received image (PSNR). In table VII we have illustrated the errors bits number per symbol. This number has a direct impact on the pixels in the images. The number of pixels errors has a direct impact on the quality of received image.

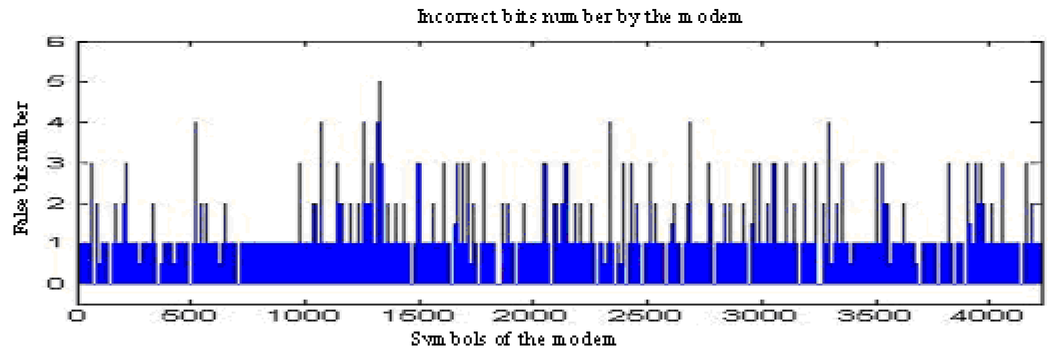
The most number of bits errors per symbol is equal to one for binary image, it's equal to three for grey level image and it's equal to four for colored image. So for the two last cases we need to add an interleaving module with coding block in transmission scheme.

TABLE VI
ERRORS NUMBERS (QUALITY)

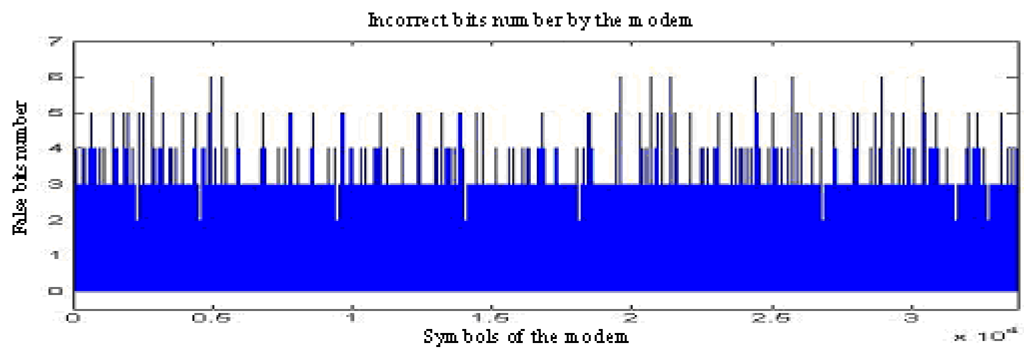
Image	Binary	Gray	Colored
Size (bits)	25344	202752	608256
Err_Bits	889	15283	44916
Err_Pixels	889	8903	18261
PSNR (db)	14.5497	17.2563	17.5978

TABLE VII
ERRORS BITS NUMBER PER SYMBOL

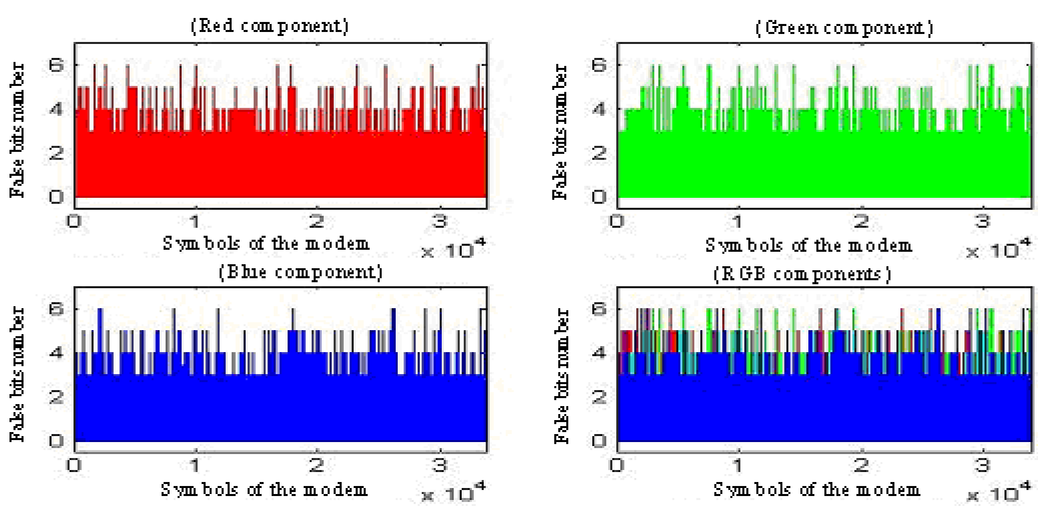
Binary Image



Gray level Image



Colored Image



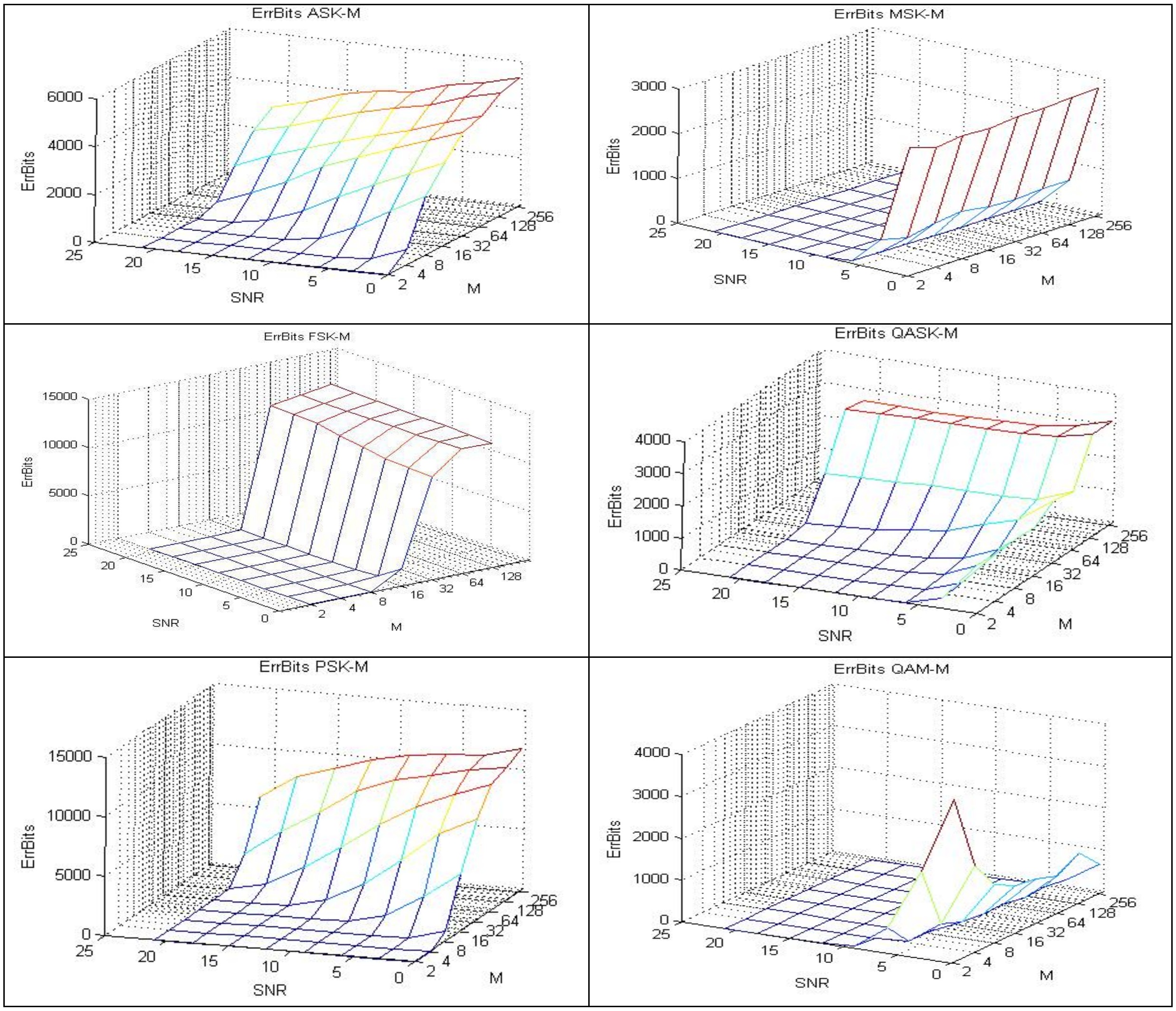
We have also studied, the behavior of different m-areas modems for binary LENA QCIF image transmission. We have calculated the number of errors bits generated by every modem according to channel quality deterioration and modulation induce.

In Table VIII we have evaluated the error bits number for LENA QCIF image transmission over different modulation schemes for different SNR.

The ASK modem presents a good immunity to the errors, a weak BER and a good image quality for M=2 whatever is SNR of the channel. This immunity is deteriorated when SNR value is low and when the modulation induce M is increased. This deterioration becomes important whatever is SNR of the channel when the modulation induce M is high.

The FSK modem is very robust to the errors, the BER is low and the image quality is good whatever is SNR of the channel especially for M=2, 4, 8 and 16. Beyond those values (M > 16), it presents considerable errors.

TABLE VIII
LENA IMAGE TRANSMISSION WITH DIFFERENT MODULATION SCHEMES



The PSK modem is very robust to the errors, the BER is low and the image quality is good whatever is SNR of the channel and when the modulation induce M is low, beyond, it presents considerable deteriorations.

The MSK modem is little sensitive to the variations of M, it is very robust to the errors, the BER is low and the image quality is good for the SNR channel > 5 db and whatever is the modulation induce M

The Modem QASK is very robust to the errors, the BER is low and the image quality is good for the SNR channel > 5 and M <16, beyond, it presents considerable deteriorations.

The QAM modem is little sensitive to the variations of M, he is very robust to the errors, the BER is low and the image quality is good for the SNR channel > 5 db and whatever is M. Beyond, it presents a number of errors lower to all others modulation techniques.

The QAM modulation is one of the most used modems in the telecommunication systems at high rate. We chose this modem to evaluate the gap on the number of errors transmission for different modulation induce (M) and different SNR. Knowing that the gap in errors is the maximum gap on the number of the erroneous bits generated by the transmission of images having different histograms. This gap informs us on the maximum of errors gotten on the modem output when we change the information type. In fig.8 we illustrate the error gap for different binary images transmission (in the same conditions).

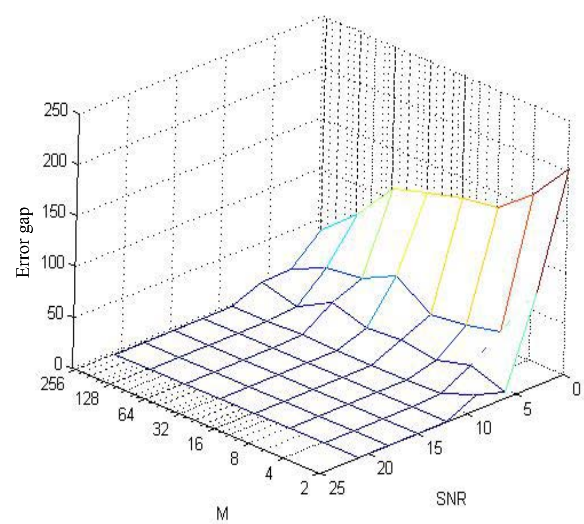
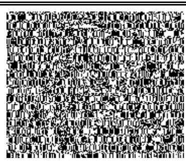
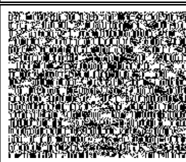
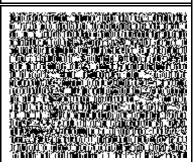
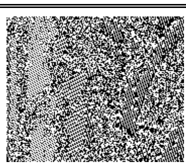
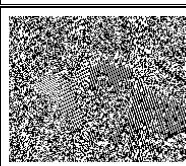
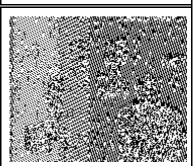
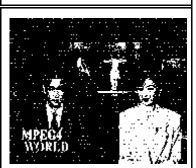


Fig.8: Error gap for different binary QCIF images transmission

In order to compare modems in worst case transmission (At high rate and low SNR channel), we have analyzed the transmission scheme quality over different modems with indice modulation equal to 256 and SNR channel equal to 0 dB. Results of different simulations are regrouped in table IX and fig.9.

In the worst-case, QAM modulation presents the better performance among all transmission schemes.

TABLE IX
QUALITY IN WORST-CASE TRANSMISSION

	Lena	Forman	News
Emitted			
ASK-256			
	PSNR = 6.6884	PSNR=6.4106	PSNR=7.0586
PSK-256			
	PSNR= 3.2593	PSNR= 3.4495	PSNR=3.2238
FSK-256			
	PSNR=2.9440	PSNR=3.1875	PSNR=2.8853
QAM-256			
	PSNR=15.5940	PSNR= 15.4400	PSNR= 16.017
MSK-256			
	PSNR = 9.5424	PSNR = 9.6211	PSNR=9.5363
QASK-256			
	PSNR = 8.9186	PSNR = 8.0563	PSNR=11.534

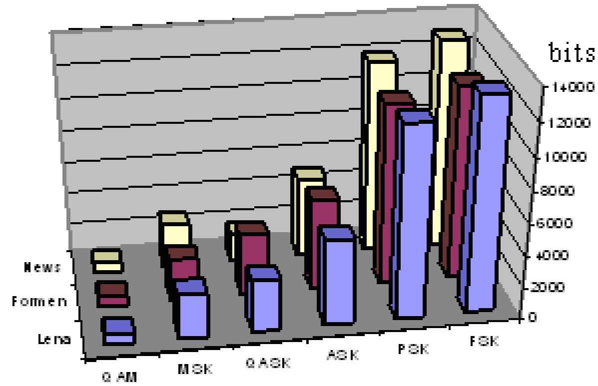


Fig.9: Errors numbers in worst-case transmission

V. CONCLUSIONS

In digital communication theory, the modulation scheme performance depends on the received signal-to-noise ratio. For a given SNR, simpler modulation schemes tend to have higher quality. That is, since simpler modulation schemes generally represent lower bit rates. At the same SNR, a frame transmitted with a higher bit rate it incur more errors than a frame transmitted with a lower bit rate

The modulation scheme performance can be measured by its robustness against path loss, interferences, and fading that cause variations in the received SNR. Such variations also cause variations in the quality, since the higher the SNR, the easier it is to demodulate and decode the received bits.

Compared to other modulations schemes, BPSK has the better quality for a given SNR. For this reason, it is used as the basic mode for each physical layer since it has the maximum coverage range among all transmission modes. At high rate we can only use QAM-M modulation schemes in order to obtain a good quality at a medium SNR channel.

we suggest the use of higher order modulation techniques in order to have a high data rate and we compensate for the degradation due to the effect of the channel with the help of filters.

Our work can be considered as a fertile field for conceiving selector mode for adaptive modulation with cross layer approaches. Furthermore it can exploited to develop a generic adaptive modulation for the SDR systems.

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