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Coded Cooperation In Turbo-Code Using Log-Map Decoder

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Abstract:

The user cooperation technique called, coded cooperation, where cooperation is achieved through channel coding method using turbo decoder. Each code word is partitioned into two subsets that are transmitted from the user's and partner's antennas respectively. Coded cooperation achieves impressive gains compared to a non-cooperative system while maintaining the same information rate, transmit power and bandwidth. In this paper we have analyzed the performance of the Log-Map (log-maximum a posteriori probability) for the Turbo Decoder. The various decoding algorithms are available for decoding of turbo codes. The performance of log-map over the AWGN channel is obtained. The BER and SNR performances of Log-Map are compared. It has been verified by the simulation results that the proposed adaption to the fixed scaling factor method gives enhanced results of the performance of Log-Map. The performance of SOVA (Soft Output Viterbi Algorithm) for turbo decoder to be analyzed. The performance of SOVA will be compared to the Log-Map over the AWGN channel. Using coded cooperation method gives superior performance than existing method like amplify-and-forward, decode-and-forward. Simulations of this work will be in MATLAB.

Key words: *Turbo-code, Decoder, Log-Map, SOVA, AWGN*

1. Introduction

Cooperation between pairs of wireless communication achieves (1,2,3,6),diversity by a signaling plot that allows two single-antenna mobiles (users) to send their information using both of their antennas. the basic approach to the cooperation has been for a mobile to “listen” to a partner’s transmission, and in a diverse time or frequency slot to retransmit either an amplified version of the received signal (amplify-and-forward) or a decoded version of the received signal decode-and-forward (7).The user might simply forward the analog signal received from its partner, a technique known as amplify-and-forward. Alternatively, the user may retransmit estimates of the received symbols, obtained via hard detection this technique is generally as decode- and-forward. This paper presents a user cooperation methodology called coded cooperation, where cooperative signaling is integrated with channel coding method using turbo decoder.

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 a 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.

1.1.Cooperative Communication

In cooperative wireless communication, we are anxious with a wireless network or ad hoc variety, where the wireless agents, which we call users, might increase their effectual quality of service (measured at the physical layer by bit error rates, block error rates, or outage probability) via cooperation. In a cooperative communication scheme each wireless abuser is assumed to broadcast data as well as act as a cooperative agent for another user (Fig. 1).

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 his/her own bits as well as some information for his/her partner; one might think this causes loss of rate in the system. However, the spectral efficiency of each user improves because; due to cooperation diversity the channel code rates can be increased. Again a tradeoff is observed. The key question, whether cooperation is worth the incurred cost, has been answered positively by several studies, and is demonstrated by plots toward the end of this article.

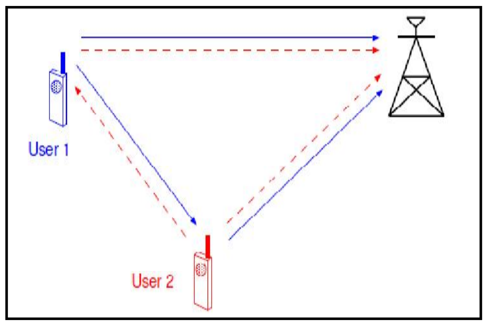

Figure 1: Cooperative Communication

2. Existing Methods

2.1.Amplify-And-Forward

Amplify-and-forward is conceptually the most simple of the cooperative signaling scheme. 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 merge 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 separately-faded versions of the signal and is thus able to make enhanced decisions for the transmitted symbols. A potential challenge in this scheme is that sampling, amplifying, and retransmitting analog values may be technologically non-trivial. Nevertheless, amplify-and-forward is a simple method that lends itself to analysis, and therefore has been very practical in furthering the understanding of cooperative communication systems (3).

Laneman first proposed amplify-and-forward as a cooperative signaling scheme. In this work, they compute the bit error rate (BER) for uncodedsymbol-wise amplify-and-forward, and demonstrate that, despite the noise propagation from the partner, amplify-and-forward performs significantly superior than non-cooperative transmission.

2.2.Decode-And-Forward Method

This method a user attempts to detect the partner's bits and then retransmits the detected bits. The partners may be assigned equally by the base station, or via some other technique. For the purposes of this tutorial we consider two users partnering with each other, but in reality the only important factor is that each user has a partner that provides second (diversity) data path. The easiest way to visualize this is via pairs, but it is also possible to achieve the same effect via other partnership topologies that remove the strict constraint of pairing. Partner assignment is a rich topic whose details are beyond the scope of this introductory article.

To avoid the problem of error propagation, Lanemanet al proposed a decode-and-forward method where, at times when the fading channel has high instantaneous signal-to-noise ratio (SNR), users detect and forward their partners' data, but when the channel has low SNR, users revert to a non-cooperative mode.

2.3.Coded Co-operation

Coded co-operation (6,8) is a technique that integrates cooperation into channel coding. Coded cooperation works by sending different portions of each user's code word via two independent fading paths. The basic idea is that each user tries to transmit incremental redundancy to its partner. Whenever that is not possible, the users automatically revert to a non-cooperative mode. The key to the effectiveness of coded cooperation is that all this is managed automatically through code design, with no feedback between the users.

The users divide their source data into blocks that are augmented with cyclic redundancy check (CRC) code. In coded cooperation, each of the users' data is encoded into a codeword that is partitioned into two segments, containing N1 bits and N2 bits, respectively. Consider that the original codeword has N1 + N2 bits; puncturing this codeword down to N1 bits, we obtain the first partition, which itself is a valid (weaker) codeword. The remaining N2 bits in this example are the puncture bits. Of course, partitioning is also possible via other means, but this example serves to give an idea of the intuition behind coded cooperation.

The data transmission period for each user is divided into two time segments of N1 and N2 bit intervals, respectively. We term these time intervals frames. For the first frame, each user transmits a code word consisting of the N1-bit code partition. Each user also attempts to decode the transmission of its partner. If this attempt is successful (determined by checking the CRC code), in the second frame the user calculates and transmits the second code partition of its partner, containing N2 code bits. Otherwise, the user transmits its own second partition, again containing N2 bits. Thus, each user always transmits a total of N = N1 + N2 bits per source block over the two frames. We describe the level of cooperation as N2/N, the percentage of the total bits for each source block the user transmits for its partner. Figure illustrates the coded cooperation framework.

In general, various channel coding methods can be used within this coded cooperation framework. The code bits for the two frames may be selected through puncturing, product codes, or other forms of concatenation. To obtain the concert results given in this article, we utilize a simple but effective implementation using rate-compatible punctured convolutional (RCPC) codes [6]. In this implementation the Code word for the first frame is obtained by puncturing a code word of length N bits to obtain N1 code bits. The additional code bits transmitted in the second frame are those punctured to form the first frame code word.

The users act separately in the second frame, with no knowledge of whether their own first frame was correctly decoded. As a result, there are four possible cooperative cases for the transmission of the second frame: both users cooperate, neither user cooperates, user 1 cooperates and user 2 does not, and vice versa. Investigation of the effects of these four cases is beyond the scope of this article, and we refer the reader to the literature for more comprehensive treatment. We only note that the performance curves shown in this article include all the effects of the inter user channel. The coded cooperation framework is very flexible and can be used with virtually any channel coding scenario. The coded cooperation will develop the performance of the partner with the poor uplink SNR at the expense of the partner with the better uplink SNR. The code bits for the two frames may be selected through puncturing, product codes, or other forms of concatenation.

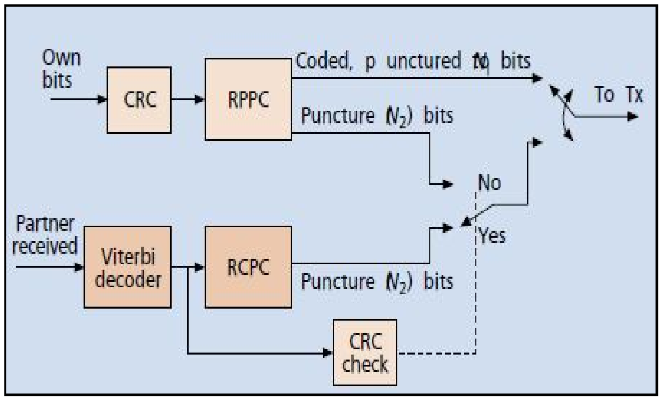

Figure 2: coded cooperation

3. Proposed Method

3.1.Coded Co-Operation-Turbo Decoder

In our system a user cooperation technique called coded- cooperation using turbo-decoder**.** Each codeword is transmitted from the user's and partner's antenna respectively. Coded cooperation has a graceful degradation compared to non-cooperative system. Generally it performs superior than other cooperative methods for moderate to high signal-to-noise ratio. Coded Cooperation achieves impressive gain which maintaining the same information rate, transmission power and bandwidth.

3.2.Turbo-Decoder

The fundamental Turbo code decoder is built with two identical recursive systematic convolutional (RSC) codes with analogous concatenation. These two component decoders are alienated by an interleaver. The interleaver changes the input sequence with a certain rule. Only one of the systematic outputs from the two component decoders is used because the systematic output from the other component decoder is just a permuted version of the chosen systematic output. Figure shows the fundamental Turbo code decoder. The first RSC decoder outputs the systematic V0 and recursive convolutional V1 sequences while the second RSC decoder rejects its systematic sequence and only outputs the recursive Convolutional V2 sequence.

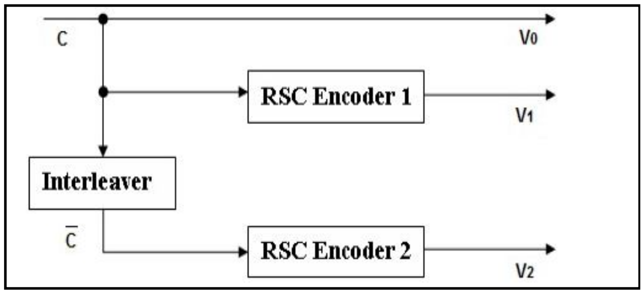

Figure 3: Turbo Decoder

3.3.Decoding Algorithm

The trellis based estimation algorithms are classified into two types. They are sequence estimation algorithms and symbol-by-symbol estimation algorithms (9,10). The Viterbi algorithm, SOVA (soft output Viterbi algorithm) and improved SOVA are classified as sequence estimation algorithms. Whereas the MAP algorithm, Max-Log-Map and the Log-Map algorithm are classified as symbol-by-symbol estimation algorithms. In general the symbol -by-symbol estimation algorithms are more complex than the sequence estimation algorithms but their BER performance is much enhanced than the sequence estimation algorithms. In this we have analyzed the performance of the Log-Map (log-maximum a posteriori probability) for the Turbo Decoder. The performance of log-map over the AWGN channel is obtained. The BER and SNR performances of Log-Map are compared.

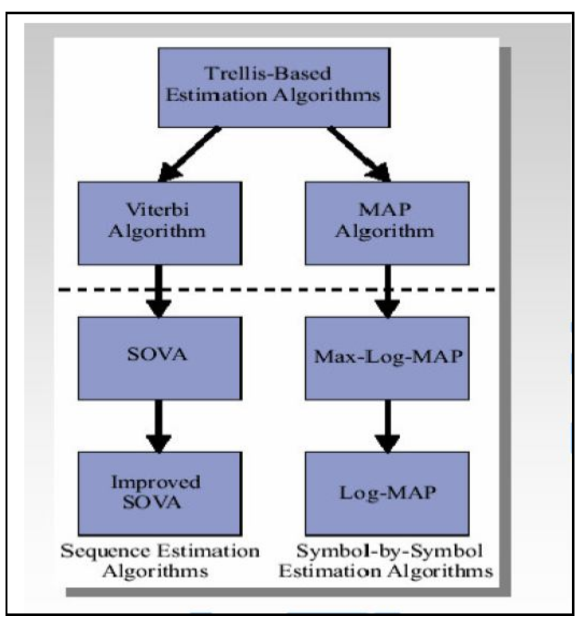

Figure 4: Decoding algorithms for turbo decoder

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 Log-Map. Simulations of this work will be in MATLAB .The simulation result is shown below.

4.Result

The figure5 shows the performance of various cooperative signaling methods. Here we analyzed the performance of Log-Map over the AWGN channel. This simulation compares the BER and SNR performance. 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 Log-Map. Using coded cooperation method it shows better performance than previous method like amplify-and-forward & decode-and-forward.

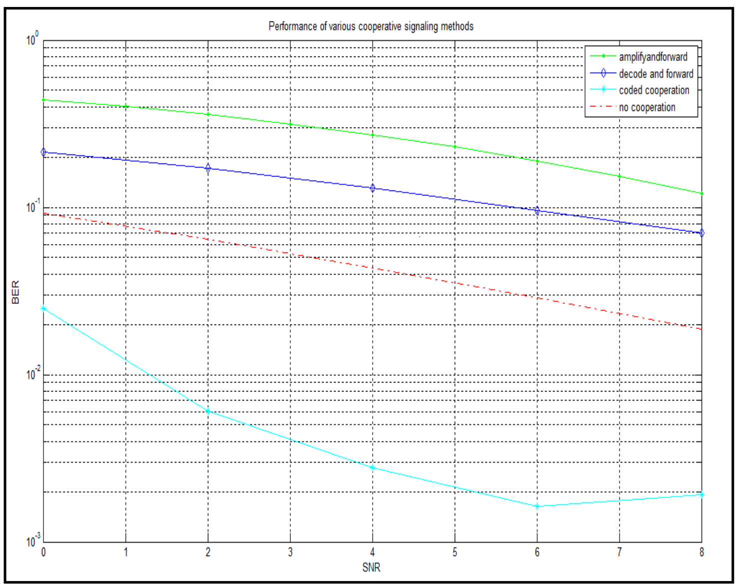

Figure 5: Comparing the performance of cooperative signaling methods

5.Conclution

In this system the co-operation is achieved through channel coding using turbo decoder by the method of coded co-operation. The performance of the log map algorithm for the turbo decoder is analyzed and found that the performance is high when compared with other decoding algorithmic techniques. The continue work will be given below.

- Explore the characteristics of coded cooperation technique using turbo decoder.
- To analyze the performance of SOVA (Soft Output Viterbi Algorithm) for turbo decoder.

- The performance of SOVA will be compared to the Log-Map.
- To compare the BER and SNR performance of SOVA over the AWGN channel.
- To show better performance of coded cooperation method using SOVA compared to the previous methods like amplify-and-forward & decode-and forward.

6.Acknowledgement

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