Performance Analysis of Turbo Code using EXIT Chart in Cooperative Communication

Nirali Mehta
M. Tech Scholar
NRI Collage of Science and Technology
Bhopal, Madhya Pradesh, India

Puran Gour
Prof. E C E Department
NRI Collage of Science and Technology Bhopal, Madhya Pradesh, India

ABSTRACT
Whenever size, power or other constraints precluded the use of multiple transmit antennas, wireless systems cannot benefit from the well-known advantages of space time coding methods. Cooperation between wireless users has been proposed as a means to provide transmit diversity in the face of this limitation. This paper firstly analyse an ad-hoc network with a sender, a destination and a third station acting as relay is analyzed. Secondly in this paper Cooperative communication is performed with various well-known codes like convolution code and Turbo code. Using convolution code with cooperative communication provides full diversity and excellent coding gain. Turbo code offer better performance than Convolutional coding, Punctured Convolutional coding, Alamouti Scheme. [3] The turbo like decoding algorithm generally does not converge to a maximum-likelihood solution, although it is able to it is able to provide a good performance in practice. In this paer mostly extrinsic information transfer charts is used as tool to analyze the convergence behavior. We first design a PCCC-ID scheme for the sake of achieving decoding convergence at low SNR, using EXIT charts. Then invoke this PCC-ID scheme for cooperative communication, where the source employ PCCC-ID encoder and the relay encoding, interleaving and re-encoding which is then combined at destination using MRC.[5]

1. INTRODUCTION
Cooperative communications is a new communication technique which allows single antenna mobiles to share their antennas and to produce virtual multiple antenna system. Each mobile has one antenna and cannot individually generate spatial diversity. However, it may be possible for one mobile to receive the other, in which it can forward some version of “overheard” information along with its own data. Because the fading paths from two mobiles are statistically independent, this generates transmit diversity. [17] Cooperation leads to interesting tradeoffs in code rates and transmit power. Cooperative communication with turbo code gives the best performance. Turbo code achieve near Shannon limit error correction performance with relatively simple component codes. Turbo coding is a forward error correction (FEC) schmem.Interative decoding is the key feature of turbo codes. Turbo code consists of concatenation of two convolution code. [9] Turbo codes give better performance at low SNR.

2. TURBO CODE
Turbo codes achieve near Shannon limit error correction performance with relatively simple component codes. Turbo coding is forward error correction (FEC) scheme. Iterative decoding is the key feature of turbo codes. Turbo codes consist of concatenation of two convolution codes. Turbo codes give better performance at low SNRs. [Reference – 3]

2.1 Turbo code encoder
Generally, as a basic encoder RECUSIVE CONVOLUTIONAL ENCODER9RSC0 is used. If the component encoder is not recursive, the unit weight input sequence (0 0 0 1 1 1…..) will always generate a low weight codeword at the input of the second encoder for any interleaver design. In other words, interleaver would not influence the output codeword weight distribution if the component encoders were not recursive. However, it the component encoders are recursive, a weight-1 input sequence does not yield the minimum weight codeword out of encoder. The encoder output weight is kept finite only by trellies termination, a process that forces the coded sequence to terminate in such away that the encoder returns to zero state. [9]

Using figure the parallel configuration for the turbo encoder is shown figure. Good turbo codes have been constructed form component codes having short constraint lengths (k=3 to 5).

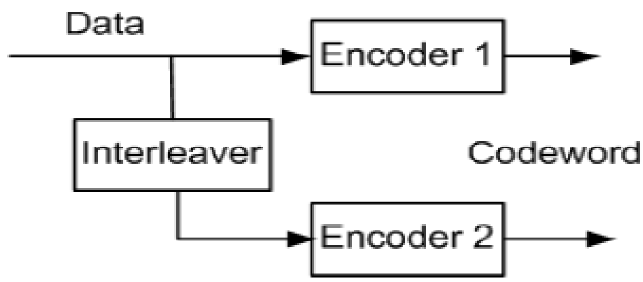

Fig 3: Turbo Encoder

2.2 Turbo Decoder
In typical communication receiver, a demodulator is often designed to produce soft decisions which are then transferred to a decoder. With Turbo codes, where two or more component codes are used and decoding involves feeding outputs from one decoder to the input of the other decoders in an iterative fashion Soft input soft output (SISO) decoder is used.

As shown in figure the output LLR of a systematic decoder can be represented as having three LLR elements. [19]

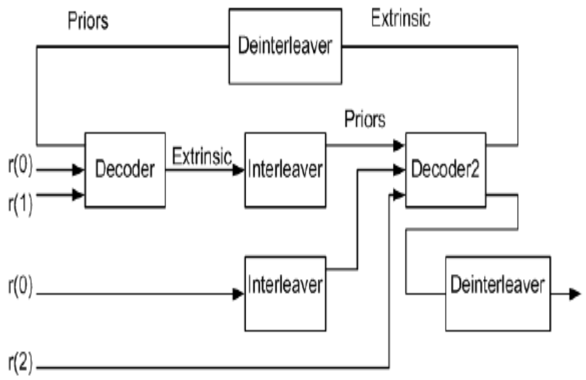

Fig 4: Block Diagram of Turbo decoder

The following the Block diagram of the turbo decoder. The received systematic bit and parity bit(r(0),r(1)) associated with the first encoder are fed to decoder1.This decoder initially uses uniform priors on the transmitted bits and produces probabilities are called the extrinsic probabilities of the bits conditioned on the observed data. The output probabilities of decoder 1 are interleaved and passed to decoder 2,where they are used as "prior" probabilities in the decoder, along with the data associated with the second encoder, which are received systematic bitr(0) and parity bitr(2). [14] The extrinsic output probabilities of decoder2 are deinterleaved and passed back to become prior probabilities to decoder 1.The process of passing probability information back and forth continues until the decoder determines that the process has converged, or until some maximum number of iterations is reached. [11]

2.3 Cooperative Diversity using turbo codes

Here, consider a single relay system, consisting of one source one relay and one destination. Following figure-5(a) gives a block diagram of the two-hop relay system with a direct link from the source to the destination. A block diagram of a parallel concatenated DTC system is shown in figure-5(b).

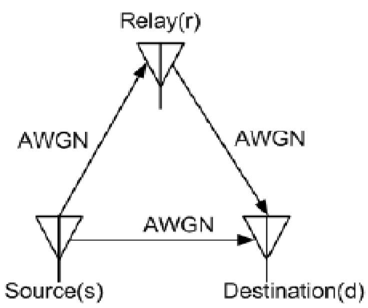

Fig 5- a: Cooperative diversity system

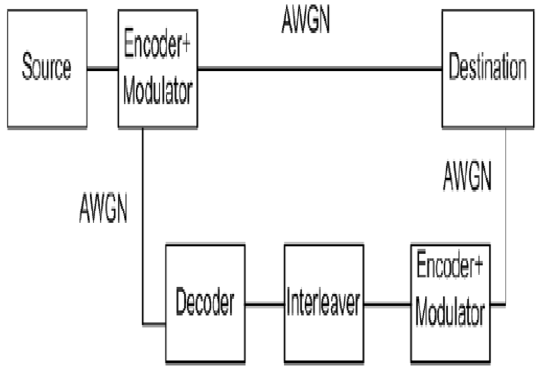

Fig 5 b: Block Diagram of a cooperative Communication with turbo code

3 TURBO CODE USING EXIT CHART

With Wide application of turbo principle originally invented for decoding concatenated codes, the EXIT charts has been a powerful tool to visualize the convergence behavior of iterative decoding process based on mutual information. The Extrinsic Information Transfer EXIT chart was _rst introduced by Stephan ten Brink in [12]. The EXIT chart was mainly introduced due to the problem that occurs with BER chart when iteratively decoding is that it gives bad performance at low SNR. [7]

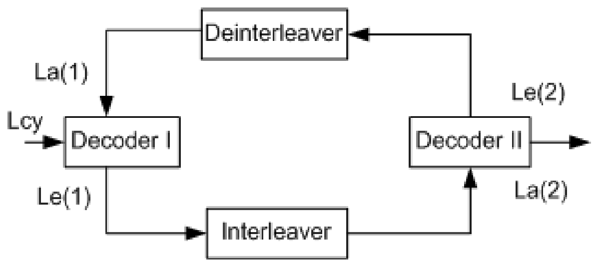

Figure 6 Iterative decoder for parallel concatenated codes

The iterative decoder for PCC is shown in Fig.4.2 For each iteration the two decoder soft-in/soft-out decoders that accept and deliver probabilities or soft values and extrinsic part of the soft-output of one decoder is passed on to other decoder to be used as a priori input. Thus it constitutes an iterative process with an information transfer between the two decoders which is analyzed using EXIT chart. For EXIT chart we require following parameters:

a. Mutual Information

b. Mutual information Transfer characteristics of iterative decoders

c. Combination of Transfer characteristics [13]

4. SIMULATION RESULT

The simulation results shows the EXIT chart for the system model described in this chapter, in which the relay plays the most important role i.e. relay decoding, inter-leaving and re-encoding is done. Eb/N0. The Eb/N0 value serves as a parameter to the curves. The BCJR algorithm is applied to a rate 1/2 recursive systematic convolution code of memory 4; the parity bits are punctured to obtain a rate 2/3 constituent code. The code polynomials (1010, 1110) is used. The influence of different code polynomials is for the prominent case of a memory 4 code. The (1001, 1111)-code provides good extrinsic output at the beginning, but returns diminishing output for higher a priori input. For the (1101, 1110)-code it is the other way round. The constituent code of the classic rate 1/2 PCC with polynomials (1110, 1010) has good extrinsic output for low to medium a priori input.[15]

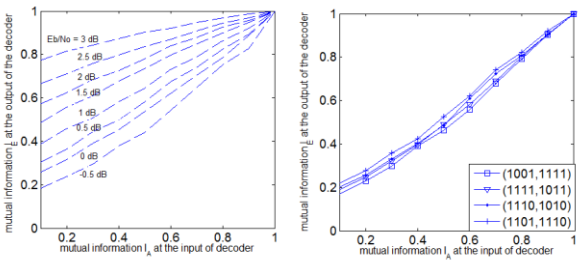

Fig7 Influence of Eb/No and code polynomial on transfer characteristics

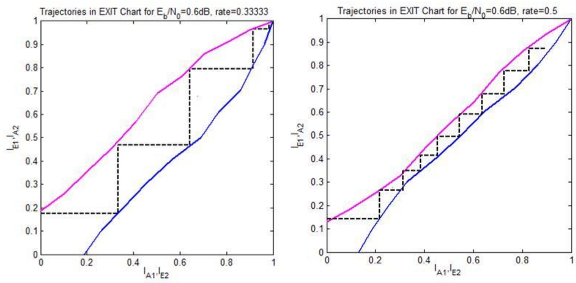

Figure 8: Exit chart for Eb/N0 = -0.2dB, rate = 0.33333 and Exit chart for Eb/N0= 0.6 dB, rate = 0.33333

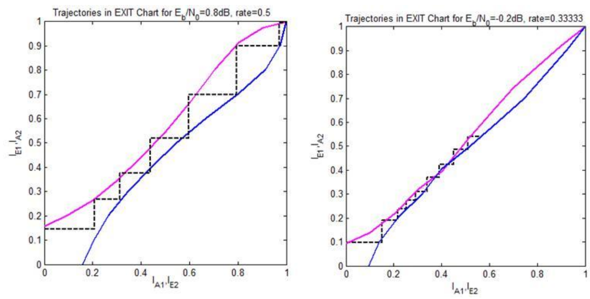

Figure 9: Exit chart for Eb/N0 = 0.6dB, rate = 0.5 and Exit chart for Eb/N0 =0.8dB, rate = 0.5

Fig.8 and Fig.9 shows the inuence of code rate on transfer characteristics. To account for the iterative nature of the suboptimal decoding algorithm, both decoder characteristics are plotted into a single diagram. However, for the transfer characteristics of the second decoder the axes are swapped. Thus from the results it shows that the rate=1/2 gives better performance as there is more convergence.[16]

6 CONCLUSIONS

We can use turbo code with EXIT chart in cooperative communication. It gives better performance in terms of BER and SNR. The EXIT chart can be used to obtain an estimate on the BER after an arbitrary number of iterations. We can analyze the performance of mutual information at the input and output of decoder of Turbo code with help of EXIT chart.

7 REFERENCES

[1] V. Tarokh, N. Seshadri, and A. R. Calderbank, "Space-time codes for high data rate wireless communication: Performance criterion and code construction," *IEEE Transactions on Information Theory*, vol. 44, pp. 744–765, March 1998.

[2] G. Foschini Jr. and M. Gans, "On limits of wireless communication in a fading environment when using multiple antennas," *Wireless Personal Communications*, vol. 6, pp. 311–335, March 1998.

[3] S. X. Ng and Hanzo, "On the MIMO Channel Capacity of MultiDimensional Signal Sets," *IEEE Transactions on Vehicular Technology*,vol. 55, pp. 528–536, March 2006.

[4] A. Sendonaris, E. Erkip and B. Aazhang, "User cooperation diversity part I: System description," *IEEE Transactions on Communications*, vol. 51(11), pp. 1927–1938, 2003.

[5] N. Laneman, D. N. C. Tse and G. W. Wornell, "Cooperative diversity in wireless networks: efficient protocols and outage behavior," *IEEE Trans. on Information Theory*, vol. 50, no. 12, pp. 3062–3080, 2004.

[6] E. Zimmermann, P. Herhold and G. Fettweis, "On the performance of cooperative relaying protocols in wireless networks," *European Transactions on Telecommunications*, vol. 16, no. 1, pp. 5–16, 2005.

[7] G. Forney, *Concatenated Codes*. MIT Press, 1966.

[8] C. Berrou and A. Glavieux, "Near optimum error correcting coding and decoding: Turbo codes," *IEEE Transactions on Communications*, vol. 44, pp. 1261–1271, October 1996.

[9] S. Le Goff, A. Glavieux, and C. Berrou, "Turbo-codes and high spectral efficiency modulation," in *IEEE International Conference on Communications*, (New Orleans, LA, USA), pp. 645–649, May 1994.

[10] S. Benedetto, D. Divsalar, G. Montorsi, and F. Pollara, "Bandwidth efficient parallel concatenated coding schemes," *Electronics Letters*, vol. 31, pp. 2067–2069, Nov. 1995.

[11] P. Robertson and T. W¨orz, "Coded modulation scheme employing turbo codes," *IEE Electronics Letters*, vol. 31, pp. 1546–1547, 31st August 1995.

[12] S. Benedetto, D. Divsalar, G. Montorsi, and F. Pollara, "Serial concatenated trellis coded modulation with iterative decoding," in *IEEE International Symposium on Information Theory*, (Ulm), p. 8, June/July 1997.

[13] S. Benedetto, D. Divsalar, G. Montorsi, and F. Pollara, "Selfconcatenated trellis coded modulation with self-iterative decoding," in *IEEE Global Telecommunications Conference*, vol. 1, (Sydney, NSW, Australia), pp. 585–591, 1998.

[14] S. ten Brink, "Convergence behavior of iteratively decoded parallel concatenated codes," *IEEE Transactions on Communications*, vol. 49, pp. 1727–1737, Oct. 2001.

[15] M. F. U. Butt, S. X. Ng, and L. Hanzo, "EXIT chart aided design of near-capacity self-concatenated trellis coded modulation using iterative decoding," in *67th*

IEEE Vehicular Technology Conference, VTC '08 Spring, (Marina Bay, Singapore), pp. 734–738, May 2008.

[16] M. F. U. Butt, R. A. Riaz, S. X. Ng, and L. Hanzo, "Near-capacity iteratively decoded binary self-concatenated code design using EXIT charts," in *IEEE Global Communications Conference, GLOBECOM '08*, (New Orleans, USA), Nov./Dec. 2008.

[17] B. Zhao and M. C. Valenti, "Distributed turbo coded diversity for relay channel," *IEE Electronics Letters*, vol. 39, pp. 786–787, May 2003.

[18] H, Ochiai, P. Mitran and V. Tarokh, "Design and analysis of collaborative diversity protocols for wireless sensor networks," in *Proceedings of IEEE VTC Fall*, (Los Angeles, USA), pp. 4645 – 4649, 26-29 September 2004.

[19] J. Hagenauer, "Rate-compatible punctured convolutional codes (RCPC codes) and their applications," *IEEE Transactions on Communications*, vol. 36, pp. 389–400, Apr. 1988.

[20] S. Benedetto, D. Divsalar, G. Motorsi, and F. Pollara, "A soft-input softoutput APP module for iterative decoding of concatenated codes," *IEEE Communication Letters*, pp. 22–24, 1997.

[21] L. Hanzo, S. X. Ng, T. Keller, and W. Webb, *Quadrature amplitude modulation: From basics to adaptive trellis-coded, turbo-equalised and space-time coded OFDM, CDMA and MC-CDMA systems*, pp. 746–748.