Performance Analysis of Amplify Zoom and Forward Cooperative Relaying Protocol

Alamgir Khan, Haneef Hamza, Mehboob Alam, Imran Khan, Ibrar A. Shah, Muhammad Usman, and Haroon Rasheed

***Abstract* – This paper suggests and explores amplify, zoom and forward relaying protocol which is based on cooperative transmission over Rayleigh Fading medium. The proposed relying protocol efficiently zooms the received signal at the relay node before forwarding it to the destination. Binary phase shift keying has been used as the underlying modulation scheme. Simulation results show that the proposed protocol outperforms the predefined amplify and forward protocol in terms of signal to noise ratio and bit error rate.**

***Index Terms* – Bit Error Rate, BPSK Modulation, Cooperative Transmission, Amplify Zoom and Forward, Maximum Ratio Combining.**

I. INTRODUCTION

In Cooperative Diversity Networks (CDN), the source node sends multiple replicas of signal directly to the destination node. The destination receives numerous replicas of the data signal from source as well as the relay node. In various scenarios, the receiver adopts the diversity without installing multiple antennas. Due to these advantages, CDN is a potential candidate technology to play imperative role in the future wireless and cellular networks. CDN concept has been presented in [1], [2] where the data signal, being transmitted from source to destination, suffers from a variety of fading properties. To mitigate fading diversity, the data signal is transferred over several routes. The techniques of space diversity, time diversity, macro diversity and frequency diversity are used at transmitter and receiver sides to provide diversity in communication [3]. The concept of cooperative transmission in Relaying Network (RN) builds upon a network structural design where nodes support each other to understand spatial benefits of diversity. Even while the RN has emerged, it has led to bring in new challenges, *i.e*., limited throughput, coverage area, low reliability, high data rate and service's quality [4]. The CDN reduces fading and increase signal strength [5]. In latest studies, many algorithms have been proposed to enhance the performance of CDN through best possible power allocation [6], [7] and [8]. The two key protocols D-Forward and A-Forward have been used in CDN [9]. In the research work of the last decade, amplify and forward(AF) technique has been applied where the relay node only amplifies the desired signal and then it is retransmitted.

In recent research studies, decode and forward(DF) technique has been investigated in which the incoming signal is first detected, decoded and then transmitted to the destination node. An opportunistic relay is a single relay node which delivers the first-rate end-to-end transmission between source and destination nodes as discussed in [10]. To cope up with this problem, cooperative relaying protocols have already been devised in order to enhance the Quality of Service(QoS) and efficiency of wireless networks such as pace-time cooperation and code cooperation [11], [12], [13]. In this article, we present a new relaying protocol called amplify, zoom and forward (AZF). AZF has been compared with AF for BPSK modulation scheme over Rayleigh fading channel with addition of Gaussian noise. This protocol efficiently zooms the received signal and then forwards it to destination node in which long-term average of received signal is required. Based on the benchmark comparison, the proposed protocol provides an accurate bit error rate (BER) vs signal to noise ratio (SNR).

The rest of the article is organized as follows: For cooperative relaying channel, the system model is described in section II. Section (III) presents comparative results for AZF with AF. At the end, section (IV) provides conclusion and future work.

II. SYSTEM MODEL

Let us consider wireless network scenario presented in Fig. 1 where a source node (S) sends signal to destination node (D) through relay node (R). Both source and destination nodes have single antenna. The data is transmitted from S to D in two steps as follows: Initially, S transmits the signal directly to D while in the second case, signal is transmitted over two hops. At first hop, S transmits the data signal to R which applies a relaying algorithm while at the second hop, R forwards the desire signal to D. BPSK is being used as modulation technique for transferring the signals over both hops. Mathematically, the fading version of signal received by R from S is generally represented by:

$$T_i = h_i w_i \tag{1}$$

Where $h_i w_i$ is fading signal being received. Signal after addition of Gaussian noise is expressed as:

$$R_i = T_i + \eta_o \tag{2}$$

Where η_0 is Gaussian noise. Signal received at destination is expressed mathematically as:

$$R_{sd} = h_i w_i + \eta_{sd} \tag{3}$$

Where $h_i w_i$ is the fading signal and η_{sd} is the noise being added over the channel from S to D.

Since the signal w_i is transmitted toward relay R using same fading channel but with different noise value, therefore, the signal received at relay is:

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$$R_i = h_i w_i + \eta_{sr} \quad (4)$$

Where $h_i w_i$ is the fading signal and η_{sr} is the noise being added over the channel from source(S) to relay(R).

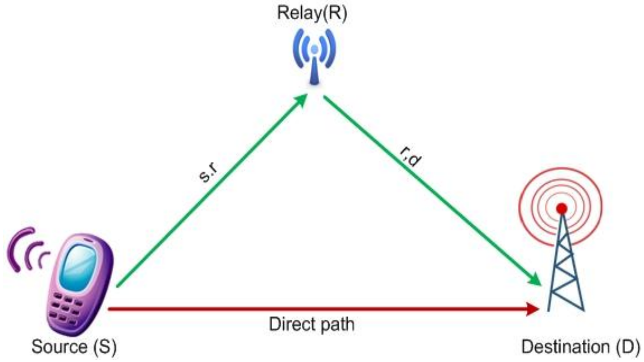

Fig. 1 Source (S), Relay (R) and Destination (D)

A. Amplify and Forward Protocol

AF protocol is used in the situations when there is limited time for encoding and decoding. In this case, the relay amplifies the received signal and forwards it to destination (D). The drawback of this protocol is that it also amplifies the noise. Since the relay applies AF protocol on the received signal, therefore, the given expression for the amplify signal becomes:

$$R_r = (h_i w_i + \eta_{sr})\, \beta \quad (5)$$

Where β is amplification factor, which is expressed as:

$$\beta = \sqrt{\frac{1}{|hi|^2 \quad +\eta sr}} \quad (6)$$

Where η_{sr} is channel noise value from source to relay. The amplified signal received at the destination is expressed as:

$$R_d = (h_i w_i + \eta_{rd})\, \beta \quad (7)$$

Where R_d is the received signal as the destination node(D), $h_i w_i$ is the fading single as given in Equation (1), η_{rd} is the noise being added over the channel from R to D and β is the simplification factor as outlined in Equation(5).

B. Amplify, Zoom and Forward

The proposed AZF protocol focuses on the small portion of data signal which is being distorted by AF due to noise amplification during the process. In this case, the protocol received maximum SNR. In AZF protocol, the relay magnifies all portion of the signal. In this case, the received signal from the source(S) can be expressed mathematically as:

$$R_i = h_i w_i + \eta_{sr} \quad (8)$$

After applying AZF protocol by the relay(R)) on the received signal as outlined in Equation (8), the desire signal at destination can be expressed as:

$$R_d = (h_i w_i + \eta_{rd})\, \alpha \quad (9)$$

Where α is magnification factor which is expressed mathematically as:

$$\alpha = \sqrt{\frac{\frac{p}{2}}{rs+1}} \quad (10)$$

Where p is decimal value of SNR and r_s is the instantaneous relay channel SNR.

C. Maximum Ratio Combining

After receiving the signal at destination (D) and combining it by Maximum Ratio Combining (MRC) technique, the expression becomes:

$$bsd(n) = \sum_{i=1}^{k} hi, sd[n] \quad (11)$$

III. SIMULATION RESULTS

We adopt point-to-point performance of AZF cooperative protocol by using Matlab simulator and compare it with AF protocol at different level of noise at Rayleigh fading channel.

Curve colors, various paths between S, D and R, noise levels and the obtained values of noise are summarized in the Table 1.

Table 1. Noise Values at Rayleigh Fading Channel

Noise value for different paths and curves			
Curve	Path between S, D and R	Noise Level(η)	Obtain Noise values (η)
B_x	s,d	1	1
B_x	s,r	1	1
B_x	r,d	1	1
R_y	s,d	1	1
R_y	s,r	1	10
R_y	r,d	1	1
G_z	s,d	1	1
G_z	s,r	1	1
G_z	r,d	1	10

The first column in Table 1 represents the curve which have been selected in different colors. For example, B_x represents black curve for given noise values from S to D, S to R and R to D, respectively. Similarly, the Red and Green represent different noise values for others curve in Table 1. The second column shows the combination of paths between relay, source and destination. The third column represents the channel noise values which is constant in all the given cases. The last column shows the value of noise which has been obtained for these paths. According to these values, the simulation results obtained are presented in Fig. 1, Fig. 2, Fig. 3 and Fig. 4. Fig. 2 shows the performance of AF protocol in terms of BER against various SNR values using BPSK as the modulation scheme. Here, the parameter α^2 represents the obtained noise values from S to D directly, S to R and then R to D in the relaying scenario for each curve type as outlined in Table 1.

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From Fig. 2, it can be observed that the BER of 10^{-2} is achieved with SNR values at 13dB, about 16dB and 17dB for G_z, R_y and B_x, respectively. It is evident from the result that BER is decreasing for G_z as compared to R_y and B_x. We can observe that according to the noise value at G_z, AF protocol gives much better results than the others. Fig. 3 shows the performance analysis of the proposed AZF protocol. In this case, the BER value of 10^{-3} is achieved for SNR values at 15dB, about 14 dB and 17 dB for G_z, R_y and B_x, respectively. It is proved that BER is has decreased in this case for G_z as compared to G_z of AF protocol. We have considered the BER values at 10^{-2} as reference point in AF while 10^{-3} in AZF protocols. Less BER values means that AZF protocol outperforms AF protocol for almost the same SNR values. Fig. 4 shows the comparative performance analysis of AF and AZF protocols. The noise values at different paths is same for both protocols. The blue curve represents AF which yields a value of BER 10^{-2} at SNR of 14 dB while the green curve represents AZF protocol which produces a BER of 10^{-4} at SNR of 19dB. This proves that the proposed protocol give better performance as compared to AF.

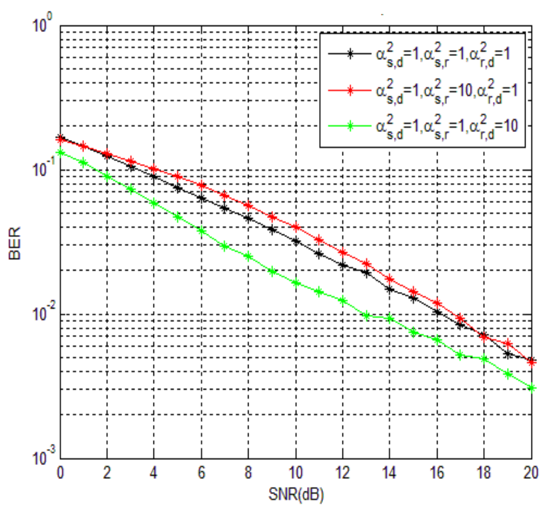

Fig. 2 Performance Analysis of AF Protocol (BER vs $SNR_{(dB)}$)

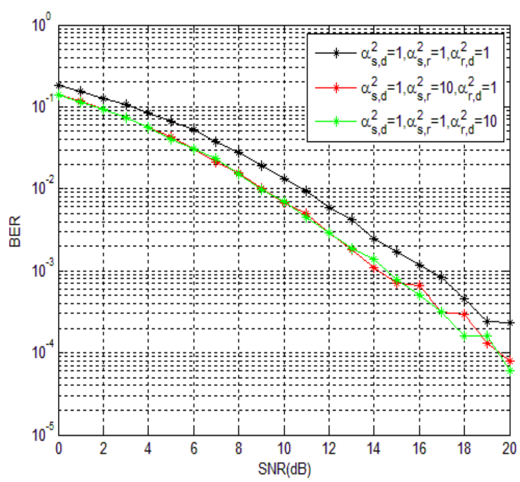

Fig. 3 Performance Analysis of Proposed AZF Protocol (BER vs $SNR_{(dB)}$)

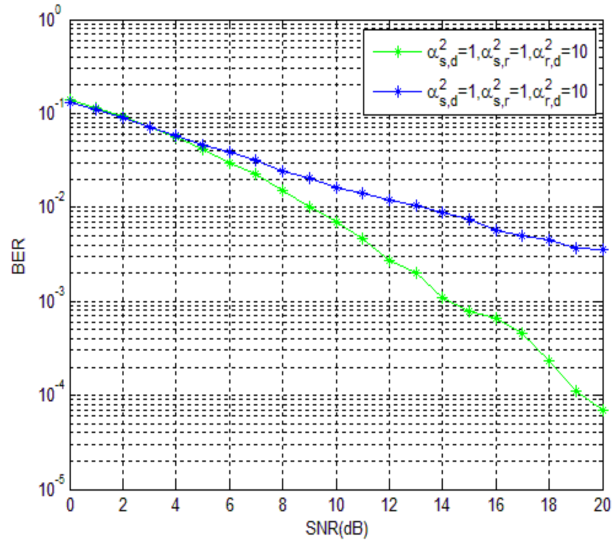

Fig. 4 Comparison AF and AZF Protocols

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