BER ANALYSIS OF CHANNEL CODING TECHNIQUES FOR 5G NETWORKS

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Abstract. All Achieving error free communication is the major challenge in wireless technology because it provides the basement for reliable communication. But, practically error free communication is not possible due to impairments caused in wireless channel. The practical option that is available for reliable communication with minimized error rate is a channel coding technique. The various channel encoding techniques used are RS, convolutional codes, turbo codes etc., in various generations of wireless communication. The advanced version of 5G technologies needs a new type of channel coding technique that focuses on low complexity and minimized bit error rate. In this system candidate error correction coding schemes that can be used for 5G technology is reviewed in terms of bit error rate and complexity. This proposed system mainly focuses on two channel coding techniques namely convolutional codes and LDPC codes. The LDPC codes are currently used in 4G technologies and its feasibility with 5G wireless communication is evaluated in terms of BER performance and complexity and it is compared with the coded and uncoded convolutional codes. The results show that LDPC codes outperform the other coded system in terms of BER and complexity, also channel capacity of the MIMO-OFDM system is achieved nearer to the Shannon limit by using LDPC codes. According to the conducted studies, it is evident that the LDPC codes are excellent in having improved BER performance such that it could be used for next generation wireless communication.

1. Introduction

These When a digital signal is transmitted it follows several channels coding schemes in order to avoid the noise across the communication medium or channel. Those noise or distorted signals can be rectified using advanced algorithms in wireless environment. One of the most prominent and widely available subjects in the communication field is the channel coding. Channel coding, in general often deals with the bit-rate or information storage capacity. This system is designed to analyze and compare distinctively the two different types of codes namely convolutional codes, LDPC codes all simulated in MATLAB environment. Mobile communication has evolved drastically in recent times in which the evolution of 1G communication to the advance 5G communication provides wider functions and benefits. This change mainly leads to the advancements in technology and future innovations. These advanced 5G networks require low power, high-data rate and bandwidth which lead to faster communication. The Real wireless world with no more limitations and worldwide access to the
internet and wearable devices for faster communication is happening. The major functions are multipath and multiple connections and access using the wireless technology. The data transfer speed has increased enormously by the introduction of 5G network technology. Basically, the increase in transmission rate is achieved by the increase in spectral efficiency. (eg. Using efficient channel coding). The present cellular systems and satellite systems uses LDPC codes and Turbo codes. It provides intelligent QoS (quality of service) and management. The 5G will be the unified standard LAN, WAN, WWW, IP and broadband. The dynamic information at low cost and high speed with less errors and resource management are the major benefits of this technology. The implementation 5G provides security and solution to the faster way of communication. Here, we proposed a system with 5G wireless design with the use of LDPC and convolutional codes to accomplish low noise and improved BER performance for the system by proven results with the BER plot comparison for both the codes.

2. NOISE

In any transmission medium, noise is the unwanted or distorted signal. The errors occurring in a signal mainly depends upon the noise in the system which causes major changes at the output signal. These are reduced by several advanced techniques with the use filters and other coding mechanisms. It reflects the originality of the system to stop performing it and reduces the efficiency. The several types noises responsible for the information loss across the system.

- Gaussian noise occurs at random frequency with a crackling sound.
- Drift noise moves randomly with respect to time.
- Shot noise mainly affects the amplitude of the signal.

Shannon proved that for a band limited Additive White Gaussian Noise (AWGN) channel, with bandwidth B, there exist a sequence of coding patterns responsible for achieving less number of errors at the output channel, which can be given as follows:

\[ C = B \log_2 (1+S/N) \text{ bits/sec} \]  

Where C - capacity of the channel,  
S - Signal power and  
N - Noise power.

3. COMMUNICATION SYSTEM

3.1 SHANNON CAPACITY THEOREM

Shannon states that the capacity of a system is related to the average received power, average noise power and average bandwidth. It mainly encodes the transmitted message and avoids distortion. In recent times the channel codes and the ratios are compared to the performance of the system in order to examine the several data rates and distorted messages across the system. The two major communication system resources are power-limited and bandwidth-limited systems. The model for the system is shown in fig1.

3.2 OFDM – MIMO SYSTEM

OFDM is a multi carrier modulation technique. It improves the spectral efficiency but it gives solution only to an extent. There are also several alternative methods performed to achieve high data rate transmission over wireless channels. Multiple antennas are used at both ends of the wireless channel. This method does not require any bandwidth expansions or any extra transmission power for the increasing feature of the system’s spectral efficiency values. It mainly prevents interference between overlapping carriers. The given wireless system has both antennas \( N_t \) for transmission and \( N_r \) for reception of the datas with possible error free rate and efficiency. The maximum and minimum data rates are both proportional \( N_t \) and \( N_r \) (i.e.) both the antennas are independent to each other. \((N_t N_r)\).
The use of adaptive algorithms and radio spectrum requires carriers which are marked close to avoid the downlink errors in the system. It is mainly used to increase data rates, improve capacity and BER of the system. A guard band is placed between nearby carriers in order to provide a guard space. These guard bands are waste of spectrum. The data for transmission is of higher range, so the use of short symbol periods is applicable. The symbol period $T_{sym}$ is the inverse of the broadband data rate $R$:

$$R = \frac{1}{T_{sym}}$$

So $R$ increases $T_{sym}$ decreases.

It converts a selected frequency channel to a parallel sub channels. In order to increase the performance loss occurring in multipath channels, the OFDM system addresses mainly the two problems with its distinct modulation and multiplexing. It improves multipath fading issues in the channel. The good sub carriers with power gain are made to carry more number of bits to the allocated channel, with less transmission power. Multi beam MIMO antennas are used at the system for better efficiency.

### 3.3 CONVOLUTION CODE

Convolutional codes can be either systematic or non-systematic. These codes are characterized by three parameters $(n,k,m)$ number of output bits, input bits and memory registers. The code rate and constraint length are the two important factors responsible for convolution code. The code rate $(k/n)$ can be defined as the ratio of number of output bits $(k)$ to the number of input bits $(n)$ in a given encoder cycle.

These codes are mainly used for error correction in communication system. Similarly, the encoded bits mainly depend on the present input bits and past input bits. The viterbi algorithm is responsible for the function of decoding in convolutional code. In recent times, there were several approaches for advanced modifications and implementations globally for this method of coding patterns. The major examples in this case are Trellis coded modulation (TCM) and turbo codes.

### 3.4 BIT FLIPPING METHOD

It is mainly used to correct the error rate while receiving and decoding the messages. It involves tanner graphs for analyzing the messages send to the node by either one or zero. Every checked node sends a message to each connected bit node based on the availability of the information. In order to check each and every node the value of the bits are declared. In this step, the parity check equation is satisfied only when the modulo-2 sum of the input bit values are zero.
4. BER PLOT FOR OFDM-MIMO SYSTEM

Figure 3 Simulation result for OFDM-MIMO system

Figure shows bit error rate versus SNR for an OFDM MIMO system. By varying the SNR value the bit error rate is calculated. The output plot shows that as SNR value increases BER decreases which will result in interference at the receiver of uncoded OFDM MIMO system. Also the result shows that BER for uncoded system ranges from $10^{-1}$ to $10^{-4}$ as SNR increases. But practically the system will have low SNR value due to channel impairments. This non-linearity can be minimized using proper channel coding techniques.

4.1 BER PLOT FOR CONVOLUTIONAL CODES

Figure 4 Simulation result for convolutional codes

Figure shows bit error rate versus Eb/No for convolutional codes. In this graph both the theoretical value and the simulated value is calculated and plotted. In this figure the graph is plotted for an code rate of $\frac{1}{2}$ and the input is [7,5]. It is clear that improvement in BER is achieved only in the simulated graph whereas in the theoretical graph the BER is not upto the desired level.
4.2 BER PLOT FOR LDPC CODES

![BER under different SNR](image)

Figure 5 BER plot for LDPC codes

Figure shows bit error rate versus SNR for LDPC codes for different iterations as SNR value increases BER decreases. Also for different values of SNR, BER is plotted. The output shows that the BER performances of LDPC codes are better for high SNR values. While compared to the uncoded system and convolutional coded system, an LDPC code provides a better BER performance.

5. CONCLUSION AND FUTURE WORK

LDPC codes with hard decision decoding algorithm has been done for an OFDM-MIMO system. The uncoded system and convolution coded system is bought in comparison with the performance of BER. The results show that the system using LDPC codes have improved BER performance over the existing convolutional codes and it is found to be in order of $10^{-6}$. Also the complexities of LDPC are reduced by reducing the number of iterations while compared to the existing turbo codes. The LDPC codes are calculated only by BER performance and complexity in this paper. Further the performance measurement of spectral efficiency, coding gain, latency, it could be evident that these codes will be effective candidate for the 5G wireless communication networks.

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