Image transmission quality analysis over adaptive BCH coding

LAMIA CHAARI, MOHAMED FOURATI, NOURI MASMOUDI, LOTFI KAMOUN
Laboratoire d'Electronique et des Technologies de L'Information (L.E.T.I)
Ecole National d'Ingénieur de Sfax, 3038 SFAX TUNISIE
Lamia.chaari@tunet.tn
Mohamed.Fourati@isecs.rnu.tn

Abstract . Image communication over telephone wireline and wireless networks is becoming a standard way of communication due to very efficient compression algorithms for reducing the required channel capacity. However, all standard compression techniques are strongly sensitive to channel noise. For noisy channels it is necessary to investigate in order to select the appropriate channel coding method as a tradeoff between the image quality and the ability to control errors caused by noise. BCH (Bose, Chaudhuri, Hocquenghem) codes are becoming more frequently used due to the availability of VLSI components. BCH codes have a powerful random and burst correcting ability. BCH codes also leave the data in its original form which allows image and video decoders to be specified with "optional" error correction. In order to overcome the outlined drawbacks of fixed channel protection, *Adaptive Protection* is needed. AP adds redundancy as a function of the current channel characteristics. The BCH code can be adapted towards the burst error correcting capabilities and this will be shown in the contribution. This paper investigates the effects of noise-induced transmission errors on the performance of BCH coding methods for different errors correction capability. First, the relations among the bit error rate, signal-to-noise ratio (SNR), and code lengths are analyzed. Further, the transmission performance of BCH codes association with different modem schemes are analyzed. QCIF image transmission quality over BCH codes for different errors capability are simulated, discussed and compared. The results listed in this article denote the effects of the using BCH codes in a selected method. Based on this analysis an adaptive BCH scheme is proposed to pick the correcting capabilities that offers the best reconstructed image quality for each average SNR.

Keywords: BCH , QCIF image, transmission, AWGN, PSNR performance, adaptive.

1. Introduction

Videoconferencing has been conjured to be a key mode of communication between people in the future. Multimedia allows people to share media rich information in a format that is comprised of text, audio, images, and video. The advances in low bit-rate for images and video coding technologies have led to the possibility of delivering services to users through band-limited wireless networks but transmission quality guarantee is still one of the major challenges that need solution to overcome signal interference, route disruption, congestion and fluctuations which cause several consecutive bits arriving at the receiver in error. Error control such as FEC and retransmission protocols are the primary tools for providing QoS. Among the techniques to limit the effect of error propagation in low bit rate image and video coding, the use of forward error correction (FEC) [1] and automatic repeat request strategies each has its own benefits with regard to error robustness and network trafic load. The error handling method in tradition communication protocols (HDLC, ISO/OSI-TP4, TCP/IP) is error detection and retransmission which is very used because of the following reasons:

- Error detecting codes require less redundancy than error correcting codes thus save bandwidth.
- Error detecting codes require less computational effort.
- Retransmission is implemented in order to recover from loss of complete packets.

However this method is inappropriate for distributed multimedia systems for two reasons: It introduces variable delay unacceptable for isochronous streams, and it is very inefficient and difficult to use in the multicast environment typical for many multimedia applications.

Retransmission of corrupted data introduces additional delay which may be critical in some practical applications. In such cases, only a FEC strategy is feasible at the expense of a significant increase of the overall transmission bit rate. Also, ARQ may not be appropriate for multicast scenarios due to their inherent scalability problems. This is because retransmission typically benefits only a small portion of receivers while all others waiting unproductively, resulting in poor throughput. For these reasons, FEC-based techniques are currently under consideration by the Internet Engineering Task Force (IETF) as a proposed standard in supporting error resilience.

Other advantage of FEC techniques is that they do not require a feedback channel. In addition, these techniques improve system performance at significantly lower cost than other techniques aiming to improve channel SNR, such as increased transmitter power or antenna gain.

Forward error correction [2], which is regarded as the proactive mode of error control, is a popular strategy adopted in most system attributing to its low recovery time and latency. In FEC, irrespective of whether the channel has error at that particular instant, error protection is provided. Powerful Forward Error Correction (FEC) codes are therefore necessary to protect the data so that it can be successfully transmitted at acceptable signal power levels.

The choice of the FEC method depends on the requirements of the system and the nature of the channel Different criteria's must be taken into account when selecting a FEC scheme for any given application[3].

1. Probability of uncorrected errors: Since it is impossible for any coding scheme to detect all errors and correct them, it is important to choose coding schemes for which the probability of both undetectable and uncorrectable (but detectable) errors is minimized (or satisfies the application under consideration).
2. Overhead: The FEC codes should add as little as possible overhead and maximize the code rate. However, increased code capability generally leads to lower code rate.
3. Complexity: The implementation complexity of the coding/decoding scheme which typically increases with increase in code length and its capability to detect and correct errors.

For Internet applications, which can usually be modeled as a packet erasure channel, many researchers have considered using erasure codes to recover packet losses [5]. In [18] a comprehensive study of transmission techniques for reducing packet loss and delay in multimedia over IP was elaborated. The most commonly studied erasure codes are BCH[4] and Reed-Solomon (RS) codes. They have good erasure correcting properties [6].

For wireless network, adaptation [7] is a key issue to get best performance for data communications in wireless channels, with dynamic channel fluctuations which often cause high frame-error rates. For a system in order to make parameter changes it must be able to make simple measurements in the system. For example, if rate adaptation is to be employed, the receiver cannot easily determine its distance from the transmitter, but it can easily measure the ratio of the received signal power to the noise power spectral density. As distance increases, this ratio decreases. When its value reaches a certain point, the receiver can tell the transmitter (on a control channel perhaps) to lower the transmission rate. In another example, consider a system that uses adaptive FEC coding. The receiver could use the packet success rate as a factor for determining how much FEC coding should be used. The receiver can easily calculate the packet success rate simply by finding the ratio of the number of packets received without error to the total number of packets considered when the sample space is large. At close distances, the signal arrives strong and few errors are made resulting in a high packet success rate. As the transmission distance increases, the packet success rate will decrease. Once it has reached a certain value the receiver can tell the transmitter to increase the FEC coding (i.e. increase the number of correctable errors, t).

For DVB_S2, the reason for the BCH code use is to avoid error floors at low bit error rates. The use of this particular FEC scheme is what ensures error protection close to the Shannon limit [8].

In [9] an enhanced MAC node cooperation with two-stage forward error correction scheme to be used on WLANs was proposed. In the FEC sub_stage an adptive BCH codec is used.

In [10] a new method for digital image watermarking with BCH codes has been proposed. The encoded watermark with adaptive BCH codes is more robust against JPEG compression. In [19] novel speech watermarking algorithm using wavelet transform and BCH coding has been proposed

Adaptive BCH code is selected by research committee in many other systems and applications such as the following:

- Wireless ATM networks (WATM)[11] : A BCH error recovery scheme for adaptive error control in wireless networks that attempts to minimize the system throughput in order to satisfy the user defined quality of service (QoS) constraints for this an intelligent-agent architecture uses an adaptive BCH FEC (A-BCH-FEC) scheme for a Rayleigh fading environment is implemented;
- Biometrics authentication: In [12] a method, based on adaptive BCH error correction codes and distributed cryptography, to secure biometric authentication system architecture. The proposed architecture is applied either to signature and iris recognition;
- Wireless sensor networks [13],
- Digital Terrestrial TV Broadcasting[14].

In order to provide an adaptive schemes based on BCH error corrections codes we have analyzed BCH codes performances for different errors correction capability. In this paper after a brief description of the BCH code and its burst capabilities discussion, first we analyze bit error rate which is defined as the ratio of erroneous transmitted information bits to overall bits transmitted and can be used for evaluating the transmission performance function for BCH codes, then based on that we propose an adaptive coding scheme that maximizes the transmission efficiency according to channel conditions (received SNR). Simulation results show that with the proposed adaptive coding, transmission efficiency can be significantly enhanced. Second we simulate and discuss image transmission quality and compare the performances of BCH code for different errors capability. Third we evaluate the BCH codes performance cascaded with different modems schemes. Finally the scopes and conclusions of this paper are given.

2. Bose – Chaudhuri – Hocquenghem (BCH) codes

2.1 Description

BCH (Bose, Chaudhuri [1], Hocquenghem [2]) codes are a class of linear and cyclic block codes that can be considered as a generalization of the Hamming codes that permit the correction of more than one wrong bit in a block of code words. It is one of the most important coders belonging to the class of the cyclic linear block-codes. It is possible to make BCH coders with different configurations of parity bits and correction capabilities t, that is with different block sizes. These codes are defined in the binary field GF(2). For any positive integer m =3 and t <2 m-1 , there exists a binary BCH code C (n, k, t) with the following properties:

- Code length n =2 m-1
- Number of parity bits n-k =mt
- Minimum Hamming distance dmin =2t +1
- Error-correction capability t errors in a code vector.

These codes are able to correct any error pattern of size t or less, in a code vector of length n.

The generator polynomial of a BCH code is described in terms of its roots, taken from the Galois field GF(2m). If α is a primitive element in GF(2m), the generator polynomial g(X) of a BCH code for correcting t errors in a code vector of length n=2m-1 is the minimum-degree polynomial over GF(2) that has $\alpha,\alpha^2 ,\ldots, \alpha^{2t}$ as its roots: g(αi)=0, i =1, 2 ...,2t.

The encoding is simple due to its cyclic properties The decoding is carried out in four steps:

1. calculate syndromes s(j)=r(αj)(j =1,...,2t),
2. determine error location polynomial (Berlekamp-Massey or Euclides) [15,16],
3. determine the error locations polynomial (Chien search),
4. correct the received pattern by f(x)=r(x)-e(x).

2.2. BCH code rate analysis

Before proceeding further we present some numerical results and illustrate the performance of BCH codes. Let's first analyze the relationship between BCH code rate and errors correction capability. In this part we have classified BCH codes set (n < 255) according their code rate; The classification of BCH codes is presented in table 1.

Code specification	Code rate	Code specification	Code rate
0% < Code rate <25		50% < Code rate <75	
(7,1,3)	14%	(7,4,1)	57%
(15,1,7)	6%	(15,11,1)	73%
(31,6,7)	19%	(31,16,3)	51%
(31,1,15)	03%	(31,21,2)	67%
(63,10,13)	15%	(63,36,5)	57%
(63,7,15)	11%	(63,39,4)	61%
(63,1,31)	02%	(63,45,3)	71%
(127,1,63)	1%	(127,64,10)	51%
(127,8,31)	06%	(127,71,9)	55%
(127,15,27)	11%	(127,78,7)	61%
(127,22,23)	17%	(127,85,6)	66%
(127,29,21)	22%	(127,92,5)	72%
25% < Code rate		75% < Code rate	
(15,5,3)	33%	(31,26,1)	83%
(15,7,2)	46%	(63,51,2)	80%
(31,11,5)	35%	(63,57,1)	90%
(63,16,11)	25%	(127,106,3)	83%
(63,18,10)	28%	(127,113,2)	89%
(63,24,7)	38%	(127,120,1)	94%
(63,30,6)	47%		
(127,36,15)	28%		
(127,43,14)	34%		
(127,57,11)	45%		

Table1: BCH code rate evaluation

For any given code rate the error correction capability of a block coding scheme increases with increase in block size. Therefore, a larger block size enables one to utilize the channel more efficiently. Larger block codes also help mitigate the effect of burst errors, that often characterize wireless channels. However, the use of larger block sizes creates several problems [3]. First, the packetization delay increases with increase in block size, and this limits the maximum block size that can be used in various applications. Second, the implementation complexity of a coding system grows exponentially with increase in the block length for block codes, limiting code word lengths. Considerable effort has been directed towards implementing long, powerful codes with minimal complexity. Cascading of two or more codes was proposed as a means of constructing long codes which could be encoded and decoded in a simple manner.

3. BCH codes quality analysis over AWGN channels

In this section, we evaluate the impact of using binary BCH codes on a channel that is characterized by random errors. Simulations are used to derive Bit Error Rate values for a range of BCH codes with different error correction capability. Simulations used in this section were developed using the MATLAB Communications Toolbox. The communications library form this software package was adapted to define the BCH codes set.

The BER performance in AWGN environment of BCH set codes are simulated and the results are shown in table 2.

It is observed that, when FEC is optimized in conjunction to an optimization over coding rate, benefit is gained at higher SNRs. At lower levels of SNR, the cases are close, however there are gains, particularly for lighter codes.

When errors appear in bursts, it is clear that more redundant information is required to clean the link using FEC where FEC is used alone. This result comes about since the BER in a small localized part of the traffic stream can be very high so that significant redundancy is required to clean the link during an error burst.

For a fixed code length for example n=63, BCH(63,7,15), BCH(63,10,13), BCH(63,16,11) and BCH(63,18,10) codes, the associated overheads are 11%, 15%, 25%, and 28% respectively. As expected, increased code error correction capability reduces decoding error rate but requires more redundancy.

For a given bit error rate such as 10^{-3} the gap between two codes with different error correction capability (BCH(63,7,15) and BCH(63,57,1)) is equal to 8 dB.

For a given code rate for example around 50% , we can consider the following codes BCH(7,4,1), BCH (15,7,2), BCH (31,16,3), BCH (63,30,6), BCH (127,64,10) and BCH (255,123,19) which have respectively 57%, 46%, 51%, 47%, 50%, 48% as associated overheads. The BER for a medium SNR= 10 dB vary from $2*10^{-2}$ to $2*10^{-3}$.

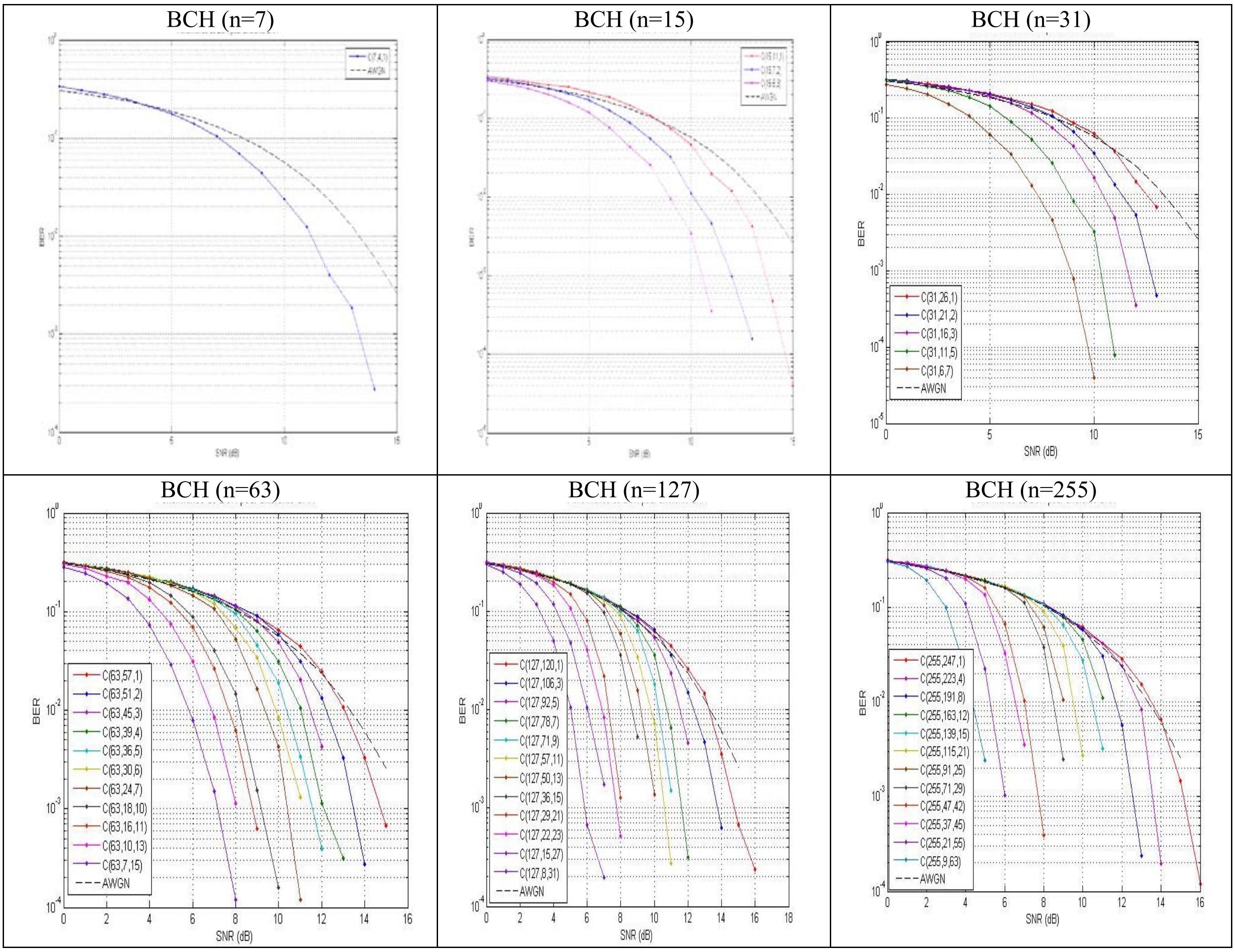


Table 2: BER performance of BCH codes set.

4. Images transmission quality analysis using BCH codes

4.1 Quality estimation using PSNR

The definition of image quality requirements for a particular application is likely to prove difficult and will need to take into account the principal objectives and purposes of

the system under review. e.g. high altitude photo reconnaissance and real time will almost certainly have very different requirements for image quality. Methods for objective assessments of image quality are available, based on mathematical formulas that provide a numerical measure based on the difference between an original image and one that has been processed. Such methods have the advantage that they offer a definitive means of comparing the performance of different techniques and implementations. The disadvantage is that mathematical measures do not always indicate whether an image is acceptable to human observers. Ideally this subjective

A widely used image quality measurement is the PSNR (peak signal to noise ratio). This relates to the sum of the squared differences between corresponding pixels of two images (original and received). The basic idea is to compute a single number that reflects the quality of the reconstructed image. 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 (1) and (2) [17].

$$MSE=\frac{\sum_{x=0,y=0}^{W,H}\left[O(x,y)-R(x,y)\right]^2}{W*H} \quad (1)$$

$$PSNR=20\log_{10}\left(\frac{\max(S(i))-\min(S(i))}{\sqrt{MSE}}\right) \quad (2)$$

In (1), 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 (3)

$$PSNR=20\log_{10}\left(\frac{\max(S(i))-\min(S(i))}{\sqrt{MSE_{RGB}}}\right) \text{ and } MSE_{RGB}=\frac{MSE_R+MSE_G+MSE_B}{3} \quad (3)$$

4.2. Analysis

To put in evidence the performances of the different BCH codes, we characterized the transmission quality of the binary QCIF image received by these codes by the measure of the PSNR.

The correspondence between the objective criteria and the subjective criteria is presented in table 3.

PSNR (db)	Quality
> 37	5 (Excellent)
31 - 37	4 (Good)
22 - 30	3 (Fair)
15 – 22	2 (Poor)
< 15	1 (Bad)

Table 3: PSNR evaluation to image quality.

Simulation results that illustrates PSNR obtained by transmitting Lena image (Qcif) over AWGN channel using BCH codes are regrouped in Table 4. Qcif format is adopted in many standards such as H263 which supports five different video resolutions. In addition to QCIF and CIF that were supported by H.261 there is Sub-QCIF (SQCIF), 4CIF, and 16CIF. SQCIF is approximately half the resolution of QCIF, while 4CIF and 16CIF represent 4 and 16 times the resolution of CIF, respectively. The support of 4CIF and 16CIF implies that the codec could then compete with other higher bit-rate.

Based on simulation results presented in table 4, we picked different PSNR values for a medium SNR= 9 db for all transmissions cases when BCH codes are used over an AWGN channel. Those values which are related to error correction capability (t) are regrouped in table 5.

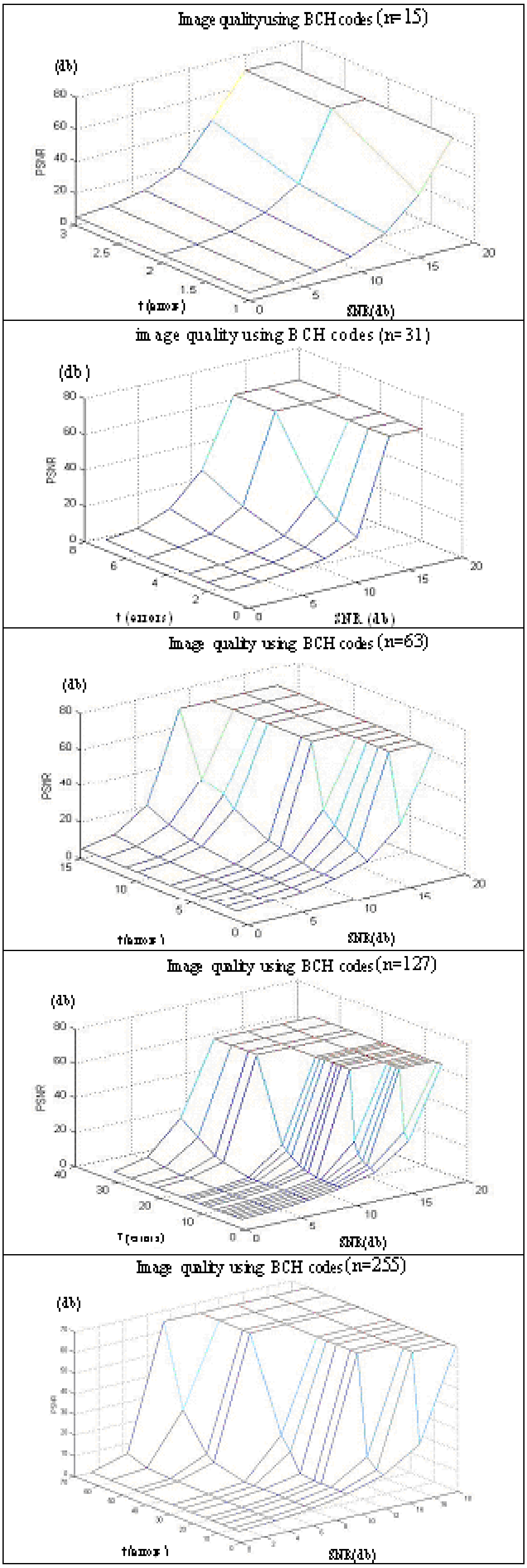


Table 4: image quality ANALYSIS over AWGN channel using BCH codes.

t	n=15	n=31	n=63	n=127	n=255
1	11.1518	10.2657	10.4862	10.6902	10.6902
2	15.3523	11.8351	10.6047	10.7003	10.7085
3	19.8723	13.5427	10.9085	10.7164	10.8358
4	-	-	11.9948	10.7306	10.8790
5	-	20.8166	13.2325	10.7366	10.8813
6	-	-	15.2249	11.0046	10.8971
7	-	32.2778	16.9207	11.2444	10.9064
9	-	-	-	12.5220	10.9103
10	-	-	26.4800	13.2723	10.9327
11	-	-	32.2778	14.8375	10.9510
13	-	-	26.2572	17.9003	10.9715
14	-	-	-	20.2366	10.9981
15	-	-	70	23.0350	11.0219
21	-	-	-	70	11.3680
23	-	-	-	70	14.3359
27	-	-	-	70	20.3839
31	-	-	-	70	26.4800
63	-	-	-	-	70

Table 5: PSNR (db) values when SNR = 9 db.

To implement adaptive BCH FEC scheme , we suggest the following method in order to find the appropriate BCH code for a given level SNR. The adaptive scheme is obtained by changing the code C(n,k,t). The code is used within a period. At the end of a period, the receiver checks the average SNR to see if this case has been already encountered. It also evaluates for the last received packet the number of errors inside a packet. The following four cases are possible:

1) Correction capability is much higher than bit errors number and calculated SNR is higher then SNR average for the current period. In this case BCH FEC used in next period is obtained by changing the code C(n,k,t) to C (nx, k, tx) with nx < n and tx < t. The receiver send a positive acknowledge Pack.

2) Correction capability is much higher than bit errors number and calculated SNR is less than SNR average for the current period or correction capability is much less than bit errors number and calculated SNR is higher then SNR average for the current period . In those cases BCH FEC used in next period is conserved .

3) Correction capability is less than bit errors number and calculated SNR is less than SNR average for the current period. In this case BCH FEC used in next period is obtained by changing the code C(n,k,t) to C (ny, k, ty) with ny < n and ty < t. A NACK packet is sent back to sender in case of FEC decoder failure.

- Both sender and receiver store in knowledge base the closed case that verify (nx < n and tx < t.) or (ny < n and ty < t).

5. Transmission quality analysis using BCH codes cascaded with modems

The use of adaptive modulation and coding (AMC) is one of the techniques key allowing to future generations wireless systems to guarantee a higher spectral efficiency . Simulations are used to evaluate Bit Error Rate values for a range of modulation schemes (ASK_32, PSK_128, MSK_128 and QAM_128) efficiency and BCH FEC error correction capability parameters. Simulation results are regrouped in table 6.

The codec BCH (15,11) that corrects only one error associated to an ASK-32 modem, doesn't bring a visible coding gain compared to the scheme with only ASK32 modem. The coding gain begins to grow with the codes C (15,7) and C (15,5) correcting respectively 2 and 3 errors.

The codec BCH (15,11) that corrects only one error associated to a MSK-128 modem, bring a visible coding gain compared to the scheme with MSK-128 modem only for SNR>6db . The coding gain begins to grow with the C (15,7) and C (15,5) codes.

The codec BCH (15,11) when it associated to a QAM-128 or PSK-128modem it brings a coding gain compared to the scheme with modem only.

In table 7 we illustrates the received images quality when BCH (15,5,3) is used. Based on simulation results, the effect of modems and BCH(15,5,3) codec associations on MOS quality is evaluated for the binary, gray and color images and illustrated in table 8.

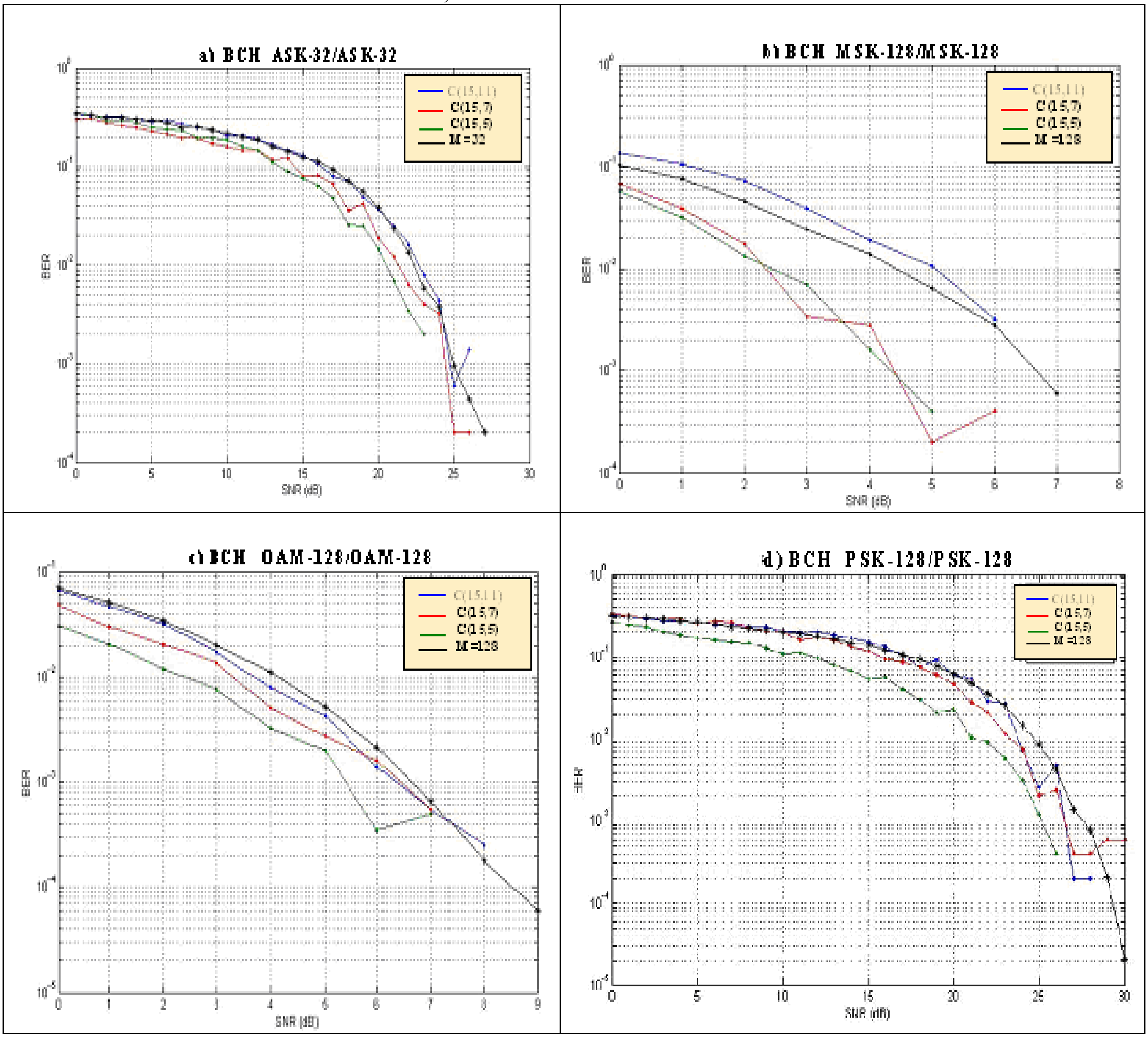


Table 6: BER over AWGN channel using BCH codes cascaded with modems.

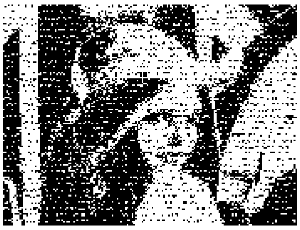
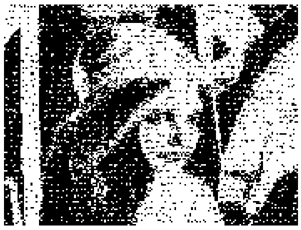
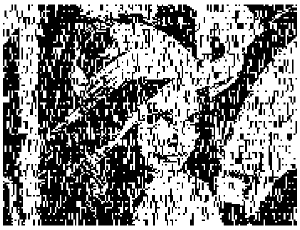
	Modem without codec	BCH (15, 5, 3), SNR=0db	BCH (15, 5, 3) ,SNR=9db	BCH (15, 5, 3), SNR=12db
ASK-16	 PSNR = 8.6305db	 PSNR=7.2074 db	 PSNR=14.5546 db	 PSNR=19.4148 db
PSK-16	 PSNR=7.207 db	 PSNR=8.3921 db	 PSNR=32.8993 db	 PSNR=70db
FSK-16	 PSNR=11.6458 db	 PSNR=17.5260 db	 PSNR=70db	 PSNR=70db
QASK-16	 PSNR=12.2289 db	 PSNR=19.8557 db	 PSNR=70db	 PSNR=70db
MSK-16	 PSNR=9.6867 db	 PSNR=11.9490 db	 PSNR=70db	 PSNR=70db
QAM-16	 PSNR=13.4697 db	 PSNR=22.5466 db	 PSNR=70db	 PSNR=70db

Table 7: BCH (15,5,3) codes cascaded with modems effects on Images quality transmission

	No FEC			BCH (15,5,3)		
	Binary images	Gray images	Color images	Binary images	Gray images	Color images
ASK-16	1	2	2	1	2	2
PSK-16	3	3	3	4	5	5
FSK-16	5	5	5	5	5	5
MSK-16	5	5	5	5	5	5
QASK-16	3	5	3	5	5	5
QAM-16	5	3	5	5	5	5

Binary images / Gray images / Color images

Table 8: Modems and BCH(15,5,3) codec associations effects on MOS quality.

6. Conclusions

The FEC technique employed has direct effects in transmission quality. We analyzed the performance of a set BCH coding schemes in terms of BER and PSNR used for different signal to noise ratio values. An adaptive BCH FEC scheme is suggested.

We have also evaluate and analyze the transmission quality when BCH FEC are cascaded with modems.

We suggest also evaluating in future work the effect on quality image transmission of cascading different BCH stages taking into consideration correction capability as parameter .

As an open issue, it might also be possible to take in consideration:

- Cross layer approach in order to develop and implement an adaptive BCH-FEC for specific system and application.

Software radio to implement a reconfigurable BCH FEC for different systems

References :

[1] Fan Zhai, Yiftach Eisenberg, Thrasyvoulos N. Pappas, Randall Berry, and Aggelos K. Katsaggelos, " An integrated joint source-channel coding framework for video transmission over packet lossy networks", *IEEE International Conf. Image Processing*, (ICIP'04)

[2] Joseph Frederick Ziegler, "automatic recognition and classification of forward error correcting", *Thesis, Spring 2000,George Mason University, Fairfax, Virginia*

[3] Hang Liu a , Hairuo Ma a , Magda El Zarki a and Sanjay Gupta , "Error control schemes for networks: An overview", Mobile Networks and Applications, (1997) 167–182 , *Baltzer Science Publishers BV.*

[4] Jorge Castiñeira Moreira, Patrick Guy Farrell, "essentials of error control coding", *John Wiley & Sons, ISBN-13 978-0-470-02920-6, 2006*

[5] Todd K. Moon, "Error Correction Coding Mathematical Methods and Algorithms", *JOHN WILEY & SONS, INC, ISBN 0-471-64800-0 , 2005*

[6] NL,FRG,UK, "Comparison Bose-Chaudhuri-Hocquenghem BCH and Reed Solomon", *CCITT SGXV, Doc.#476 ,Working Party XV/4, Specialists Group on Coding for Visual Telephony*

[7] Richard J. Lavery, "Throughput optimization for wireless data ", Thesis (Telecommunications Networks), Polytechnic university, June 2001.

[8] Michael Francis and Robert Green, "Forward Error Correction in Digital Television Broadcast Systems", *XILINX, White Paper: Virtex-5, Virtex-4, Spartan-3, LogiCORE, WP27*, September 5, 2007

[9] Kenguka M. Kenguka, Atindimile S. Kumchaya, "Improving WLAN performance with enhanced MAC node cooperation and two stage FEC scheme", *Journal of Theoretical and Applied Information Technology © 2006 JATIT.*

[10] Petr.Cíka, "The Improvement of the Method for Digital Image Watermarking in Frequency Domain using BCH Codes", *IJCSNS International Journal of Computer Science and Network Security, VOL.7 No.3, March 2007*

[11] H.Labiod, "A BCH error recovery scheme for adaptive error control in wireless networks", Vehicular Technology Conference, 1999 IEEE 49th Volume 3, Jul 1999 Page(s):2019 - 2023 vol.3

[12] Emanuele Maiorana, Chiara Ercole, "Secure Biometric Authentication System Architecture using Error Correcting Codes and Distributed Cryptography". Rapport, 2007 *Gruppo nazionale Telecomunicazioni meeting - GTTI , Roma, 18-20 giugno 2007 ,12 pages*

[13] Honglin Hu, Yan Zhang, Jijun Luo, "Cross Layer Design for Wireless Sensor Networks with Virtual MIMO" , *chapter 1 in " Distributed Antenna Systems: Open Architecture for Future Wireless Communications" book , Copyright © 2008 Taylor and Francis Group, LLC*

[14] Chao Zhang, Xiao-Lin Zhang, Cheng Lu , Zhan Zhang, "The Technical Analysis on the China National Standard for Digital Terrestrial TV Broadcasting,", state of the art of modibec project, 2007.

[15] E.R.Berklamp," Algebric coding theory, McGraw-Hill, New york, 1968: revised edition Aegean Park Press, Laguna Lills, CA, 1984.

[16] J. Massey, "Shift-register synthesis and BCH decoding," IEEE Trans. Inform. Theory, vol. IT-15, pp. 122–127, Jan. 1969.

[17] S.A. Goor "Experimental Performance Analysis of RTP-Based Approaches for Low bt rate Transmission of MPEG-4 Video Content", Thesis presented for the degree of Masters in Computer Science, *Computer Science Department Faculty of Science University College Dublin*, February 2005.

[18] M.F.Ngatman , M. A.Ngadi , J.M.Sharif "Comprehensive Study of Transmission Techniques for Reducing Packet Loss and Delay in Multimedia over IP", *IJCSNS International Journal of Computer Science and Network Security*, VOL.8 No.3, March 2008.

[19] Shi-Huang Chen, Shih-Yin Yu, Chung-Hsien Chang, "Speech Watermarking Based on Wavelet Transform and BCH Coding," *sutc*, pp. 507-512, 2008 *IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing* (sutc 2008), 2008

Biography

First Author: Dr Lamia.CHAARI was born in Sfax, Tunisia, in 1972. She received the engineering and PhD degrees in electrical and electronic engineering from Sfax national engineering school (ENIS) in TUNISIA. Actually She is an assistant professor in multimedia and informatics higher institute in SFAX She is also a researcher in electronic and technology information laboratory (LETI). Her scope of research are communications, networking and signal processing which are specially related to wireless and 4th generation networks.

Mmohamed FOURATI was born in Sfax, Tunisia, in 1968. he received the engineering degree in electrical and electronic engineering from higher normal school technical studies in tunisia, master thesis degree from Sfax national engineering school (ENIS) in TUNISIA. Actually he is an assistant professor in multimedia and informatics higher institute in SFAX, he is also a researcher in electronic and technology information laboratory (LETI). His scope of research are channel coding and signal processing .

Nouri MASMOUDI was born in Sfax, Tunisia, in 1955. He received the electrical engineering degree from the Sfax Sciences and Techniques Faculty in Tunisia, in 1982, the DEA degree from the Applied Sciences National Institute in Lyon and Claude Bernard University ,Lyon, France in 1982 . he received his Thesis from the Tunis National School of Engineering (ENIT), Tunisia in 1990. Since 2000, he has been an Associate Professor and head for the 'Circuits and Systems' group of the Sfax Electronics and Information Technology Laboratory. Currently, he is responsible for the Electronic Master Program at ENIS. His research activities have been devoted to several topics: power system, embedded systems, DSP and FPGA implementation for digital algorithms, and information technology.

Lotfi Kamoun was born in Sfax Tunisia, 25 January. 1957. He received the electrical engineering degree from the Sciences and Techniques Faculty in Tunisia. Actually he is a Professor in Sfax national engineering school (ENIS) in TUNISIA, Director of SFAX Higher Institute of Electronics and Communications In Tunisia and director of electronic and technology information laboratory (LETI). His scope of research are communications, networking, Software radio and signal processing which are specially related to wireless and 4th generation networks.