بسم الله الرحمن الرحيم

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تم رفع هذه الرسالة بواسطة / حسام الدين محمد مغربي

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

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AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics Engineering and Electrical Communications Department

Performance Enhancement of DVB Systems Using Polar Codes

A Thesis submitted in partial fulfillment of the requirements of
a Doctor of Philosophy degree in Electrical Engineering
Electronics Engineering and Electrical Communications Department

by

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Master of Science degree in Electrical Engineering
Electronics Engineering and Electrical Communications Department
Faculty of Engineering, Ain Shams University, 2016

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Statement

This thesis is submitted as a partial fulfillment of Doctor of Philosophy in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Abstract

Digital Video Broadcasting (DVB) systems have been evolved to improve the spectrum efficiency of current multimedia communications. Over time, the demand for more interactive services with less latency and more throughput is increasing. Latest DVB systems use error correction coding techniques which cause delay in decoding of the received signal. Therefore, a new Forward Error Correction (FEC) schemes are introduced to balance between Bit Error Rate (BER) performance and decoding latency.

Recently, polar codes were proposed by Arikan to achieve optimum channel capacity given by Shannon theorem for symmetric binary input-discrete memoryless channels. They are featured by their low encoding/decoding complexity to improve the spectrum efficiency of current multimedia communication systems. As a result, polar code is a good candidate to enhance DVB performance.

Firstly, polar codes generalization formulas and algorithms were introduced to provide more code lengths and rates to match with DVB systems code lengths without the need for shortening or puncturing. Secondly, as the size of the kernel matrix increases, computing the Log-Likelihood Ratio (LLR) functions in successive cancellation decoder for these codes becomes mathematically more complicated. Therefore, a new simplified general method is proposed to calculate

these LLR functions based on the schematic diagram of the selected kernel matrix for sizes higher than 2. After that, the generalized polar codes are compared with punctured polar codes based on the 2×2 binary kernel matrix to select the suitable scheme for DVB systems.

Then, we compare the performance of polar and Low-Density Parity Check (LDPC) codes in terms of BER, encoder/decoder latencies, and throughput. The results show that both channel coding techniques have comparable BER. However, polar codes are superior to LDPC in terms of decoding latency, and system throughput. Moreover, we present the possible performance enhancement of DVB systems in terms of decoding latency and complexity when using optimized polar codes as a FEC technique instead of Bose Chaudhuri Hocquenghem (BCH) and LDPC codes that are currently adopted in DVB standards.

Finally, according to the previous results, we propose to use polar codes with flexible Fully Adaptive- Successive Cancellation List (FA-SCL) decoders in DVB systems to meet the growing demand for more bit-rates. In addition, they can provide more interactive services with less latency and more throughput compared to the current FEC techniques of DVB systems.

Keywords:

Polar Codes; LDPC Codes; Bhattacharyya Parameter; Kernel Matrix; Adaptive Successive Cancellation List Decoder; DVB Systems

Thesis Summary

The thesis is divided into six chapters as listed below:

Chapter 1:

It introduces polar codes noting their importance, illustrates the motivation and objectives of performance enhancement of DVB systems using polar codes presented in this thesis. The chapter ends with a brief summary of the thesis organization.

Chapter 2:

It presents an overview about channel coding and linear block codes with a complete overview on currently most used channel coding techniques and illustrates error correction coding techniques used in DVB systems like BCH and LDPC codes including their encoding and decoding procedures.

Chapter 3:

It focuses on polar codes and gives a literature review about it and briefly presents its construction, encoding, decoding, and some related preliminaries. We propose a new mathematical relation to get the optimized design point for the polar code construction. Also, it presents

polar code construction, which depends on two main foundation criteria which are kernel matrix and Bhattacharyya parameter related to each other; therefore the selection method for both should optimize the polar code's performance. Firstly, derivation of the expressions of the Bhattacharyya parameter bounds is proved and a method to select between different kernel matrices to achieve optimum capacity is introduced. Then, it presents the decoding method for the selected 3×3 kernel matrix including the proof of recursive channel transformations for this matrix. Moreover, it shows a detailed discussion about the polar code complexity. Finally, the simulation results are presented to confirm the results of the selection methodology.

Chapter 4:

It proposes a generalized schematic successive cancellation decoding for polar codes. Our proposed method fragments the main block into some basic components whose formulas have been previously proven by Arikan for 2×2 kernel matrix. The validity of the resulting LLR functions is tested on different kernel matrices and proven to be similar to those in literature. Finally, it presents the simulation results using Cyclic redundancy check Aided - Successive Cancellation List (CA-SCL) decoding and compare the generalized polar codes with punctured polar codes.

Chapter 5:

It presents an overview for the simulation system model for simulation measurements including the simulation results for optimized design point of polar codes followed by the comparison between LDPC and optimized polar codes. Then, it presents an overview for DVB standards and proposes polar codes to be utilized in DVB systems

by describing the proposed functional block that are changed to enhance the performance of DVB systems. Moreover, the optimized polar codes are compared with LDPC and BCH codes of DVB systems in terms of BER, latency, throughput and proved that it can be proposed as a FEC coding technique instead of LDPC and BCH codes in wireless communication systems such as DVB systems. Finally, it compares the complexity of polar code with (LDPC + BCH) codes.

Chapter 6:

It shows the main thesis conclusions and ends with suggestions for future work.