QCIF image transmission quality analysis over different modem schemes

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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.

Keywords: modulation, QoS, image QCIF, transmission, AWGN, performance, SNR

1 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, 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 sushi as legibility in telephone communications, 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 [3][4].
- 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 [5].
- 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 evaluated with the following criterions, which are faults tolerance, system reparability, faults detections, localization and isolation [6][7].

This paper is structured in four sections. The first section is the introduction, which describes the principle aspects of quality of service. Section 2 shows the analytical and simulation results of images transmission over the AWGN channels. Section 3 illustrates the modulations schemes effects on the images transmissions quality. Finally the conclusions of this paper are given in section 4.

2 Quality analysis of images transmission over AWGN channel

2.1 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 [8][14]. It is used in order to modelise transmission real channels in direct visibility.

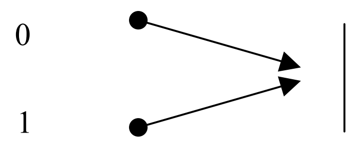


Fig.1: AWGN channel

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

$$R = E + B \quad \text{Eq 1}$$

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 equation 2[9]:

$$P_B(b) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(b)^2}{2\sigma^2}} \quad \text{Eq2}$$

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.

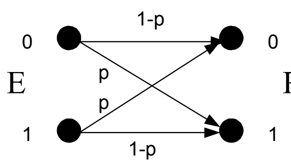


Fig.2: BSC channel

The symmetrical Binary channel use alphabets of binary input ant 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 [10]. We have used this channel (shown in fig.3) to analyze image transmission quality.

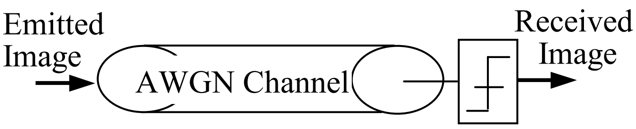


Fig.3: Transmission scheme over AWGN channel

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 [11][12].

A signal transmitted on a mobile radio channel is scattered, reflected and refracted by objects in the radio environment [13].

2.2 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. Table1 illustrate those QCIF binary images and their histograms.

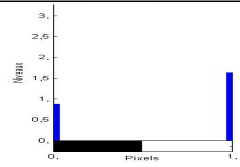
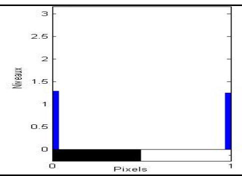
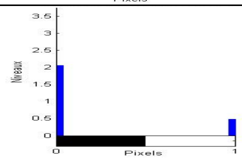
	QCIF Image	Histogram
Forman		
Lena		
News		

Table 1: LENA, FORMAN and NEWS images Histograms

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 proach, 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.

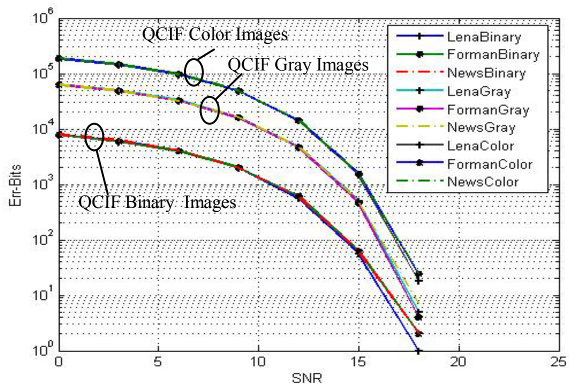


Fig. 4.a Bits errors of different QCIF Images

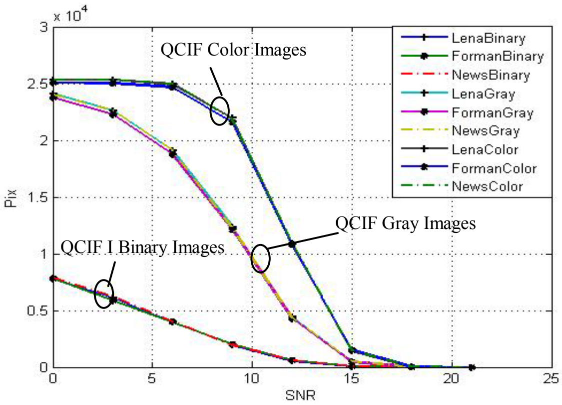


Fig. 4.b Pixels errors of different QCIF Images

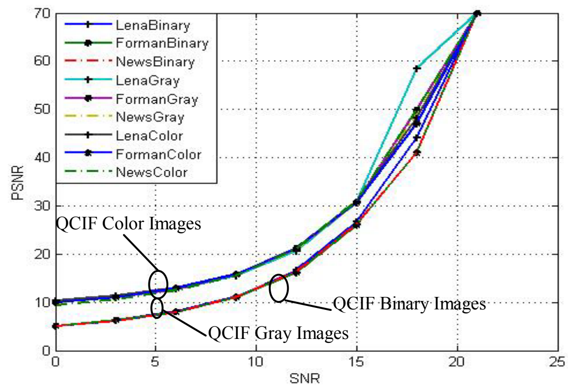


Fig.4.c PSNR of different QCIF Images

3 Images transmission quality analysis over different modulation schemes

Standards such as HSDPA, WiFi and WiMax operate using a large number of modulations and coding modes [8]. Each mode offers a Packet Error Rate (PER) versus Signal to Noise Ratio (SNR) performance.

In table 2 we have regrouped the most modulation techniques used in new generation networks.

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	GPRS, Satellite, avionic, 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

Table 2: Modulations applications domains

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.

To evaluate the impact of the channel on the image quality, we need to compare the received (possibly distorted) image with the actually emitted image. In table 3 we have evaluated LENA QCIF image transmission quality by illustrating emitted and received images.

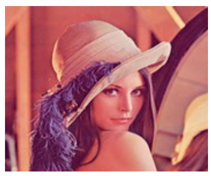
	Emitted Image	Received Image
Binary		
Gray		
Color		

Table 3: Images transmission quality over QAM-64 modem with SNR=0db

This analysis is done for three images types (binary, gray level and colored image) with QAM-64 modulation used for worst case (SNR channel = 0 dB.

In QAM-64 modulation, we have used symbol with six bits, so in table 4 we have illustrated the errors bits number per symbol. This number has a direct impact on the pixels in the images.

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.

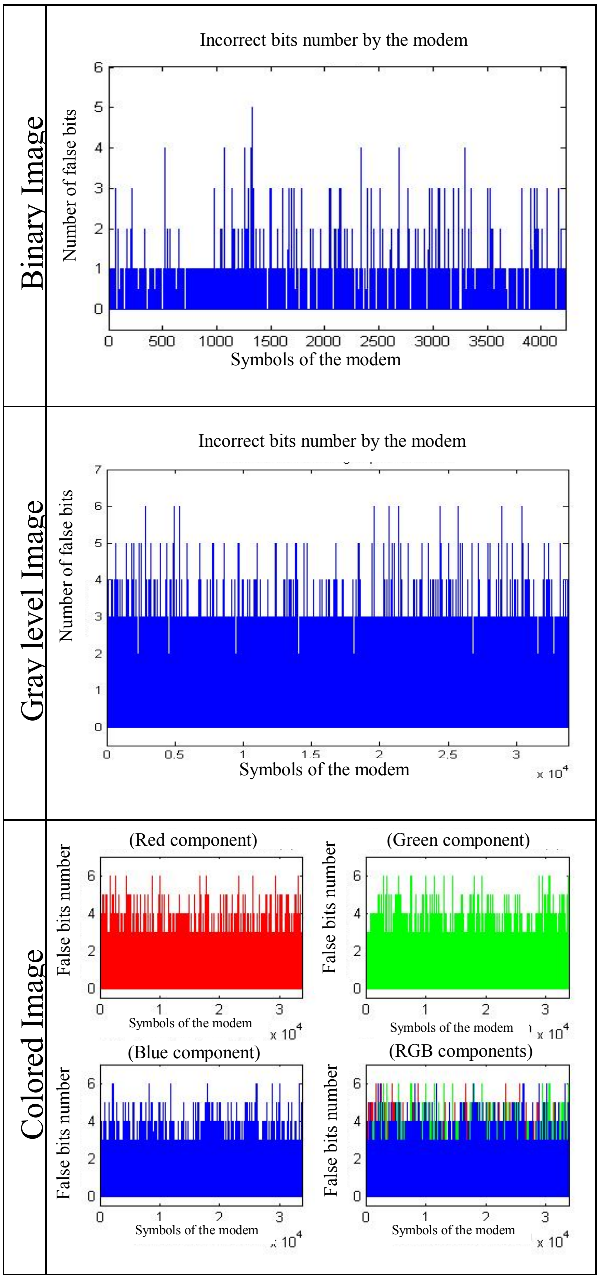


Table 4: the errors bits number per symbol

The number of pixels errors has a direct impact on the quality of received image. In table 5 we have regrouped the number of errors bits, number of errors pixels and the quality of the received image (PSNR).

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

Table 5: Errors numbers

The pixels errors values are represented in table 6.

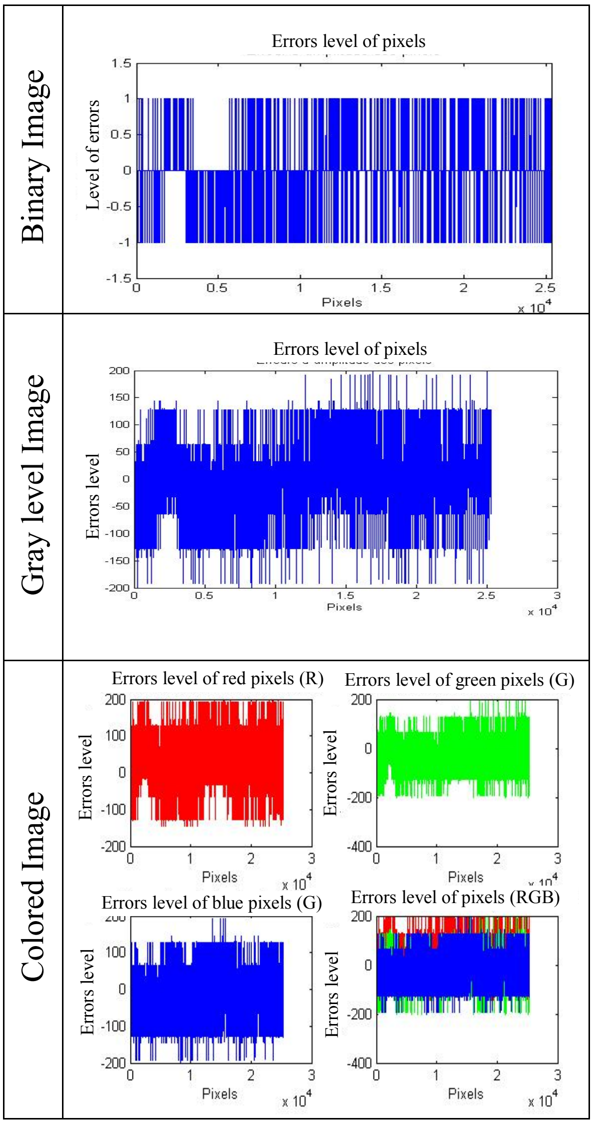


Table 6: Pixels errors values

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 7 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 TEB 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 TEB 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.

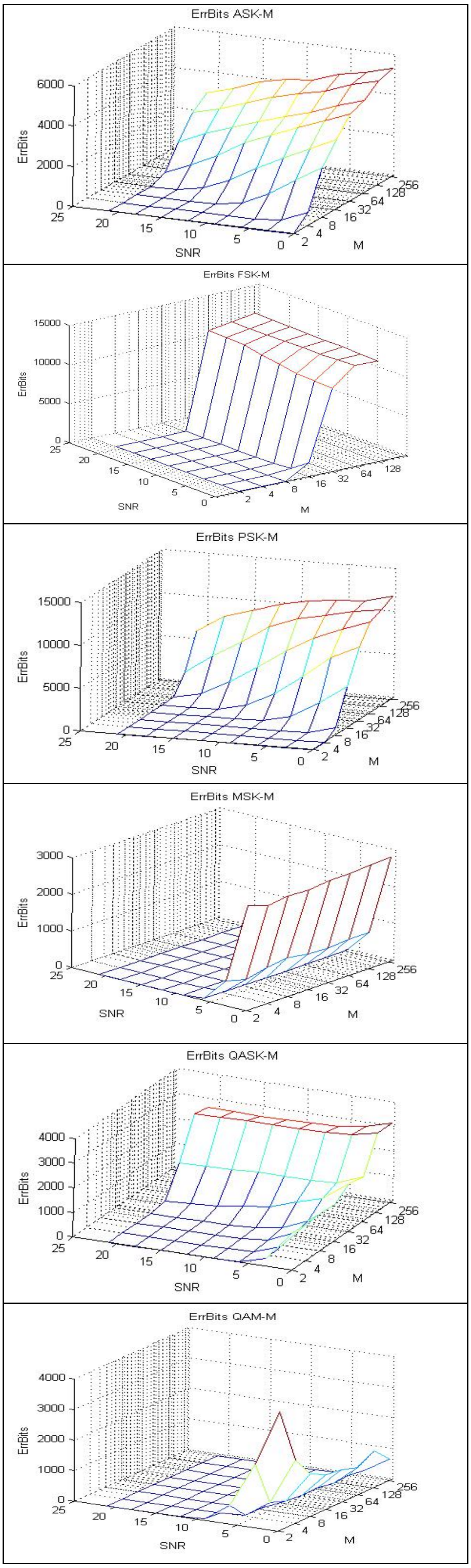


Table 7: Errors numbers of LENA QCIF image transmission with different modulation schemes.

The PSK modem is very robust to the errors, the TEB 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 TEB 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 TEB 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 TEB 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.5 we illustrate the error gap for different binary images transmission (in the same conditions).

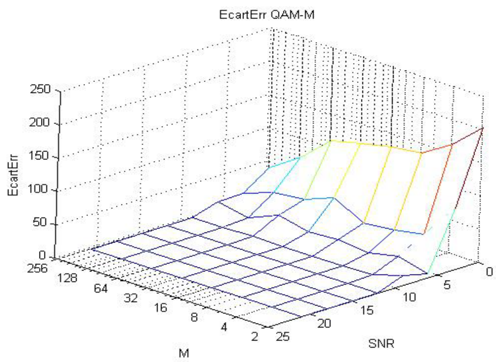


Fig.5: Error gap for different binary QCIF images transmission

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 8 and figure 6.

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

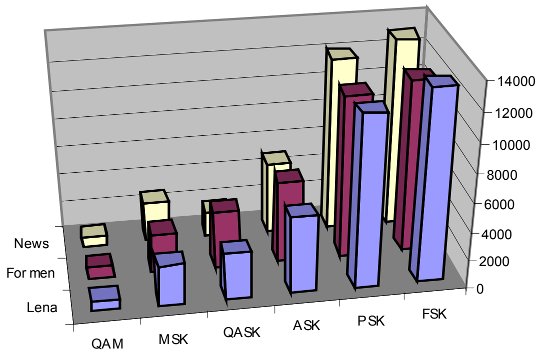


Fig.6: Errors numbers in worst-case transmission

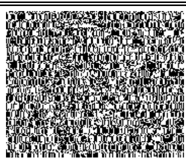
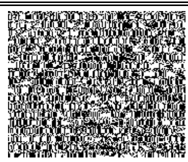
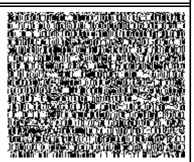
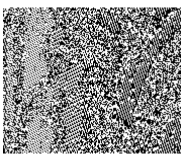
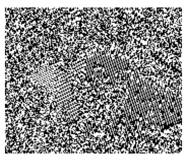
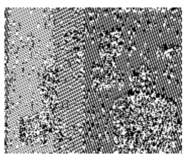
	Lena	Forman	News
Emitted			
ASK-256			
	PSNR = 6.6884	PSNR=6.4106	PSNR=7.0586
PSK-256			
	PSNR= 3.2593	PSNR= 3.4495	PSNR=3.2238
FSK-256			
	PSNR=2.9440	PSNR=3.1875	PSNR=2.8853
QAM-256			
	PSNR=15.5940	PSNR= 15.4400	PSNR= 16.017
MSK-256			
	PSNR = 9.5424	PSNR = 9.6211	PSNR=9.5363
QASK-256			
	PSNR = 8.9186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

Table 8: Quality in worst-case transmission

4 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.As an open issue, we can take in consideration the SDR and cross layer approaches in order to develop a generic adaptive coding modulation system.

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