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Performance of Co-operative Communication Networks using Error Control

Archana Pandit[1] and Arnab Nandi[2*]

[1,2*]Dept. of ECE, Dr. B C Roy Engg. College, Durgapur, India
archana.rudra10@gmail.com, nandi_arnab@yahoo.co.in

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***Abstract*—**Signal transmission in Wireless Networks suffers considerably from much impairment, one of which is channel fading due to multipath propagation. Cooperative Communication is a technique which could be employed to mitigate the effects of channel fading by exploiting Diversity gain achieved via cooperation between nodes and relays. In this scenario, a network containing a sender, a destination and a relay is analyzed. Three cooperative communication schemes which include Amplify and Forward, Decode and Forward and Coded Cooperation are employed with different combining techniques are investigated. The idea behind Cooperative communication is to shows two mobile users communicating with the same destination. Each mobile has one antenna and cannot individually generate spatial diversity. However, it may be possible for one mobile to receive the others transmitting signal, in which case it can forward some version of "overheard" information of other users along with its own.

***Keywords/Index Term*—**Cooperative communications, Amplify and forward protocol, Decode-and- forward protocol, Symbol error rate · Rayleigh fading · LDPC coding. Convolution coding)

I. INTRODUCTION

In conventional point-to-point wireless communications, channel links can be highly uncertain due to multipath fading and therefore continuous communications between each pair of transmitter and receiver is not guaranteed [1]. Spatial diversity has been studied intensively in the context of point-to-point communications, where it is introduced by utilizing the multiple-input–multiple- output (MIMO) systems, i.e., multiple antennas at the transmitter and/or the receiver sides [5]. Recently, the concept of cooperative communications, a new communication paradigm, was proposed for wireless networks such as cellular networks and wireless ad hoc networks [2-4]. The basic idea of the cooperative communications is that all mobile users or nodes in a wireless network can help each other to send signals to the destination cooperatively. Each user's data information is sent out not only by the user, but also by other users. Thus, it is inherently more reliable for the destination to detect the transmitted information since from a statistical point of view, the chance that all the channel links to the destination go down is rare. Multiple copies of the transmitted signals due to the cooperation among users result in a new kind of diversity, i.e., cooperative diversity that can significantly improve the system performance and robustness. In this work, we propose method to enhance the capacity of wireless communication systems in small cells through the use of coding systems and cooperation between terminals. A wireless network system can traditionally be viewed as set of node trying to communicate with each other. However, from another point of view, because of the broadcast nature of wireless channels, one may think of those nodes as a set of antennas distributed in the wireless system. Transmission between these antennas suffers from much degradation which inspires Considerable research on how to effectively combat these negative effects that impair signal transmission. Some of these channel problems will be outlined for a clearer understanding of the Cooperative Communication methodology.

While evaluating the performance of coded modulation scheme based on LDPC codes and convolution codes we considered direct transmission over additive white Gaussian noise (AWGN) and flat Rayleigh fading channels. The main objective of this scheme is to achieve higher spectral efficiency while guaranteeing the same diversity order as that of the conventional cooperative scheme. To improve spectral efficiency, we introduced the two coding methods .

II. RELATED WORKS

A certain amount of research has recently been done to investigate various cooperative communication schemes in [4-5]. The system performance of cooperative schemes can further be improved if energy is optimally allocated across the collaborative system. In [6], the authors optimized energy allocation among relay nodes, with the objective of minimizing the link outage probability. It has to be noted that the collaborative pattern in [6] is deterministic. In [7], the authors presented an optimal power allocation scheme for a decode-and-forward cooperation protocol based on symbol error rate (SER) analysis. The results are for a two-node cooperation system, where the source and the relay need to know the link state information. With such channel state information (CSI) at both the source and the destination, the outage performance of different cooperative protocols has been analyzed in [8]. It is shown that power control could provide significant performance improvement.

Corresponding Author: *Arnab Nandi,* nandi_arnab@yahoo.co.in

For two node amplify-and-forward cooperation protocols, significant energy savings can be obtained through power control, provided that even only a few bits of quantized channel information are available at the source [9]. The analysis in [8]–[14] is based on the average power constraint where the average transmission power over all possible channel realizations is limited by a predefined value.

Some issues arise while using cooperative communication, such as how to select which relay(s) will be used to cooperate and how often they are reassigned. Compared to cooperative diversity schemes where all relays transmit their message to the destination concurrently, several recent results have demonstrated the performance and implementation advantages of one or a subset of relays assisting transmissions in a wireless network [10-12]. With relay selection, the complexity, synchronization, and overhead of the cooperative system are relaxed, leading to an increase in the spectral efficiency. The rest of this paper is organized as follows. In section II, we introduce a system model of the proposed cooperative wireless communication system which includes source destination and relay in a Rayleigh fading environment with AWGN. section 3 describes about the error correcting codes. The simulation model and MATLAB® simulation results of the proposed cooperative wireless communication system is presented in Section 4 and is followed by the conclusion in section 5

III. COOPERATIVE-COMMUNICATION SCHEMES

The most important cooperation signalling schemes are: detect and forward, amplify and forward and coded cooperation.

Detect and forward **-** In this method a user attempts to detect the partner's bits and then retransmits the detected bits. The partners may be assigned mutually by the base station, or via some other technique. This signalling scheme has advantage of simplicity and adaptability.

Amplify and forward **-**Another simple cooperative signalling is the amplify-and-forward method. 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 version. The base station combines the information sent by the user and partner, and makes a final decision on the transmitted bit. Although noise is amplified by cooperation, the base station receives two independently faded versions of the signal and can make better decisions on the detection of information. AF schemes provide spatial diversity to fight against fading; for capacity estimation of relay networks, such schemes provide achievable lower bounds that are known to be optimal in some communication scenarios; and for analog network coding, given the broadcast nature of the wireless medium that allows the mixing of the signals in the air, these schemes provide a communication strategy that achieves high throughput with low computational complexity at internal nodes.

Coded cooperation**-**In coded cooperation each of the users' data is encoded in codeword that's partitioned into two segments. Likewise the data transmission period is divided into two segments. Each user sends its codeword via two independent fading paths. The basic idea is that each user tries to transmit incremental redundancy to its partner when that is possible; otherwise the users revert to non-cooperative mode. The key to efficiency of coded cooperation is that all this managed automatically through coded design.

Different types of channel coding techniques can be used for coded cooperation. The code may be block or convolutional or combination of both. In addition cooperative relaying can be selectively where the partners choose a suitable cooperative or non-cooperative action according to the measured SNR between them. In coded co-operation [13] instead of repeating some form of the received information, the user decodes the partner's transmission and transmits additional parity symbols (e.g., incremental redundancy) according to some overall coding scheme. This framework maintains the same information rate, code rate, bandwidth, and transmit power as a comparable non-cooperative System. The users employ error checking (i.e., via cyclic redundancy check (CRC) code to avoid transmitting erroneous data for their partner. As a result of this, coded cooperation exhibits graceful degradation behaviour such that in the worst case it always performs at least as well as a comparable non-cooperative system.

IV. ERROR CONTROL CODES (ECC)

In wireless communication systems, errors in data transmission can come from many different sources (i.e., random noise, interference, channel fading and physical defects etc.). These channel errors must be reduced to an acceptable level to ensure reliable data transmission. To combat the errors, we normally use two strategies, either stand-alone or combined.

ECC are used for detecting the presence of errors and correcting them. It first adds redundancy (parity bits) to the message to be sent and form a codeword that contains both the message and the redundancy; this process is called encoding and is carried out at the transmitter. It then corrects errors based on the redundancy in a process called decoding that is performed at the receiver [15].

Several different types of ECC exist, but we may loosely categorize them into two families of codes. One is called block codes, which encode and decode data on a block-by-block basis where the data blocks are independent from each other. Block codes include repetition codes, Hamming codes [16], Reed Solomon codes, and BCH codes

In , another family of codes, namely, the convolution codes (works on a continuous data stream) and the LDPC coding are most popular in present scenario.

A. convolution coding

Convolution Codes Convolutional codes are characterized by thee parameters: (n, k, m) Where, n= Number of output bits k= Number of input bits m= Number of memory registers Code Rate = k/n =Number of input bits /Number of output bits Constraint length "L"= k (m-1) L represents the no. of bits in the encoder memory that affects the generation of n output bits. In cooperative communication, the cooperative code has to simultaneously carry information for the destination and the partner. Therefore, part of the code used to transfer information to the partner has to be a good code for the inter user channel.

In this scheme, each codeword of the source node is partitioned into two frames that are transmitted in two phases. In the first phase, the first frame is broadcast from the source to the relays and destination. In the second phase, the second frame is transmitted on orthogonal sub channels from the source and relay nodes to the destination. Each relay is assumed to be equipped with a cyclic redundancy check (CRC) code for error detection. Only these relays (whose CRCs check) transmit in the second phase. Otherwise, they keep silent. At the destination, the received replicas (of the second frame) are combined using maximal ratio combining. The entire code word, which comprises the two frames, is decoded via decoding algorithm. For cooperative channel coding, finite block lengths N has been considered for cooperative.

B. LDPC coding

Low-density parity-check (LDPC) codes, also known as the Gallager codes are a class of linear block error correction codes. LDPC codes were first discovered by Robert Gallager in the early 60s. For some reason, though, they were forgotten and the field lay dormant until the mid-90s when the codes were rediscovered by David MacKay and Radford Neal. Since then, the class of codes has been shown to be remarkably powerful, comparable to the best known codes and performing very close to the theoretical limit of error correcting codes. An LDPC code is an linear block code whose parity-check matrix *H* contains only a few 1's in comparison to 0's (i.e., sparse matrix). LDPC codes can also be represented by a bipartite Tanner graph, which was proposed by Tanner in 1981. A Tanner graph is a bipartite graph introduced to graphically represent LDPC codes. Nowadays LDPC coding is used in some modern applications such as 10Base-T Ethernet, Wi-Fi, Wi-Max, Digital Broadcasting

V. SYSTEM MODEL

A cooperative system could be considered as a virtual antenna array, where each antenna in the array corresponding to one of the partners who can overhear each other's, process and retransmit to cooperate. This provides additional observations, of the transmitted signal, at destination, the observation which usually discarded and disappeared in space.

Motivated by all the above cooperative communication involve two main ideas

- Use relay (multi-hop) to form a system that provide spatial diversity in fading environment.
- Envision a virtual antenna array system where each relay (partner) has information to send as well as acting as relay for the other partners.

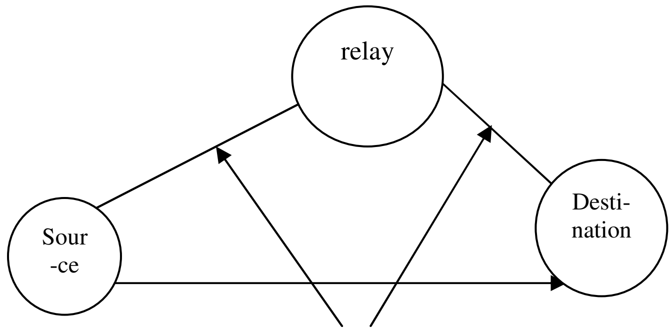

Fig. 1. Simplified co-operative communication system

We consider an arbitrary N -relay wireless network, where information is to be transmitted from source to a destination. Due to the broadcast nature of the wireless channel, some relays can overhear the transmitted information and thus can cooperate with the source to send its data. The wireless link between any two nodes in the network is modeled as a Rayleigh fading narrowband channel with additive white Gaussian noise (AWGN). The channel fades for different links are assumed to be statistically independent. This is a reasonable assumption as the relays are usually spatially well separated. The additive noise at all receiving terminals is modeled as zero-mean complex Gaussian random variables with variance N_o.

The cooperation strategy we are considering employs a selective decode-and-forward protocol at the relaying nodes. Differently to the conventional direct transmission system, we exploit a time division relaying function where this system can deliver information with two temporal phases.

On the first phase, the source node broadcasts information x_s toward both the destination and the relay nodes. The received signal at the destination and the relay nodes are respectively written as:

$$r_{,d_s} = h_{d_s} x_s + n_d, s \quad (1)$$

$$r_{r,s} = h_{r,s} x_s + n_{r,s} \quad (2)$$

Where h_d, s is the channel from the source to the destination nodes, $h_{r,s}$ is the channel from the source to the relay node, $n_{r,s}$ is the noise signal added to $h_{r,s}$ and $n_{d,s}$ is the noise signal added to $h_{d,s}$. On the second phase, the relay can transmit its received signal to the destination node except the direct transmission mode.

Each relay can measure the received SNR and forwards the received signal if the SNR is higher than some threshold. For mathematical tractability of SER calculations, we assume the relays can judge whether the received symbols are decoded correctly or not and only forwards the signal if decoded correctly; otherwise, it remains idle. This assumption will be shown via simulations to be very close to the performance of the practical scenario of comparing the received SNR to a threshold, especially when the relays operate in a high SNR regime, as, for example, when the relays are selected close to the source node. The rationale behind this is that when the relays are closer to the source node, or more generally operate in a high SNR regime, the channel fading becomes the dominant source of error , and hence measuring the received SNR gives a very good judgment on whether the received symbol can be decoded correctly or not with high probability.

Assumptions:

From the figure above, (fig: 1.1) we are assuming

Source node, destination node and a neighboring node working as a relay to the source signal. The source transmits to destination through direct path and indirect (relay) path.

- The transmission channel is assumed to be a non-selective (flat) fading channel in which all frequency components are affected by the same fading coefficients.
- The source transmits binary symbols. Coding technique is used in order to reduce errors of received signal and minimize the effect of noise and fading.
- The noise at receiver is assumed to be White Additive Noise with Gaussian distribution of zero mean and variance $N_0/2$.

VI. SIMULATION MODEL AND RESULTS

In order to measure the performance of the cooperative communication system we used MATLAB programming tool to simulate a repetition-code cooperative system. We simulate the system shown in figure 1.1 which is consist of source to transmit packet symbols, relay work on cooperation mode to receive the symbols that sent by transmitter, in the first time slot, and then retransmit them towards destination, in the second time slot. The third part in this system is the destination which receives the packet symbols that sent by source and relay respectively. Here, a Rayleigh flat fading channel is assumed and the power is considered as constant in the whole environment.

In order to know the benefits that cooperative communications technique holds over non cooperative communications, we first measured the performance of non-cooperative systems that using coding method.

In each case we count the probability of error as a function of signal to noise ratio (SNR).

The basic work we are doing is,

- Generate random binary sequence of +1's and -1's
- Multiply the symbols with the channel and then add white Gaussian noise
- At the receiver side the channel received by each receive antenna is independent from the channel experienced by other receive antenna
- After receiving the signal we, perform hard decision decoding and count the bit errors.
- Repeating for multiple values of E_b/No and plot the simulation results .

In a communication system, the receiver side BER may be affected by transmission channel noise, interference, distortion, bit synchronization problem, attenuation, fading, etc .BPSK is coherence as the phase transitions occur at the zero crossing points. The proper demodulation of BPSK requires the signal to be compare ,to a sine carrier of the same phase. BPSK is the simplest form of phase shift keying (PSK). In BPSK, individual data bits are used to control the phase of the carrier. During each bit interval, the modulator shifts the carrier to one of two possible phases, which are 180 degrees

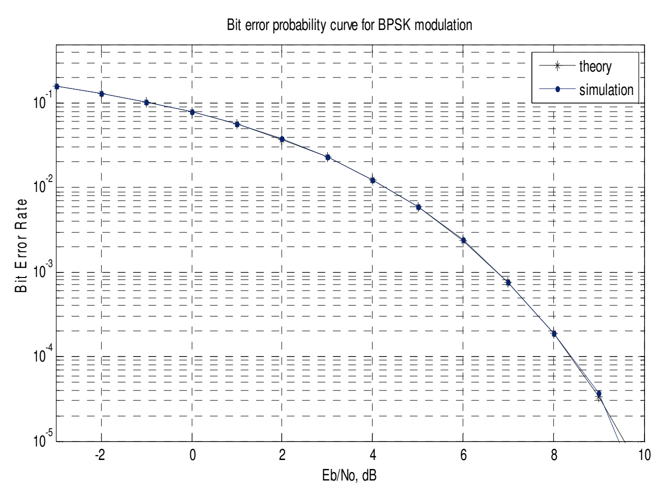

Fig. 2. Bit error probability curve for BPSK modulation

In the above figure, bit error rate (BER) with binary phase shift keying (BPSK) modulation scheme in the presence of

Additive White Gaussian Noise (AWGN) channel has been done. The graphical results prove that simulated BER of BPSK is same as that of theoretical BER of BPSK.

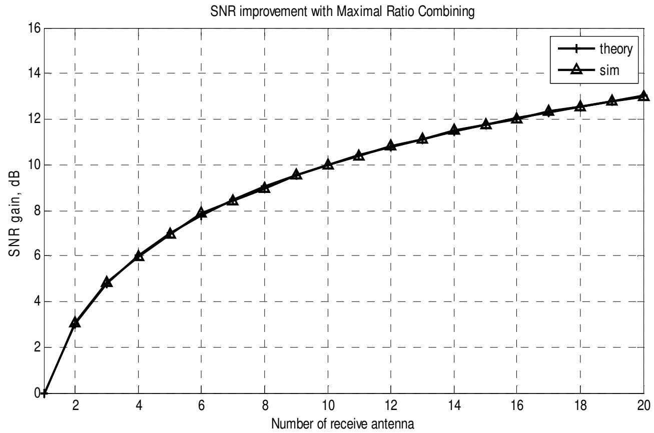

Fig. 3. SNR improvement with MRC

SNR improvement in Rayleigh fading channel with Maximum Ratio Combining has been simulated in Matlab. Above, we can see when the number of receive antenna is 20 the SNR is approximately at 12 this shows as the number of receiver increases the SNR getting improved.

While stimulating this we ,have considered N receive antenna and one transmit antenna, in a flat fading channel. BER for BPSK modulation in Rayleigh fading channel using Maximum Ratio combining has been simulated. Here, we are using two receivers and so we are getting better results for lesser SNR values. In order to get the bit error rate for BPSK with Rayleigh fading channel we,assume that the channel is flat fading and is randomly varying in time. BPSK with Rayleigh fading channel shows better results when compared to its performance in AWGN channel

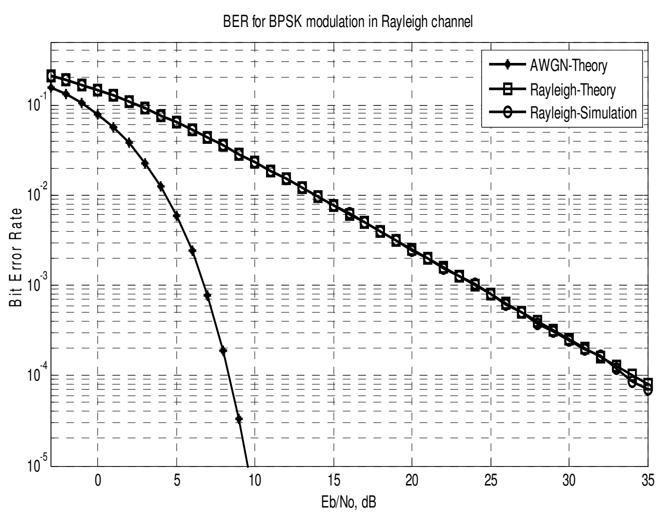

Fig. 4. BERfor BPSK modulation in Rayleigh channel

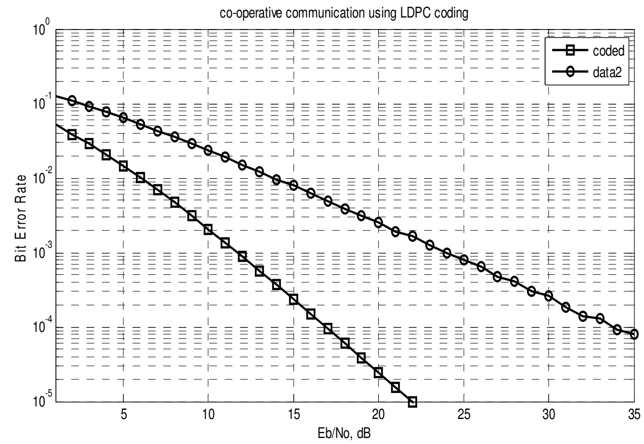

Fig. 5. Co-operative communication using LDPC coding

Figure 4 shows the BER performance for LDPC coding cooperative transmission with Rayleigh fading environment. LDPC codes are defined using sparse check parity check matrix which results significantly less computation of data.

The simulation results show that the proposed cooperative scheme achieved lower BER values as compared to convolution coding.

In the above figure we, are stimulating co-operative communication using convolution coding . Each codeword of the source node is partitioned into two frames that are transmitted in two phases. In the first phase, the first frame is broadcast from the source to the relays and destination. In the second phase, the second frame is transmitted on orthogonal sub channels from the source and relay nodes to the destination. The performance of the cooperative coding scheme is presented via simulations to illustrate the potential benefits. Here, a Rayleigh slow fading channel is assumed. The convolution code is shown in terms of Bit Error Rate (BER) versus Signal to Noise Ratio. We compare the bit error rates of non-cooperative,in order to compare both the performance.

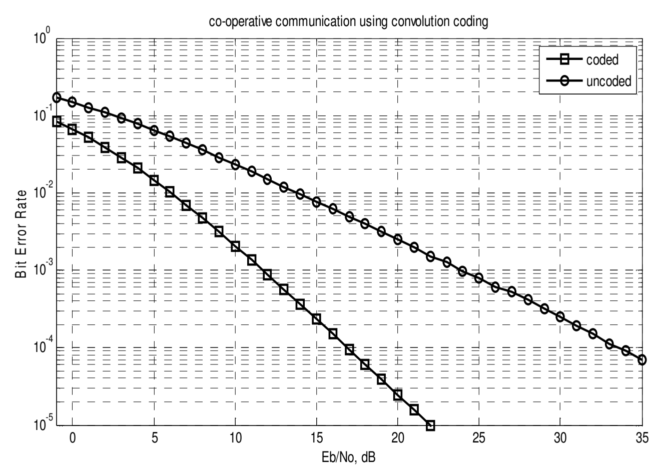

Fig. 6. Co-operative communication using convolution coding.

VII. CONCLUSION

In this paper, we propose a class of cooperative diversity protocols for multinode wireless networks employing decode- and-forward , amplify-and – forward and coded co-operation relaying. This class of protocols consists of schemes in which each relay can combine the signals arriving.We, are using two types of coding method (convolution coding & LDPC coding method) in order to improve the performance of communication in wireless network. There is a good performance for coded co-operation using convolution coding as there is less consumption of energy so, the transmission of signal takes place with more efficiency. Fundamentally, convolution codes do not offer more protection against noise However, LDPC code with a linear block code shows excellent performance. By Using co-operative communication based on LDPC coding we obtain great diversity gain and improve system performance effectively without much rise in the system bandwidth and transmitting power. LDPC codes have an inherent feature which eliminates need for the channel interleaver.

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Archana Pandit completed her B.Tech from Cambridge Institute Of Technology, Ranchi (2012). Presently She is persuing her M.Tech degree in Modern Communication from Dr. B.C Roy Engineering College, Durgapur West Bengal.

Dr. Nandi is an Associate Professor in the Dept. of Electronics and Communication Engineering (ECE), Dr. B. C. Roy Engineering College since December, 2012. Prior to that, he worked as an Assistant Professor in the Dept. of ECE at National Institute of Technology, Arunachal Pradesh. He published more than 25 International Journal and Conference papers.