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A Novel Hybrid Relaying Approach in Cooperative Communication

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Abstract – **Cooperative communications can be extremely proficient in combating fading multipath channels and enhance scope with complexity and cost. Furthermore, there is also a possibility of improving the performance of cooperative communication by optimal relay selection strategies. In the basic cooperative communication network, there is three type of devices, a source, a destination and a set of relay devices. These relay devices are responsible for forwarding the overheard information from the source node to the destination node, thereby providing diversity gain at the destination node. But practically not all available relays are efficient. Application of relay selection scheme with cooperative communication techniques not only removes communication overhead from destination node but also will enhance system performance.**

In this regard, this paper is focused towards a hybrid relay selection scheme of the cooperative network with cooperative non-regenerative (AF) and regenerative (DF) relaying technique. Bit Error Rate (BER) performance is compared using Rayleigh, Rician and Nakagami fading environment.

Keywords – **AF, BER, DF, Nakagami, Rayleigh, Rician.**

I. INTRODUCTION

A relay network is a wide range of network topology frequently utilized as a part of wireless networks, where the source and destination are interconnected using nodes. A basic cooperative relaying network system comprises of three nodes, in particular source, destination, and a third node supporting the direct communication between source and destination indicated as relay. On the off chance that the direct transmission of an information from source to destination is not (completely) successful, the eavesdropped information from the source is sent by the relay to achieve the destination by means of an alternate way.

Cooperative communication has turn into one of the famous research topics as the solution to the battery life issue and expanding the transmission limit and execution. Cooperative communication is a frame work where wireless mobiles can together transmit their signals, thus achieving a number of significant improvements in communication over multi-path fading channel: enlarged rates for data communication, enhanced clarity and coherence for voice communications, reduced transmit power and expanded battery life [1].

The basic principle of cooperative communication is using other communication devices to relay transmission. Figure 1.1 shows the data broadcasting from source node to both the nodes i.e.; destination node and relay node. The relay node then forwards the transmission to the end point (destination) node. The source node regards the relay node as a virtual antenna, enabling MIMO systems to be used without having to add physical antenna.

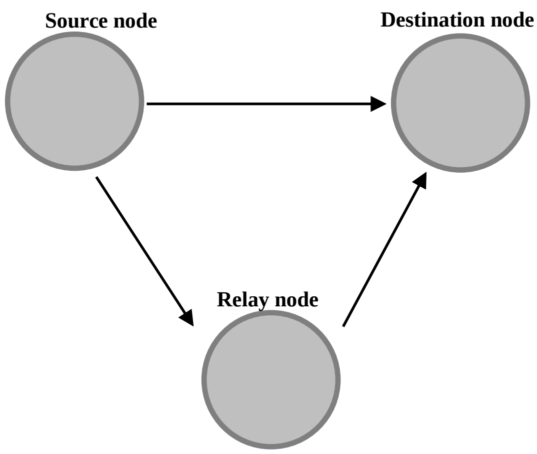

Figure 1: Basic structure of cooperative communication [2]

The primary aim of this paper is to develop a Hybrid approach of Relay Selection Algorithm for

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Cooperative Communications. The performance of proposed system will be based on BER analysis of Rayleigh fading channel.

II. Proposed Method

Consider a network arrangement with a transmitter, a receiver and two relay selection approaches. Furthermore it is considered that transmission from source to destination is divided among two phases; the first phase is known as broadcast phase, where source node transmits data to both destination and relaying terminals [3]. And second phase is known as relaying phase where relaying node transmits overheard information from source node to the destination node based on the relaying technique employed.

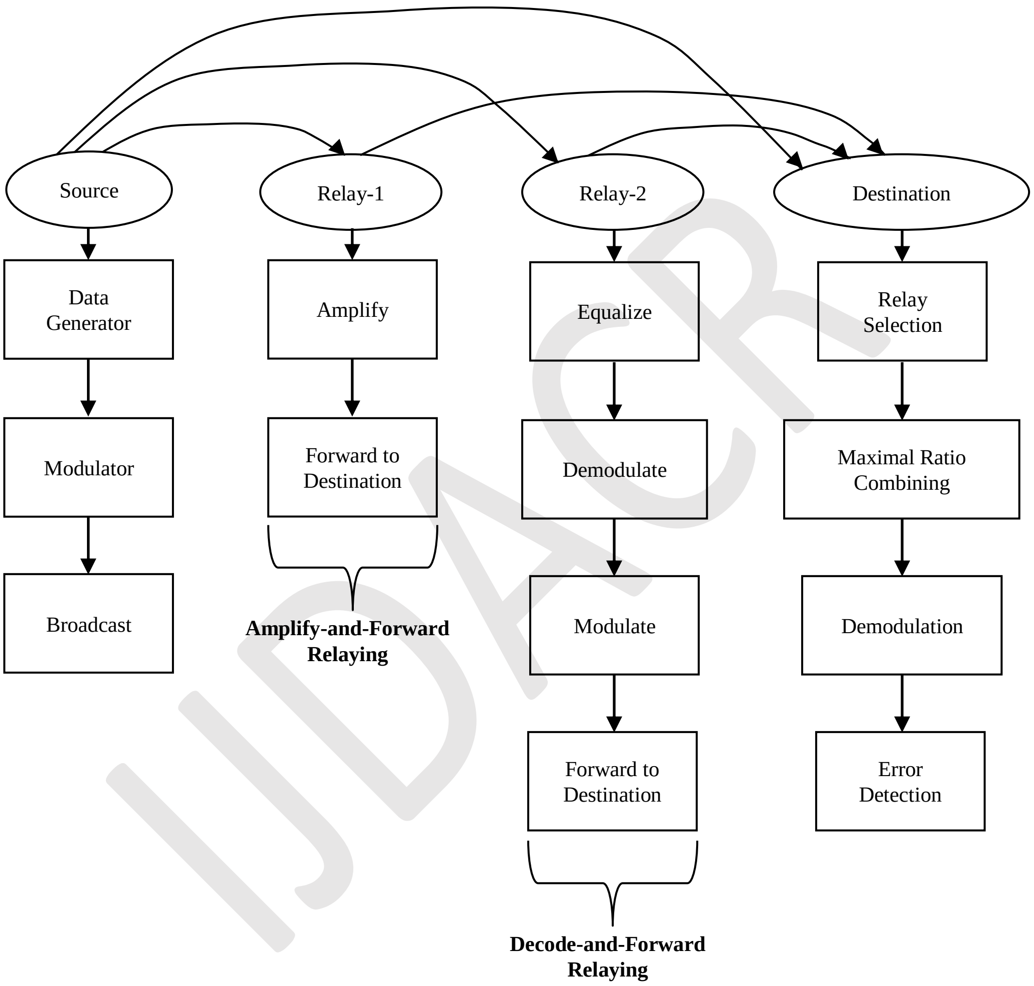

Figure 2: System model for hybrid cooperative relaying scheme

Let h_{sr_i} denotes the channel coefficient between source and i^{th} relay, h_{r_iD} represents channel coefficient between i^{th} relay and destination node. η_{s_id}, η_{sr_i} are complex AWGN noise vectors present between source and destination and source to relay nodes respectively. Then the signal propagation in relaying techniques can be given as follows.

A. *Conventional Relay Selection Scheme*

The optimal relay selection scheme works on the principle of selecting relay with minimum symbol error rate (SER), while in practice it is hard to analyse. Therefore a sub optimal relay selection scheme which selects relay with minimum SER and which is analysable is required. Max-min relay selection and Harmonic Mean relay selection schemes works on such principle and they are analysable as well [4]. Let h_{si}, h_{id} denotes the instantaneous channel condition between source

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and i^{th} relay, i^{th} relay and destination. Bletsas et al. [5] proposed two formulas to select any relay among a set of relays: under Policy I, the minimum of the two is selected, while under Policy II, the harmonic mean of the two is used [6]:

- Under Policy I

$$h_i = \min\{|h_{si}|^2 |h_{id}|^2\} \quad (1)$$

- Under Policy II

$$h_i = \frac{2}{\frac{1}{|h_{si}|^2}+\frac{1}{|h_{id}|^2}} = \frac{2|h_{si}|^2|h_{id}|^2}{|h_{si}|^2+|h_{id}|^2} \quad (2)$$

B. Amplify and Forward (Non-Regenerative Relaying)

In AF scheme, relay node forwards amplified version of received signal to the destination node. Let the source transmitted signal be X_s and the relay transmitted signal is X_{r_i}. In broadcast phase the received signal at the destination and relay will be [7]:

$$y_{sd} = \sqrt{\varepsilon} h_{sd} X_s + \eta_{sd} \quad (3)$$

$$y_{sr_i} = \sqrt{\varepsilon} h_{sr_i} X_s + \eta_{sr_i} \quad (4)$$

In relaying phase, the relay node first amplifies the received signal with a gain factor β and forwards it to the destination. The received signal at destination node in relaying phase will be:

$$y_{r_i,d} = \sqrt{\varepsilon} h_{r_i d} \beta y_{sr_i} + \eta_{r_i d} \quad (5)$$

Where $\beta = \sqrt{\frac{1}{|h_{sr_i}|^2 \varepsilon + N_{0,sr_i}}}$ is gain factor between source and relay terminal.

Using the Z-F and MMSE detection the estimated signal will be:

$$r_{s,d} = \frac{h_{sd}^* \sqrt{\varepsilon}}{N_{0sd}} y_{sd} + \frac{h_{r_i d}^* \ \beta \ h_{sr_i}^* \sqrt{\varepsilon}}{|h_{r_i d}|^2 \beta^2 N_{0,sr_i} + N_{0,r_i d}} \quad (6)$$

Here $r_{s,d}$ is estimated signal, ε represents energy of the symbol. $N_{0,sd}, N_{0,r_i d}$ represent noise power spectral density between source-destination and relay-destination pair respectively. The received SNR between a pair of nodes i, j will be:

$$\overline{\gamma_{ij}} = \frac{E\left[|h_{ij}|^2\right]\varepsilon}{N_{0,ij}} \quad (7)$$

C. Decode and Forward (Regenerative Relaying)

Decode and forward relaying scheme is regenerative since relay node first decodes the information received from source node, before forwarding it to destination. For a signal S, the transmission is carried out in two phases. In first phase, source broadcasts $\sqrt{\epsilon}S$ to available relays and destination nodes. Where ϵ represents transmission power. The received signal at destination and i^{th} relay will be same as given in equations (3) and (4). The instantaneous SNRs of channel between source to destination and channel between source to i^{th} relay are given by $\gamma_{sd} = \epsilon|h_{sd}|^2$ and $\gamma_{sr_i} = \epsilon|h_{sr_i}|^2$ respectively. In second phase, the relay first estimates the received signal to obtain the estimated signal $\hat{s}$ then amplifies $\hat{s}_i$ with amplification factor β and transmits $x_i = \sqrt{\epsilon . B} . \hat{s}_i$ to the destination node. The received signal at destination will be:

$$y_{r_i,d} = \sqrt{\epsilon . B} . \hat{s}_i . h_{r_i d} + \eta_{r_i d} \quad (8)$$

Destination node combines signal received in two phases i.e. y_{sd} and $y_{r_i,d}$. The combined signal will be:

$$y_D = g_1 * y_{sd} + g_2 * y_{r_i,d} \quad (9)$$

Where g_1 and g_2 are weight coefficients. Then the final estimate $\hat{s}$ is given by:

$$\hat{s} = arg \min_{S\in\{-1,1\}} \left|y_D - \sqrt{\epsilon}\left(g_1 h_{sd} + g_2\sqrt{\beta} h_{r_i d} S\right)\right|^2 \quad (10)$$

Let S being BPSK modulated then the conditional bit error rate probability is given as:

$$P_{error} = \left(1 - Q(\gamma_{sr_i})\right) Q\left(\frac{\sqrt{2\epsilon}\,(g_1 h_{sd} + g_1\sqrt{\beta} h_{r_i d})}{\sqrt{|g_1|^2 + |g_2|^2}}\right) + Q\left(\sqrt{2\gamma_{sr_i}}\right) Q\left(\frac{\sqrt{2\epsilon}\,(g_1 h_{sd} - g_1\sqrt{\beta} h_{r_i d})}{\sqrt{|g_1|^2 + |g_2|^2}}\right) \quad (11)$$

III. Simulation And Results

The performance of proposed algorithms has been studied by means of MATLAB simulation.

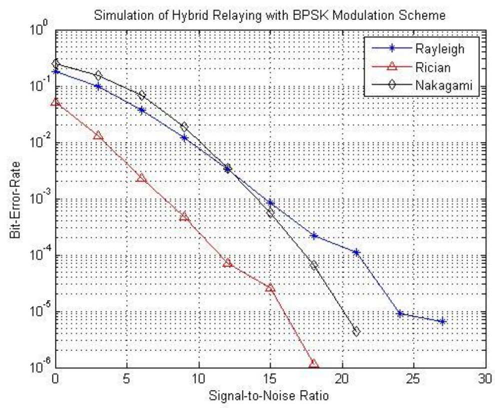

Figure 3: BER performance comparison for Hybrid Relaying for different fading channel in BPSK

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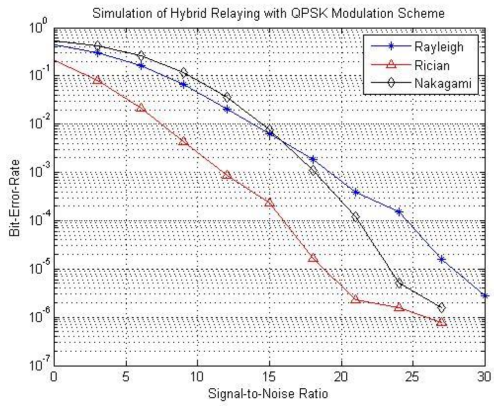

Figure 4: BER performance comparison for Hybrid Relaying for different fading channel in QPSK

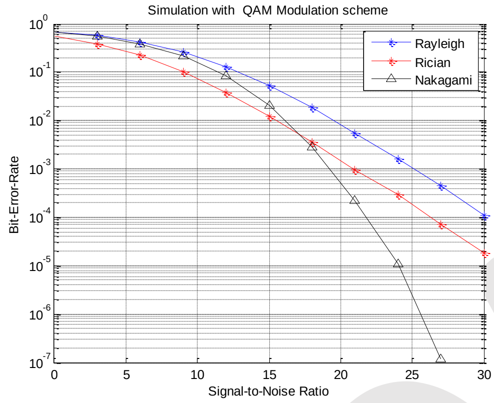

Figure 5: BER performance comparison for Hybrid Relaying for different fading channel in QAM

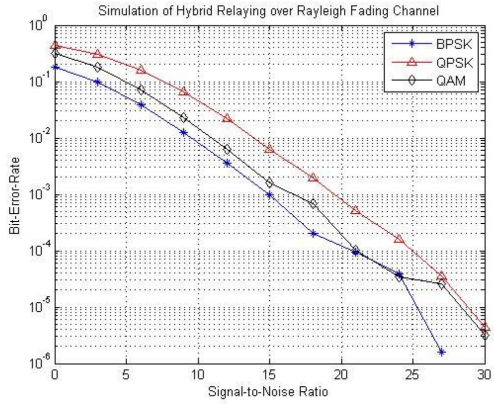

Figure 6: BER performance comparison for Hybrid Relaying for various modulation schemes

IV. CONCLUSION

In this paper, hybrid relay selection architecture is developed for regenerative (decode and forward) and non-regenerative (amplify and forward scheme). This system architecture utilizes the benefits of cooperative communication to enhance system performance. Hybrid relay selection scheme is applied to the adopted system architecture. To evaluate system performance Rayleigh fading scenario has been considered. Furthermore, the receiver is assumed to be equipped with linear and non-linear equalizers.

Bit error rate is considered as a performance evaluation parameter and Zero (0) BER is taken as reference level. Simulation results on the basis of Bit-Error-Rate vs. Signal-to-noise Ratio has been presented. It was found that the proposed hybrid relay selection in cooperative system improves system performance since it is utilizing two relays. In previous research work [8], they utilized single relay scheme which offered lower BER performance as compared to proposed hybrid relay selection scheme.

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