BER Evaluation of Forward Error Correction Coding Techniques

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Abstract

High Definition Television (HDTV) services are the major requirement in the television broadcasting. The system of broadcasting has been specified around three concepts: best transmission performance approaching the Shannon limit, total flexibility, and reasonable receiver complexity. This paper provides a brief introduction to the DVB system. The DVB-S system provides direct to- home (DTH) services, as well as collective antenna systems (satellite master antenna television SMATV) and cable television head-end stations. The paper provides a tutorial overview of the DVB system, describing its main features and performance in various scenarios and applications.

Keywords: *DTV, Channel Coding, DVB-S2, satellite broadcasting.*

1. Introduction

The availability of wireless technology has revolutionized the way communication is done in our world today. The technologies make it possible for people to be connected to the rest of the world from anywhere. A communication system deals with information or data transmission from one point to another through channel. The channel is subject to various types of noise. Error Correction is important for most next-generation sequencing applications because highly accurate sequenced reads will likely lead to higher quality results. Many techniques for error correction of sequencing data from next-gen platforms have been developed in the recent years. However, compared with the fast development of sequencing technologies, there is a lack of standardized evaluation procedure for different error-correction methods, making it difficult to assess their relative merits and demerits [1].

Data sent from the source picks up noise as it passes along the transmission line or through the air. The noise causes the data to become corrupted. The data is in the form of binary bits that may get “flipped” so that logical 0’s become 1’s and logical 1’s become 0’s. Some method must be used to ensure that the correct data is received at the other end of the transmission.

There are two basic methods for handling noise induced errors in transmitted signals.

- Errors can be detected at the receiving end and the information re-transmitted.
- Errors can be detected at the receiving end and the information is corrected using Forward Error Correction (FEC) techniques.

Retransmission techniques require a two-way link. The error is detected at the receiving end and a signal is sent to the transmitter to retransmit the data. This causes the same data to be transmitted twice. While this is happening no new data is being sent. This causes a decrease in data throughput. Forward error correction requires only a one-way link, and its parity bits target both error detection and correction. Data can continue to be transmitted and if an error is detected encoded information sent along with the data is used to correct for the error [2].

2. Coding Theory

Coding theory is the way to used codes for data compression, cryptography, error-correction and more recently also for network coding. This typically involves the removal of redundancy and the correction (or detection) of errors in the transmitted data. There are essentially two aspects to Coding theory:

- Data Compression (or, Source Coding)
- Error Correction (or, Channel Coding).

Errors in a transmission can be categorized in two main categories, single-bit errors and burst errors. A single-bit error is an isolated event that alters one bit but not any surrounding bits. Single bit errors can happen in parallel transmissions where all the data bits are transmitted using separate wires. They are less likely to occur in serial transmission. While single-bit errors can negatively affect a message transmission, the probability of such an error occurring is relatively low. Consequently, burst errors are often considered to have a greater affect and are the focus of many error detection and correction schemes. Burst Errors within communication channels do not appear evenly distributed across time. They appear in bursts and, as a result, are referred to as burst errors. A burst error is a group of bits in which two successive erroneous bits are always separated by less than a given number of correct bits [3]. The length of the error is measured from the first changed bit to the last changed bit. While single-bit errors usually occur in the presence of white noise, burst errors are caused by impulse noise and fading. Burst errors are also more likely to occur in a serial transmission. This is because the noise occurs for longer durations and, therefore, affects more bits.

3. Forward Error Correction (FEC)

Forward Error Correction (FEC) is a system of error control for data transmission, whereby the sender adds systematically generated redundant data to its messages, also known as an Error Correcting Code (ECC). The American mathematician Richard Hamming pioneered code (ECC). The American mathematician Richard Hamming pioneered this field in the 1940's and invented the first FEC code, the Hamming (7, 4) code, in 1950. The carefully designed redundancy allows the receiver to detect and correct a limited number of errors occurring anywhere in the message without the need to ask the sender for additional data. FEC gives the receiver an ability to correct errors without needing a reverse channel to request retransmission of data, but this advantage is at the cost of a fixed higher forward channel bandwidth. FEC is therefore applied in situations where retransmissions are relatively costly, or impossible such as when broadcasting to multiple receivers.

In particular, FEC information is usually added to mass storage devices to enable recovery of corrupted data. FEC is accomplished by adding redundancy to the transmitted information using a predetermined algorithm. A redundant bit may be a complex function of many original information bits. The original information may or may not appear literally in the encoded output; codes that include the unmodified input in the output are systematic, while those that do not are non-systematic. FEC could be said to work by "averaging noise", since each data bit affects many transmitted symbols, the corruption of some symbols by noise usually allows the original user data to be extracted from the other, uncorrupted received symbols that also depend on the same user data [4].

When a duplex line is not available or is not practical, a form of error correction called Forward Error Coding (FEC) is used. The receiver has no real-time contact with the transmitter and cannot verify if a block was received correctly. It must make a decision about the received data and do whatever it can to either fix it or declare an alarm. With FEC techniques for the same power, we can now achieve a lower error rate. The communication in this case remains simplex and all the burden of detecting and correcting errors falls on the receiver. The transmitter complexity is avoided but is now placed on the receiver instead.

In telecommunication & information theory, forward error correction (FEC) (also called channel coding) is a system of error control for data transmission, whereby the sender adds systematically generated redundant data to its messages, also known as an error-correcting code (ECC). The American mathematician Richard Hamming pioneered this field in the 1940s and invented the first FEC code, the Hamming (7, 4) code, in 1950 [5].

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Error-correcting codes are frequently used in lower-layer communication, as well as for reliable storage in media such as CDs, DVDs, Hard Disks, and RAM.

Error-Correcting Codes are usually distinguished between convolutional codes and block codes:

1. Convolutional codes are processed on a bit-by-bit basis. They are particularly suitable for implementation in hardware, and the Viterbi decoder allows optimal decoding.

ISSN 2348 – 7968

2. Block codes are processed on a block-by-block basis. Early examples of block codes are repetition codes, Hamming codes and multi-dimensional parity-check codes. They were followed by a number of efficient codes, Reed-Solomon codes being the most notable due to their current widespread use. Turbo codes and low-density parity-check codes (LDPC) are relatively new constructions that can provide almost optimal efficiency [8-9].

4. Results

The BER performance evaluation of various Error Correction codes are performed in MATLAB. The BER performance is analysed for various code rates. We Design, implement and evaluate performance of convolutional codes, RS codes and BCH codes with different code rates. The results of CC codes for various code rates are shown in figure 1.

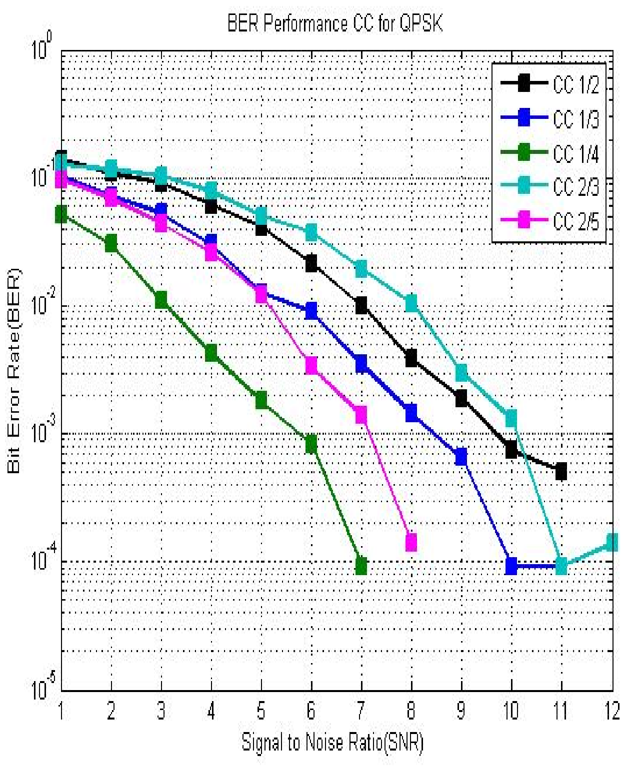

Figure 1: BER Evaluation of CC codes.

The results of RS codes for various code rates are shown in figure 2.

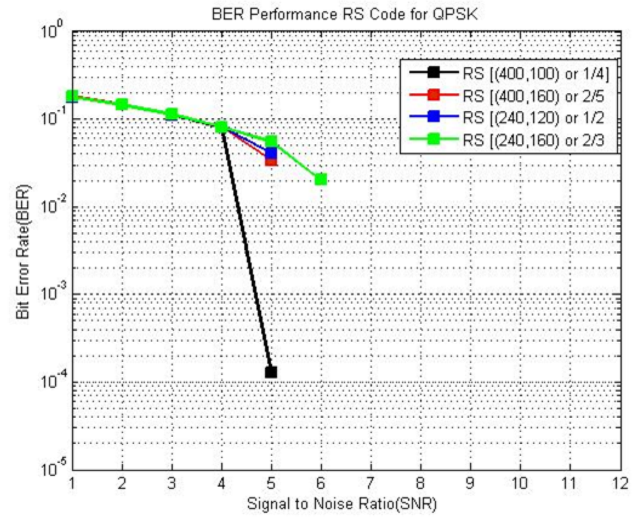

Figure 2: BER Evaluation of RS codes.

The results of BCH codes for various code rates are shown in figure 3.

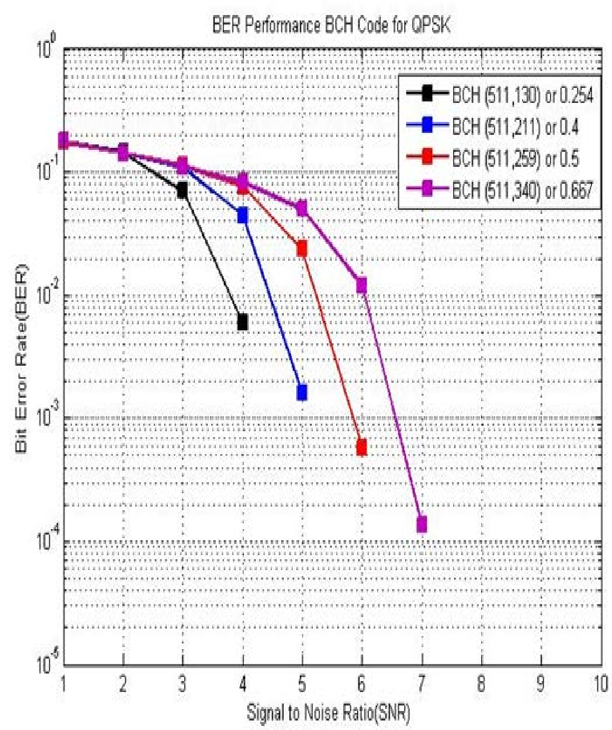

Figure 3: BER Evaluation of BCH codes.

The BER Comparison between CC, RS and BCH codes are compared in figure.4.

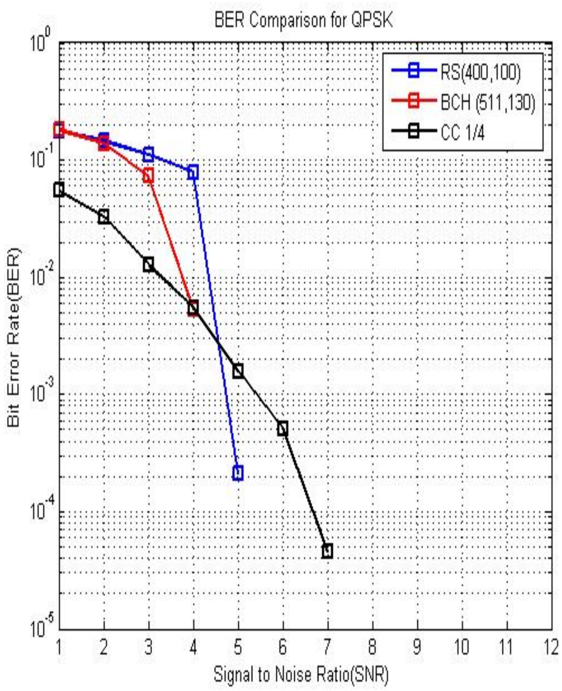

Figure 3: BER Evaluation of CC, RS and BCH codes.

5. Conclusions

BER performance of CC, RS and BCH codes increases as the code rate decreases and gives high coding gain for 0.25 (1/4) code rate. The performance of RS codes is better as the block length increases. The RS code, which is well suited for correction of burst errors, shows a poor BER performance for lower SNR values. The performance of BCH codes was found better as compared to CC and RS codes.

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