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BER Performance of Opportunistic Relaying with Direct Link using Antenna Selection

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***Abstract*— The opportunistic relaying scheme with the selection of antenna at source is the best alternative to get many of the benefits of MIMO [1]. In such a scheme, the best relay as well as best antennas at source can be selected for communication. Here, we will introduce the opportunistic amplify and forward relaying with direct link using antennas selection at source only. Under assumption of Rayleigh fading channel, in this proposed scheme the exact BER (bit error rate) performance will be analyzed and observed that the increasing antennas is a better option as compared to relays.**

***Keywords*- Cooperative Relay, Dual-hop, Antenna Selection, BER.**

I. INTRODUCTION

Cooperative relaying is considered to be an untapped means to achieve performance gains in wireless systems [2]. The basic building block of this technique is the relay channel: A source node transmits a message to a destination; a third node overhears this transmission and forwards (relays) the message to the destination; finally, the destination combines the two received messages to improve the performance. Such cooperative communication benefits from an inherent spatial diversity of the messages, thus providing a good mitigation against signal fading [3]. In this paper, the opportunistic relaying with direct link using antenna selection at source only is proposed, where we will observe the performance analysis of this scheme at different number of source antennas and relays, under assumption of independent and not necessarily identical Rayleigh fading channel. It will be concluded in this scheme that increasing number of antennas is a better option than increasing the number of relays.

II. SYSTEM MODEL

The dual-hop wireless system can be considered as in Fig.1. where, relays(R) and destination(D) have single antenna each, while a source (S) has "N" transmit antennas. In this proposed scheme the destination can be communicated directly with a source and indirectly with the help of best relay. The relaying transmission can be completed in two stages: in the first, according to the feedback from either the destination or relays, the source sends a message with one of its best antennas. In the second stage, a best relay will amplify the received message and will send that message to the destination while the source remains silent. In this opportunistic relaying scheme, the destination will receive two copies of the source message. The one is directly from the source and second from the help of best relay.

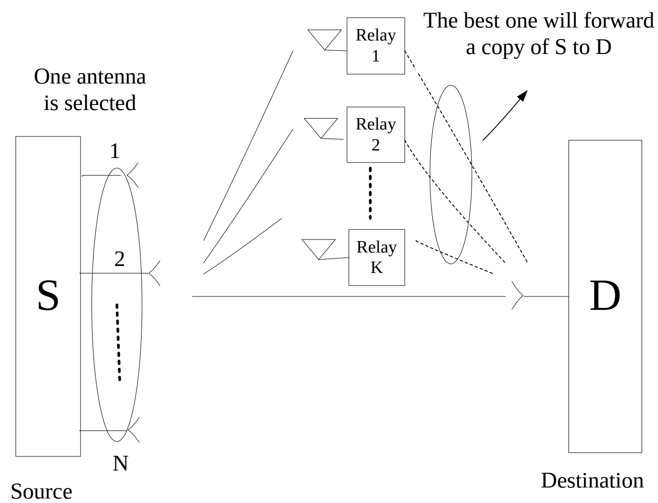

Figure 1. Opportunistic relaying scheme with Direct link using Antenna selection

Let $h_{i,k}$ $\left(i \in \{i=1,2...,N\}\ \&\ k \in \{k=1,2...,K\}\right)$ and $h_{k,D}$ represents the channel between ith antenna of source and relay R_k; and relay R_k and destination respectively, while f represents the channel between ith antenna of source and destination. We can assume that each node has same transmit power as P. We also assume that the channels are flat fading which are modeled by independent but not identically distributed complex Gaussian random variables and that the AWGN (additive white Gaussian noise) terms of all links have equal variance N_o and zero mean. With assuming that the relays and the destination knows the channel information.

The source is communicating with its best antenna "i" through direct link and with the help of selected relay (indirect link) among k relays which provides the best end-to-end SNR. Then the destination node employs the maximum ratio combining (MRC) technique, the total SNR can be written as at the destination [3]:

$$\gamma_{tot} = \max_{i=1,2...,N}\left(\gamma_{f_i}\right) + \max_{\substack{k=1,2...,K \\ i=1,2...,N}}\left(\frac{\gamma_{i,k}\gamma_{k,D}}{\gamma_{i,k}+\gamma_{k,D}+1}\right) \quad (1)$$

where $\gamma_{i,k} = h_{i,k}^2 \frac{P}{N_o}$ is the instantaneous SNR between source and relay R_k, $\gamma_{k,D} = h_{k,D}^2 \frac{P}{N_o}$ is the instantaneous SNR between relay R_k and destination and $\gamma_{f_i} = h_{i,D}^2 \frac{P}{N_o}$ is the instantaneous SNR between source and destination

III. PERFORMANCE

The selection of best antenna can be done with the help of perfect feedbacks, and then the received post-processing SNR of the direct link is the largest one in $\left\{\gamma_{f_i}\right\}_{i=1,2,...N,}$ *i.e.,*

$$\gamma_{f_s} = \max_{i=1,2,...N} \gamma_i \quad (2)$$

Using order statistics [4], the CDF (cumulative distribution function) of the highest one in (Eq.2) is shown as follows with respect to γ,

$$F_{\gamma_{f_s}}(\gamma) = \left[F_{\gamma_{f_i}}(\gamma)\right]^N \quad (3)$$

Here, $F_{\gamma_{f_i}}(\gamma)$ is the CDF of the received SNR for each direct link between the destination and source [5]:

$$F_{\gamma_{f_i}}(\gamma) = 1 - \exp\left(-\frac{\gamma}{\bar{\gamma}_0}\right)$$

Where $\bar{\gamma}_0$ is the average SNR of the source

The selected relay will be the best that can achieve the highest SNR of the indirect path with the help of best antenna which is suitable for both relay and destination during transmission. Then the achieved effective end-to-end SNR with selected relay of dual-hop is always the largest one in $\{\gamma_k\}_{k=1,2,...K}$ i.e.

$$\gamma_s = \max_{\substack{k=1,2,...,K \\ i=1,2,...,N}}\left(\frac{\gamma_{i,k}\gamma_{k,D}}{\gamma_{i,k}+\gamma_{k,D}+1}\right) = \max_{\substack{k=1,2,...K \\ i=1,2,...,N}} \gamma_k^i \quad (4)$$

According to the ordered statistics [4], the CDF of the effective SNR in (Eq.4) is shown as follows with respect to γ,

$$F_{\gamma_s}(\gamma) = \left[F_{\gamma_k^i}(\gamma)\right]^{NK} \quad (5)$$

Where, $F_{\gamma_k^i}(\gamma)$ is the CDF of indirect link of single path, given by [5]

$$F_{\gamma_k^i}(\gamma) = 1 - 2\exp\left(-\gamma\left(\frac{1}{\bar{\gamma}_{i,k}} + \frac{1}{\bar{\gamma}_{k,D}}\right)\right) \sqrt{\frac{\gamma^2+\gamma}{\bar{\gamma}_{i,k}\bar{\gamma}_{k,D}}}\, K_1\left(2\sqrt{\frac{\gamma^2+\gamma}{\bar{\gamma}_{i,k}\bar{\gamma}_{k,D}}}\right)$$

To find the BER, we will have to find the PDF and then MGF of γ_{f_s} and γ_s. By taking the derivate of (Eq.3) with respect to γ, the PDF of γ_{f_s} can be obtained and after using the binomial theorem, we can get

$$f_{\gamma_{f_s}}(\gamma) = \frac{N}{\bar{\gamma}_0}\sum_{j=0}^{N-1} C_{N-1}^j (-1)^j \exp\left(-\gamma\left(\frac{j+1}{\bar{\gamma}_0}\right)\right) \quad (6)$$

By using the (Eq.6), the MGF can be obtained as

$$M_{\gamma_{f_s}}(s) = \frac{N}{\bar{\gamma}_0}\sum_{j=0}^{N-1} C_{N-1}^j (-1)^j \int_0^\infty e^{-s\gamma}\, e^{-\gamma\left(\frac{1+j}{\bar{\gamma}_0}\right)} d\gamma \quad (7)$$

and this integral can be solved with the help of [eq.3.311, 6] and its closed form can be obtained as:

$$M_{\gamma_{f_s}}(s) = N\sum_{j=0}^{N-1} C_{N-1}^{j}(-1)^{j}\left(\frac{1}{\bar{\gamma}_0 s+(1+j)}\right) \quad (8)$$

The approximation of the first order modified Bessel function of the second kind at high average SNR per link can be $K_1(x)=1/x$ [7]. By using this approximation in (Eq.5), then the CDF of the considered path can be approximated as follows.

$$F_{\gamma_s}(\gamma) = \left[1\text{-}\exp\left(-\gamma\left(\frac{\bar{\gamma}_1+\bar{\gamma}_2}{\bar{\gamma}_1\bar{\gamma}_2}\right)\right)\right]^{NK} \quad (9)$$

By taking the derivative of (Eq.9) with respect to γ, and using binomial theorem, the PDF can be obtained as,

$$f_{\gamma_s}(\gamma) = \left[\begin{array}{l} NK\left(\frac{\bar{\gamma}_1+\bar{\gamma}_2}{\bar{\gamma}_1\bar{\gamma}_2}\right)\sum_{n=0}^{NK-1} C_{NK-1}^{n}(-1)^{n} \\ \exp\left(-\gamma(n+1)\left(\frac{\bar{\gamma}_1+\bar{\gamma}_2}{\bar{\gamma}_1\bar{\gamma}_2}\right)\right)\end{array}\right] \quad (10)$$

Using the PDF in (Eq.10), the MGF can be obtained as

$$M_{\gamma_s}(s) = \int_0^{\infty} e^{-s\gamma} NK\left(\frac{\bar{\gamma}_1+\bar{\gamma}_2}{\bar{\gamma}_1\bar{\gamma}_2}\right)\sum_{n=0}^{NK-1} C_{NK-1}^{n}(-1)^{n}$$
$$\exp\left(-\gamma(n+1)\left(\frac{\bar{\gamma}_1+\bar{\gamma}_2}{\bar{\gamma}_1\bar{\gamma}_2}\right)\right)d\gamma \quad (11)$$

and this integral can be evaluated with [eq.3.311, 6]

$$M_{\gamma_s}(s) = NK\sum_{n=0}^{NK-1} C_{NK-1}^{n}(-1)^{n}$$
$$\left(\frac{\bar{\gamma}_1+\bar{\gamma}_2}{S\bar{\gamma}_1\bar{\gamma}_2-(n+1)(\bar{\gamma}_1+\bar{\gamma}_2)}\right) \quad (12)$$

To find the average BER for a wide variety of ary-modulations can be allowed by the MGF based approach for the performance analysis of digital modulation over Raleigh fading channels [8]. According to binary DPSK modulation, the average BER can be written as [9]

$$Pb(E) = \frac{1}{2}\left(M_{\gamma_f}(1)M_{\gamma_s}(1)\right) \quad (13)$$

VI. Simulation results

On the behalf of (Eq.13), we can say that the performance of the proposed scheme is related with number of relays and antennas.

Fig.2, represents the BER performance of the proposed scheme for non-identical channels as a function of average transmit SNR with increasing the same number of antennas and relays by turn. More specifically, the numerical environment supposes D-PSK modulation. From figure we can observed that the proposed scheme achieves the better performance with increasing the number of antennas rather than increasing the relays.

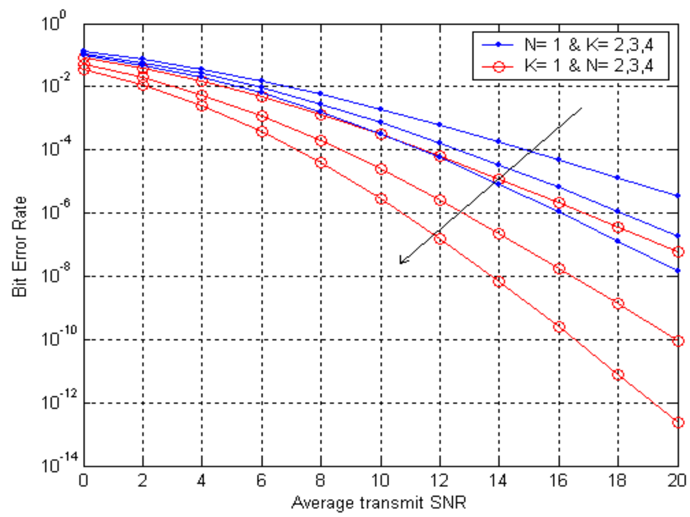

Figure 2. Comparing the BER performance as a function of transmit SNR with increasing the number of antennas and relays by turn when $\bar{\gamma}_1=\bar{\gamma}_2=1.5$ & $\bar{\gamma}_o=3$.

V. Conclusion

The performance of the opportunistic amplify and forward relaying with direct link using selection of antenna at source only and MRC is considered at destination over Rayleigh fading channels and finally we concluded that increasing the number of antennas in this proposed scheme is more beneficial as compare to considering the more number of relays.

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