A Review of High Throughput Polar Encoder

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Abstract - *In recent years the polar codes have become insane popular due to channel achieving capacity specifically in symmetric binary memoryless channels hence also become the most favorable error correcting codes. The polar codes are constructed using the method of channel polarization, the channel capacity has been achieved asymptotically. In polar code transmission, the channel is divided into the two sections: complete noisy and noiseless channels. Inspired by the rapid progress of polar codes, we propose a pipelined architecture for the FPGA implementation of polar code encoding.*

Key Words: **Polar codes, channel achieving capacity, error correcting codes, channel polarization, FPGA.**

1.INTRODUCTION

In digital communication theory, the errors have been observed while retrieving the transmitted data which are introduced due to the noise. To suppress the effect of noise use of error-correcting codes is advisable. From single error in the recovered bit sequence to long length the probability of getting errors in the recovered bit sequence also increases to suppress such errors error correcting codes like Hamming code, LDPC code, turbo code, Polar code are used. In information theory, the points to take into consideration are compression, errorless transmission, and the channel capacity. The symmetric capacity I(w) of any given Binary discrete memoryless channel can be achieved by the code sequence constructed using the method of channel polarization. The symmetric capacity can be defined as the highest rate achievable subject to using the input letters of the channel with equal probability. The main motivation is to come across a family of codes that are provably capacity achieving. Polar codes are noticeable due to its recursive structure which leads to low complexity encoding and decoding algorithm. The basic idea behind the polar coding can be explained as think of two channels let they are close to each other with respect to some metric; typically probability of error but many times mutual information. Hence the main requirement is the approximated channel must be a “pessimistic” version of the true channel so that the approximated set of good channels will be a subset of the true set. When compared with the complementary codes, polar codes achieve better error correcting performance when code length ranging from 2^8 to 2^{16}, also 16384 bytes is the normal memory requirement when a typical message is protected by the polar error correcting codes or termed polar coding.

Consider, W(X, Y) be a generic B-DMC with input alphabet X, output alphabet Y and transition probabilities W(y|x), x ϵ X, y ϵ Y. Since the channel is binary input would be always {0,1} the output alphabet and the transition probabilities may be arbitrary. To measure the rate and reliability Symmetric capacity and the Bhattacharya parameter are used:

Symmetric capacity:

$$I(W) \triangleq \sum_{y\epsilon Y}\sum_{x\epsilon X}\frac{1}{2}W(y|x)log\frac{W(y|x)}{\frac{1}{2}W(y|0)+\frac{1}{2}W(y|1)}$$

Bhattacharya parameter:

$$Z(W) \triangleq \sum_{y\epsilon Y}\sqrt{W(y|0)W(y|1)}$$

Where I(W) is the highest rate at which reliable communication is possible across W using the inputs of W with equal frequency.

1.1 Problem Formulation

Designing a polar code is almost an analogous task to find out the set of good indices.

The output alphabet of $W_N^{(i)}$ is $Y^{N*}\{0,1\}^i$.

The number of output alphabet for a particular channel at level n is exponential in the block length. Hence the exact computation of the transition probabilities becomes unmanageable and hence there is need of some efficient method to approximate these channels.

Quantization is a method that can be helpful in estimating the Bhattacharyya parameter. But in the quantization method, there is the occurrence of the quantization error which can be defined as the difference between the true set of good indices and the approximate set of good indices. Hence a suitable formulation of the quantization problem is to introduce the various methods to replace each channel say (p) with $(\bar{p})$, where $\bar{p}$ is polar degraded with respect to p such that the number of output alphabets is limited to number of channels, the set of good indices obtained with this procedure is a subset of the true set of good indices obtained from the channel polarization.

Algorithms for Quantization:

To compute the Bhattacharyya parameter the method of quantization can be implemented by using various algorithms

2. METHODOLOGY

Mainly the polar code makes the use of the phenomenon of channel polarization that each channel tends to approach perfectly reliable or completely noisy channel. For the process of encoding of polar code, it's important to take into consideration that they belong to linear block codes. While implementing the polar code encoder it is prime important to make it less complex. From the available data the size of a message protected by an error-correcting code in storage is 4096 byte and also presumed that it will rise to 8192 bytes in near future, as per the literature reviewed it is true that polar codes are associated with the less complexity but while dealing with the considerable size of long polar codes, it is seen that it suffers from severe hardware complexity and long latency.

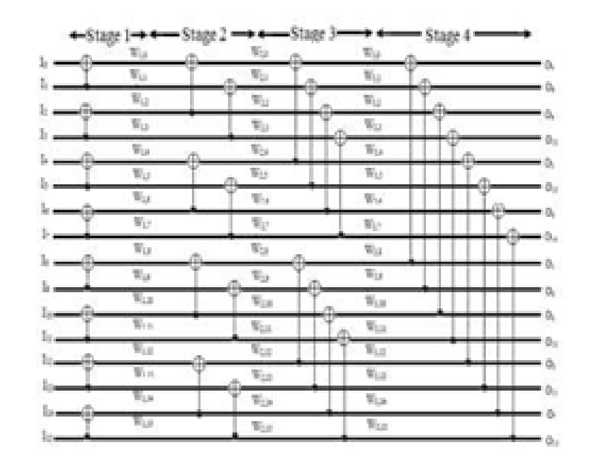

Fig.1 Fully parallel 16-bit polar encoder architecture [1]

As mentioned the code length solely increases the hardware complexity. So as to make implementation feasible another approach has been taken into consideration i.e. partially parallel polar code encoder.

3. CONCLUSIONS

In this paper, we have taken into consideration the implementation of the polar encoder using the partially parallel architecture, which in turn leads to our main objective of reducing hardware complexity for long length polar codes. From the future perspective, we have thought of providing the pipelined architecture so as to achieve optimum hardware with less number of resources used.

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