Chapter 5
Comparative Analysis of Belief Propagation and Layered Decoding Algorithms for LDPC Codes

Channaveeramma E.
https://orcid.org/0000-0002-1359-9513
Navodaya Institute of Technology, India

K. M. Palaniswamy
Dr. T. Thimmaiah Institute of Technology, India

ABSTRACT

Wireless digital communication enables instantaneous connections and conversations between people all over the world. In a digital communication system, the channel code is used to detect and fix errors. The most widely used error-correcting codes are LDPC channel codes, which are represented by a sparse parity-check matrix and have performance close to the Shannon limit. The sophistication and versatility of decoders determines the error-correcting codes' efficacy. LDPC codes are used in a wide variety of broadcasting, satellite communication, LAN, and PAN applications because of their capacity-approaching properties. Sparsity allows for the use of LDPC codes; however, simplified decoding algorithms play a crucial role in achieving high-speed, error-free communication. In this work, we focus on locating a decoding algorithm with the lowest possible complexity and the fewest possible iterations. The belief propagation algorithm and layered decoding or turbo decoding algorithms are with the code rates ½, ¾,5/8, and 13/16, which are compatible with the WLAN (IEEE Std 802.11™-2016 (Revision of IEEE Std 802.11-2012, 2012) standard. In terms of bit error rate, layered decoding or turbo decoding of the message forwarding method performs better. It is also seen that performance improves with an increase in the number of iterations.

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INTRODUCTION

A digital communication system involves the transmission and reception of digital signals to convey information over a communication channel. The key components, as depicted in Figure 1, are:

Source: The source generates the information to be transmitted, such as voice, video, or data. It could be a microphone, camera, or any other data source.

Encoder (Source and Channel): The encoder processes the information from the source and translates it into a suitable digital format for transmission (Regin et al. 2023). It may involve techniques like encoding, compression, and formatting (Abbassy, 2020). The channel encoders enhance the reliability and efficiency of communication by adding redundant bits to the message such that errors, if any, can be detected and corrected (Abbassy & Abo-Alnadr, 2019).

Modulator: The modulator takes the digital signal from the encoder and converts it into a form that can be transmitted over the communication channel. This process is called modulation and typically involves techniques such as amplitude shift keying (ASK), frequency shift keying (FSK), or phase shift keying (PSK) (Abbassy & Ead, 2020).

Channel: The channel represents the medium through which the modulated signal is transmitted. It can be a wired medium like a coaxial cable or a wireless medium like the atmosphere (Bose et al. 2023).

Demodulator: The demodulator is responsible for extracting the transmitted signal from the channel. It performs the reverse process of modulation and converts the received signal back into a digital form (Bansal et al. 2022).

Decoder (Channel and Source): The decoder processes the demodulated signal and retrieves the original information. It performs operations such as decoding, error correction, and decompression to recover the transmitted data (Fabela et al. 2017; Venkatesan, 2023).

Destination: The destination is the recipient of the transmitted information. It could be a display device, a speaker, or any other device that can interpret and present the received data (Köseoğlu et al. 2022).

For better understanding, consider a real-time example: a digital voice communication system using a mobile phone (Uike et al., 2022; Venkatesan et al. 2023). This example demonstrates how a digital communication system, specifically a mobile phone, enables voice communication by converting analog audio signals into digital form, transmitting them wirelessly, and then decoding them back into audio at the receiving end.

Encoder: The audio signal is digitized and encoded into a digital format suitable for transmission. It may involve techniques like analog-to-digital conversion and audio compression algorithms (Gaayathri et al. 2023).

Modulator: The digital audio signal is modulated onto a carrier wave, which is typically a radio frequency signal. Techniques like frequency modulation (FM) or code division multiple access (CDMA) may be used.

Channel: The modulated signal is transmitted through the air using wireless communication. It encounters various obstacles, interference, and noise that can affect the quality of the signal (Patil et al. 2021).

Demodulator: The mobile phone's receiver demodulates the received signal, separating it from other signals and noise.

Decoder: The demodulated signal is decoded, error correction techniques are applied, and the original digital audio signal is reconstructed (Praveen Kumar Sharma, 2021).

Destination: The reconstructed audio signal is sent to the mobile phone's speaker, where it is converted back into sound and can be heard by the listener.

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