International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 7 (August 2014) http://ijirae.com

A Review on Performance Analysis on LOG-MAP & SOVA DECODER

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Abstract—*SOVA and log-MAP turbo decoding algorithms are the two prime candidates for decoding turbo codes. They share common operations, making feasible a reconfigurable SOVA/log-MAP turbo decoder for reduced power consumption. Using a common scaling factor in the extrinsic information calculation of both algorithms can improve performance with minimal effort. The scaling factor is independent of the signal to noise ratio. Simulations with the 3GPP parameters over AWGN and uncorrelated Rayleigh fading channels, show improvements over standard algorithms of up to 0.22 dB and 0.5 dB for log-MAP and SOVA respectively.*

***Index Terms*—Turbo-code, Decoder, Log-Map, SOVA, AWGN**

I. INTRODUCTION

Communication systems, like computer fields, the information is represented as a sequence of binary digits. The binary message is modulated to an analog signal and transmitted over a communication channel affected by noise that corrupt the transmitted signal. The channel coding is used to protect the information from noise and to reduce the number of error bits. One of the most used channel codes are convolution codes, with the decoding strategy based on the Viterbi algorithm. The advantages of convolution codes are used in Turbo Codes (TC), which can achieve performances within a 2 dB of channel capacity [1]. These codes are parallel concatenation of two Recursive Systematic Convolution (RSC) codes separated by an interleaver. The performances of the turbo codes are due to parallel concatenation of component codes, the interleaver schemes and the iterative decoding using the Soft Input Soft Output (SISO) algorithms [2], [3]. In this paper we study the decision reliability problem for turbo coding schemes in the case of two different decoding strategies: Maximum A Posteriori (MAP) algorithm and Soft Output Viterbi Algorithm (SOVA). Instead of repeating some form of the received information, the user decodes the partner's transmission and transmits additional parity symbols according to some overall coding scheme. This method maintains the same information rate, code rate, bandwidth, and transmit power as a comparable non-cooperative system. As a consequence of this, coded cooperation exhibits a graceful degradation behavior such that in the nastiest case it always performs at least as well as an analogous non-cooperative system. This is a considerable development over the previous methods.

Through these analyses, we differentiate the performance of coded cooperation, and exhibit the impressive gains it provides relative to a comparable non-cooperative system. Co-operation leads to interesting trade-offs in code rates and transmit power. In the case off power, one may argue on one hand that more power is needed because each user, when in cooperative mode is transmitting for both users. On the other hand, the baseline transmits power for both users will be reduced because of diversity. In the face of this trade-off, one hopes for a net reduction of transmit power, given everything else being constant. In cooperative communication, each user transmits both its own bits as well as some information for its partner, so it may appear that each user requires more bandwidth. Even amplify-forward and decode-forward techniques were already shown to be significant, there has not been an equivalent study on coded cooperation using turbo decoder. In this work we use coded cooperation using turbo decoder to obtain better Performance.

II. DECODING OF TURBO CODES

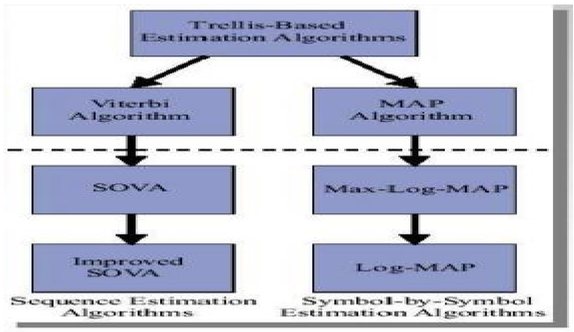

Figure 1. Below shows the various decoding algorithms available for decoding of turbo codes.

All the algorithms are based upon the trellis-based estimation. The trellis based estimation algorithms are classified into two types. They are sequence estimation algorithms and symbol-by-symbol estimation algorithms. The Viterbi algorithm, SOVA (soft output Viterbi algorithm) and improved SOVA are classified as sequence estimation algorithms

The MAP, SOVA, LOG-MAP, MAX-LOG-MAP, improved SOVA, all these algorithms produce soft-outputs. The Viterbi algorithm is a hard-decision output decoding algorithm. SOVA is soft-output producing viterbi algorithm.

III. IMPROVED SOVA

It is known that the performance of a SOVA (soft output Viterbi algorithm) turbo decoder can be improved, as the extrinsic information that is produced at its output is over optimistic. A new parameter associated with the branch metrics calculation in the standard Viterbi algorithm is introduced that affects the turbo code performance. Different parameter values show a simulation improvement in the AWGN channel as well as in an uncorrelated Rayleigh fading channel.
There are different efficient approaches proposed to improve the performance of soft-output Viterbi algorithm (SOVA)-based turbo decoders. In the first approach, an easily obtainable variable and a simple mapping function are used to compute a target scaling factor to normalize the extrinsic information output from turbo decoders.

IV SYSTEM MODEL

The system model that is used for the simulations is shown in Figure 2. The 3GPP standard parameters are used [8]. The information bits (or symbols) ui are grouped into frames whose length must be ³40 and £5114. The output bits of the turbo encoder are then modulated using a Binary Phase Shift Keying (BPSK) modulator. The output of the BPSK modulator yk is multiplied by fading amplitudes ak and noise nk is added to produce the received value rk. This value is not quantized; therefore floating point arithmetic is used. Then rk is BPSK demodulated and turbo decoded. The output of the
Turbo decoder is an estimate ui´ of the information bit ui

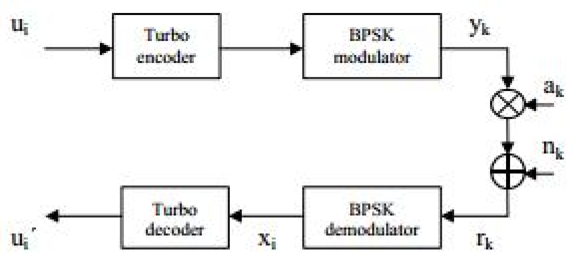

Figure 2: System model

Encoder

The turbo encoder [1], [7], [9] is made up of two ½ rate Recursive Systematic Convolutional (RSC) encoders, each with constraint length K=4 and octal polynomials 13 (feedback) and 15 (redundancy). The two encoders are concatenated in parallel and separated by an interleaver with parameters as specified in [8]. The rate of the encoder is 1/3. Furthermore, the two RSC encoders of the turbo encoder are left open (no tail bits used).

Channel

The encoded bits are transmitted as shown in Figure 1. With appropriate sampling, the discrete representation of this channel is rk=akyk+nk where k is an integer bit index (here k=3i: every symbol has 3 bits), yk is a BPSK symbol amplitude and nk is a AWGN component with zero mean and power spectral density N0/2. The variable ak is a fading amplitude that may vary from code bit to code bit. When the AWGN channel model is used ak=1 for all code bits.

Decoder

A simplified diagram of the turbo decoder [1], [7], [9] showing the compensation operation, without details of interleaving and deinterleaving, is presented in Figure 2. Turbo decoding is performed iteratively, with each SISO decoder using information from the previous step. Eight iterations are used in the decoder and no quantization is used at the reception of the data. The symbol s denotes the scaling factor.

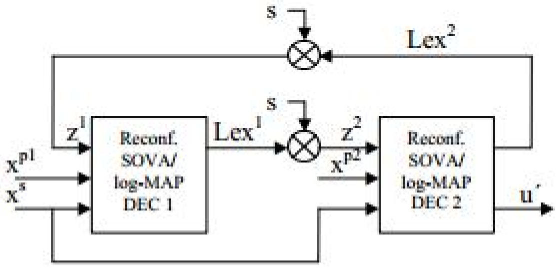

Figure 3: Turbo decoder diagram

V. CO-OPERATIVE SIGNALING METHODS

A.Amplify-and-Forward

Amplify-and-forward is conceptually the most simple of the cooperative signaling methods? Each user in this method receives a noisy version of the signal transmitted by its partner. As the name implies, the user then amplifies and retransmits this noisy signal. The destination will combine the information sent by the user and partner and will make a final decision on the transmitted symbol. Although the noise of the partner is amplified in this scheme, the destination still receives two independently-faded versions of the signal and is thus able to make better decisions for the transmitted symbols

B. The Decision Reliability of MAP Decoder

Bahl, Cocke, Jelinek and Raviv proposed the Maximum a Posteriori (MAP) decoding algorithm for convolutional codes in 1974 [1]. The iterative decoder developed by Berrou et al. [5] In 1993 has a greatly increased attention. In their paper, they considered the iterative decoding of two RSC codes concatenated in parallel through a non-uniform interleaver and the MAP algorithm was modified to minimize the sequence error probability instead of bit error probability. Because of its increased complexity, the MAP algorithm was simplified in [6] and the optimal MAP algorithm called the Log-MAP algorithm was developed.

The SOVA algorithm described in this section is the least complex of all the SISO decoders discussed in this section. In [12], Robertson shows that the SOVA algorithm is about half as complex as the Max-Log-MAP algorithm. However, the SOVA algorithm is also the least accurate of the algorithms described in this section and, when used in an iterative turbo decoder, performs about 0.6 dB worse than a decoder using the MAP algorithm. If we represent the outputs of the SOVA algorithm they will be significantly noisier than those from the MAP algorithm, so an increased number of decoding iterations must be used for SOVA to obtain the same performances as for MAP algorithm.

The same results are reported also for the iterative decoding (turbo decoding) of the turbo product codes, which are based on two concatenated Hamming block codes not on convolutional codes [19]. The Max-Log-MAP algorithm has the same linearity that is found in the SOVA algorithm. Instead of one metric, now two metrics and are calculated, for forward and backward recursions, see (17), (18) and (19), were are used only simple additions of the cross-correlation of the transmitted and received symbols. But, if an incorrect value of the channel reliability value is used, all the metrics are simply scaled by a factor as in the SOVA algorithm. The soft outputs given by the differences in metrics between different paths will also be scaled by the same factor, with the sign unchanged and the final hard decisions given by the turbo decoder will not be affected. In the iterative decoding with Log-MAP algorithm, the extrinsic information exchange from one component decoder to another, determines a rapid decrease in the BER as the number of iterations increases. When the incorrect value of is used, no such rapid fall in the BER occurs due to the incorrect scaling of the a priori information relative to the channel inputs. In fact, the performance of the decoder is largely unaffected by the number of iterations used. For wireless communications, some of them modeled as Multiple Input Multiple Output (MIMO) systems [23], the channel is considered to be Rayleigh or Rician fading channel.

If the Channel State Information (CSI) is not known at the receiver, a natural approach is to estimate the channel impulse response and to use the estimated values to compute the channel reliability factor required by the MAP algorithm to calculate the correct decoding metric. In [20], the degradation in the performance of a turbo decoder using the MAP algorithm is studied when the channel
SNR is not correctly estimated. The authors propose a method for blind estimation of the channel SNR, using the ratio of the average squared received channel value to the square of the average of the magnitudes of the received channel values. In addition, they showed that using these estimates for SNR gives almost identical performances for the turbo decoder to hat given using the true SNR

VI. CONCLUSIONS

We analyzed the performance of log-map and SOVA over the AWGN and fading channels. We observed that for both fading channels and the AWGN channels the performance of log-map algorithm is superior as compared to the SOVA. It has been verified by the simulation results that the proposed modification to the fixed scaling factor method gives improved results of the performance of SOVA. We observe that removing the scaling factor for the last iteration improves the performance of SOVA algorithm further. These results will be helpful in designing Turbo codes with reduced decoding latency particularly in fourth and higher generation mobile communication system

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