Adaptive Channel Encoder Design for Cognitive Radio Applications and Simulation

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Abstract— People have recently been afflicted by a variety of unknown pandemic diseases. Accordingly, maintaining social ties is essential for society. In order to meet this constantly rising demand, wireless communication is becoming increasingly important. Given the enormous demand for wireless communication and the internet, it is necessary to consider how best to utilize the channels and frequencies that are available, as they cannot be expanded. Cognitive Radio (CR) is a solution to this problem. But in support of CR technology and ever-growing Artificial Intelligence the paper suggests the design of Real Time Adaptive Channel Encoder for cognitive radio application. This will help to realize the existing CR technology and efficient use of available channels.

This paper is presenting the design of various channel encoders with simulation results using MATLAB and how these can be embedded together to work as a Adaptive Channel encoder for mobile application and cognitive radio technology.

Keywords—Cognitive radio(CR), channel encoder, MATLAB, FPGA

1.0 INTRODUCTION

A comparative study is done for possible channel coding techniques for Cognitive Radio Channel Encoder like Convolutional, Turbo, Low Density Parity Check (LDPC), and Polar codes. On comparison Turbo code and convolutional codes are work on bit level and more complex as implementation point of view. From literature survey we concluded that if we increase the complexity of the channel encoder by keeping the Signal power constant we can get variable BER.[1][2][3][4]

In this paper we are suggesting the design of adaptive channel encoder for the cognitive radio technology, Also the Matlab simulation outputs are shared here for various types of input viz text input, audio input and video input tested on different channel encoder to generate appropriate BER.

The first section, 1.0-Introduction, of this paper provides a quick overview of the Cognitive Radio Network and then discusses many channel encoders that are employed in this design and the basis of comparison why to choose a particular channel encoder for working design. Using the encoders listed in section 1.0, section-2.0 proposes the design of a adaptive channel encoder. Section-3.0, explains each channel encoder's design and simulation outcomes on application of same input to all encoders but for different types of input. The design implementation process is explained in the 4.0-Future scope section. Section 5.0 gives Conclusion with final thoughts.

1.1 Cognitive Radio Network

In today's rapidly evolving technological landscape, communication is essential to bringing society together. Even in times of crisis or pandemic, it contributes to the nation's progress. The need for high frequency wireless mobile communication is growing daily to meet this demand. Channel congestion is rising as a result, although capacity and accessible frequencies are constrained. Therefore, if we do not wisely use the available frequencies, this additional traffic may impair the communication infrastructure. Spectrum crunch may also result from new communication systems' increased bandwidth and data rate requirements. This happens as a result of certain customers receiving statically assigned spectrum that they are not fully utilizing. So, is there anything we can do to make use of this unused spectrum? Cognitive Radio (CR) has evolved as a adaptive technology in bridging the disparity between the availability and allocation of the radio frequency spectrum amongst multiple users.[5]

A wireless communication technology known as cognitive radio (CR) allows a transceiver to dynamically identify which communication channels are being used and which are not. After that, the transceiver quickly switches between available and occupied channels. The utilization of the available radio frequency (RF) spectrum is maximized with the aid of these capabilities.[6]

Additionally, it reduces user intervention. Also, it boosts spectrum efficiency and enhances user quality of service (QoS) by avoiding congested channels.[7]

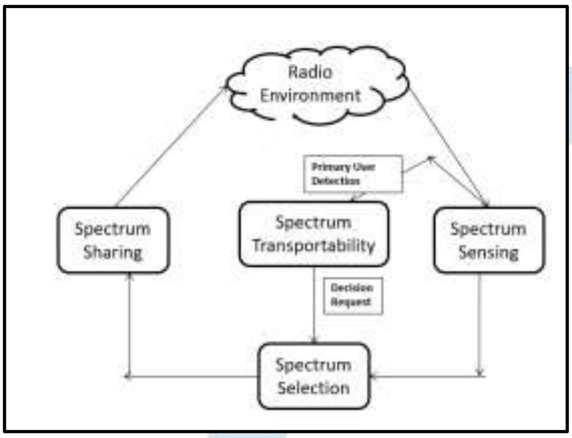

Figure 1: Cognitive Radio Cycle [3]

1.2 Channel Encoder

Although the advancement of communication technology is a continuous process, the prime objectives of near-future wireless communication systems are higher data rate, reliability, higher bandwidth, higher spectrum efficiency, energy efficient, along with lower latency and less error.

Reliability of wireless communication systems can be increased by channel encoding as it adds extra bits in controlled manner and is considered to be most efficient element of communication system.

Many channel encoding techniques are used in encoding purpose such as, Convolutional code, Turbo Code, Repeat Accumulate Code, Reed Solomon Code, Low density parity check (LDPC) code, Polar code, Hamming Code etc. Among these it is user's intelligence to choose the particular coding technique as per the application. The main motive of channel encoder is to provide secured data transmission, reduced effect of noise and achieve less bit error rate.

The two basic types of channel codes are block codes and convolutional codes. Finite field arithmetic and abstract algebra serve as the foundation for block codes. They have the ability to identify and fix errors. Reed Solomon codes and LDPC codes fall within this category. Convolution codes, on the other hand, are typically used for real-time error correction and are developed utilizing a unique, powerful mathematical framework. They create a single codeword out of all the data.[1] [5]

2.0 ADAPTIVE CHANNEL ENCODER

The adaptive channel encoder's design aims to enhance cognitive radio technology's intelligence. As it is well known, in CR technology, spectrum handover occurs based on availability after spectrum sensing [7]. The environment and all spectrum parameters will change during this transition. Therefore, in order to facilitate this migration, we are suggesting the design of a adaptive channel encoder that will choose a suitable encoding technique and transmit the data with an appropriate bit error rate. The simulation results are obtained using MATLAB [9].

In our proposed design there are four channel encoders named as E1, E2, E3 and E4. E1 is the convolutional channel encoder with lowest degree polynomial and less complex. E2 is the second convolutional channel encoder with highest degree polynomial than E1 and little more complexed than E1. E3 is Turbo channel encoder which is the convolution of E1 and E2 with interleaver and more complex than E1 and E2. E4 is the combination of Reed Solomon and Turbo encoder to introduce the complexity in the design more than E1, E2 and E3.

The complexity is considered as one of the parameters to design this adaptive channel encoder to get the appropriate Bit error rate. The intention is to select the minimum possible BER and transmit the data accordingly.

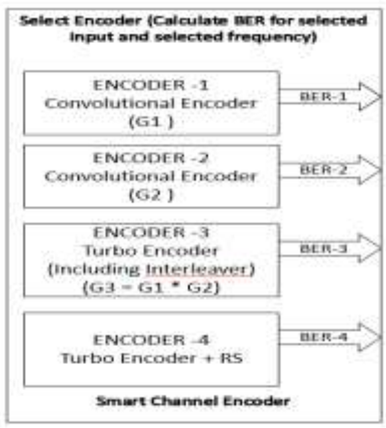

Figure 2 : Proposed Design of Adaptive Channel Encoder

3.0 PROPOSED CHANNEL ENCODERS AND SIMULATION RESULTS

A. Encoder 1 – Convolutional channel Encoder

As discussed in the section III we are using the encoders with different level of complexities. First channel encoder is E1 i.e convolutional encoder with constraint length 3 and

$$G1 = 1+D+D^2$$

With this degree of polynomial, the encoder will generate the BER in the range of 10^{-2} to 10^{-4} for different types of input applied.

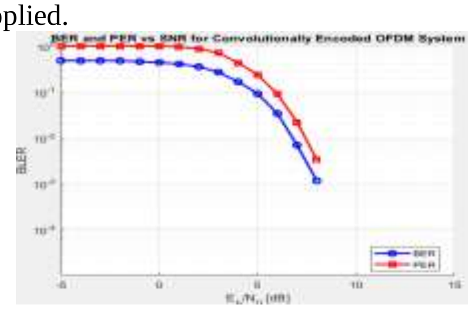

Figure 3: Convolutional Encoder E1 with text input applied.

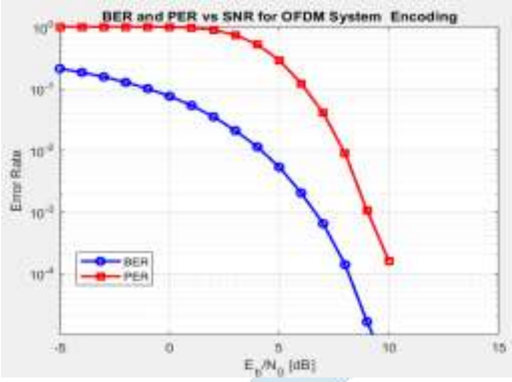

Figure 4: Convolutional Encoder E1 with Video input applied.

B. Encoder 2 – Convolutional channel encoder

Second channel encoder E2 is the convolutional encoder with the higher degree of polynomial than that of Encoder 1with constraint length six and

$$G2 = 1 + D + D^4 + D^5$$

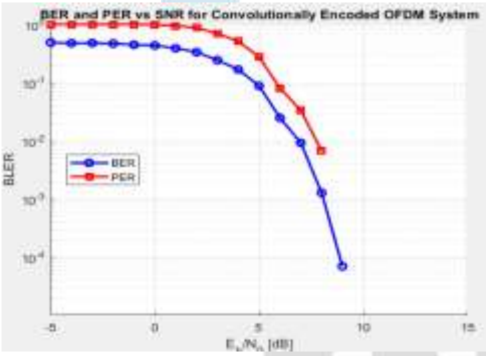

Figure 5:Convolutional Encoder E2 with text input applied.

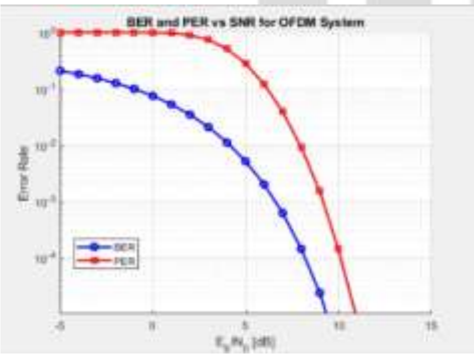

Figure 6:Convolutional Encoder E2 with audio input applied.

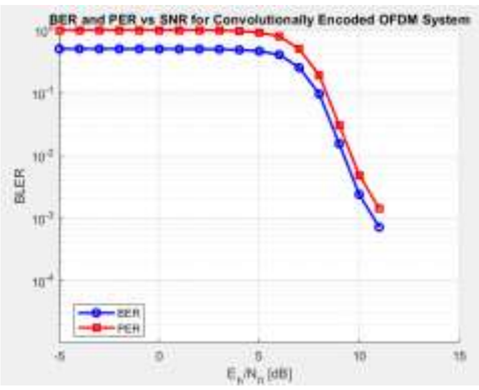

Figure 7: Convolutional Encoder E2 with video input applied.

C. Encoder 3 – Turbo Encoder

Turbo encoder is designed in such a way that it will be more complex than E1 and E2 and to get the effective BER than the E1 and E2 for the same input and when the noise level is higher. So to sustain in the higher noise level signal the more complexed encoder may work appropriately.

$$G3 = G1*G2$$

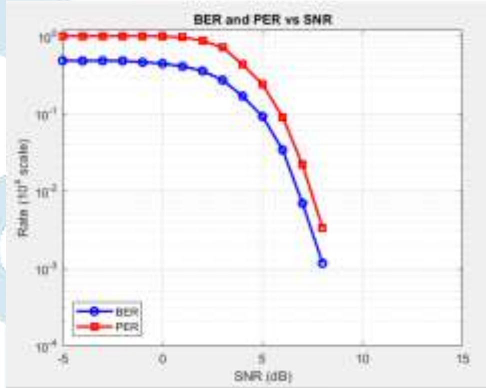

Figure 8:Turbo Encoder E3 with text input applied.

D. Encoder 4 – RS plus Turbo Encoder

RS and Turbo encoder can be tested to get the minimum BER on available channel for the applied input.

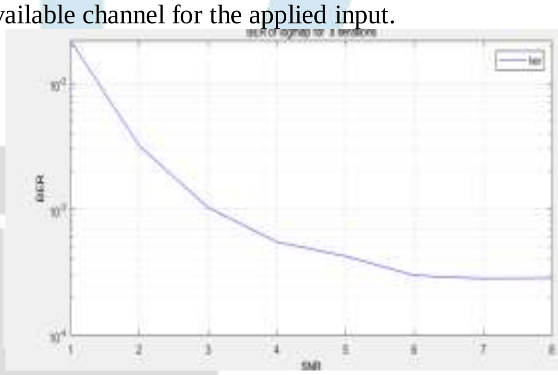

Figure 9:RS plus Turbo Encoder E4 with text input applied.

4.0 FUTURE SCOPE

In this design we have tested the different encoders to get appropriate BER for a particular application. In this noise is not considered as a testing parameter. The aim was to test the encoders to get the BER for same input.

The application can be modified to generate the minimum BER with increased complexity of encoder design and variable noise levels and various bandwidths in real time application. [10]

5.0 CONCLUSION

The cognitive radio CR is the best solution in wireless communication systems for better spectrum utilization by adopting a dynamic spectrum allocation over existing static spectrum allocation.

Channel encoder for cognitive radio can be design so that minimal bit error rate achieved with high reliability and real time change in transmission environment. So, the block code technique is more preferable as it supports to higher frequencies like next generation.

As we increased the complexity of designing of encoder it can sustain at high level of noise and can generate the appropriate BER for the input applied.

REFERENCES

[1] Bashar Tahir_, Stefan Schwarzy, and Markus Rupp (2017), "BER Comparison Between Convolutional, Turbo, LDPC, and Polar Codes", IEEE, 978-1-5386-0643-8.

[2] Dr. Priti Subramanium (2021)," Optimization Of Adaptive Coding Technique For Ber Performance Improvement", PENSEE, ISSN: 0031-4773, Vol. 51, ISSUE 7.

[3] M. Vijaya Lakshmi, G.Gagana Reddy , AlamurSucharitha (2022) , N. Akshara and N.Vaishnavi, "Performnce Comparison of Chnnel Coding Techniques for OFDM System", GC-RDCT-2022, doi:10.1088/1757-899X/1272/1/012012.

[4] Onurcan Iscan and Wen Xu (2016)," A Comparison of Channel Coding Schemes for 5G Short Message Transmission", Researchget, DOI: 10.1109/GLOCOMW.2016.7848804.

[5] Mr. D. D. Chaudhary, Mrs. V. V. Joshi, Dr. V. M. Wadhai and Dr. L. M. Waghmare (2011), "Reconfigurable cognitive radio technology fornext generation networks", S.J. Pise (ed.), *ThinkQuest 2010*, DOI 10.1007/978-81-8489-989-4_10.

[6] Ahmad M. Rateb (2008)," Introduction to Cognitive Radio Systems", DOI: 0.13140/RG.2.2.19607.83363.

[7] Amandeep Kaur, Priyanka Aryan and Gobinder Singh (2015)," Cognitive Radio, Its Applications and Architecture", IJEIT, Vol. 4, Issue 11.

[8] Ebenezer Esenogho, Tom Walingo and Fambirai Takawira (2014), "Impact of Primary Users on Secondary Users Channels in a CentralizedCognitive Radio networks", Researchgate, DOI: 10.13140/2.1.4153.7601.

[9] Kanchana Katta (2014), "Design of Convolutional Encoder and ViterbiDecoder using MATLAB", International Journal For Research In Emerging Science And Technology, Volume-1, Issue-7.

[10] S.Gnanamurugan and A.Sindhu (2013), "Vlsi Implementation of Low Power Convolutional Coding With Viterbi Decoding Using Fsm", IOSR-JEEE, Vol. 6, Issue 3, PP 10-15.