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Performance Analysis of Amplify and Forward Protocol for Cooperative Communication System over Nakagami-m channel

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***Abstract*— Multiple input multiple outputs achieves various advantages like improved signal to thermal noise ratio, increased coverage, reduction in interference, reduction in error rate. But due to obstacles to MIMO implementations like multiple antennas leading to multiple RF chains, more involved signal processing require more computing power and energy, cooperative communication has achieved benefits over it by using a single antenna at each device and achieve (partial) MIMO gains. Thus, in this paper I have analyzed the performance of Amplify and Forward protocol for Cooperative Communication System over Nakagami-m channel when single relay is used and when two relays are used with QPSK modulation technique. The combining technique Maximal Ratio Combining (MRC) is used at receiver for combining of signals.**

***Index Terms*— MIMO, Amplify and Forward, QPSK, MRC**

I. INTRODUCTION

Cooperative communication uses single-antenna mobiles to reap some of the benefits of MIMO systems. The basic idea is that single-antenna mobiles in a multi-user scenario can "share" their antennas in a manner that creates a virtual MIMO system [1]. It is a promising technique to overcome fading and interference in wireless environment. It leverages the broadcast nature of wireless channel, and enables multiple wireless terminals to assist each other for high quality transmission. By combining signals through different paths from different users in receiver node, both spatial diversity and user diversity are fully exploited, which dramatically enhances system performance in terms of reliability and throughput [2].The capacity of the three-node network consisting of a source, a destination, and a relay has been analyzed. It was assumed that all nodes operate in the same band, so the system can be decomposed into a broadcast channel from the viewpoint of the source and a multiple access channel from the viewpoint of the destination. Many ideas that appeared later in the cooperation literature were first exposited in it [3]. A new form of spatial diversity was proposed, in which diversity gains are achieved via the cooperation of mobile users. Part I describes the user cooperation strategy, while Part II focuses on implementation issues and performance analysis. [4].

The rest of the paper is organized as follows. Proposed model and amplify and forward protocol are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. PROPOSED MODEL

The Cooperative communication system includes the source S, the destination d, and relays in between both of them. It is assumed that all terminals are equipped with a single antenna and can not transmit and receive simultaneously. The fading channel coefficients are denoted by h_{sd}, h_{sr}, h_{rd}, where they are modeled as Nakagami-m distributed random variables with parameters m and Ω. Thus, the p.d.f. is given by

$$F(x;m,\Omega) = \frac{2m^m x^{2m-1} \exp(-mx^2/\Omega)}{\Gamma(m)\Omega^m} \quad (1)$$

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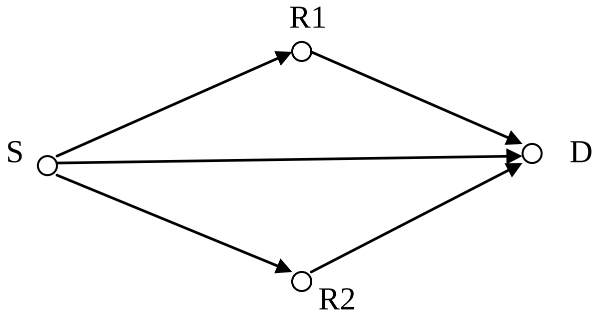

Fig. 1 A Cooperative communication system with two relays

A. *Amplify and Forward protocol*

As shown in fig. 1 a source can either transmit or receive a signal at a time. The transmission of the data from the source to the destination terminal is furnished in two phases. In the first phase, the source broadcasts data to the destination and the relay. The relay amplifies the received data and retransmits it to the destination, in the second phase. To avoid the interference, source and relay use orthogonal channels for transmission. The relay receives the information signal appended by the channel gain and noise. It is then amplified and sent to the destination. Now, the receiver can decode the combined signal using Maximal Ratio Combining (MRC).

In the first phase, the source broadcasts its information with transmission power P_s to destination and relays.

$$r_{sd} = \sqrt{P_s}\, h_{sd}\, x + n_{sd} \quad (2)$$

$$r_{sr} = \sqrt{P_s}\, h_{sr}\, x + nsr \quad (3)$$

Then, all the relays will forward the scaled versions of the received signal to D in the matched phases. So at the destination terminal, the received signals from the relay R can be written as

$$r_{rd} = \beta_k\, h_{rd}\, r_{sr} + n_{rd} \quad (4)$$

where, $\beta_k = \sqrt{[P_k / (P_s |\hat{h}_{sr}|^2 + P_s + N_o)]}$ and P_k is the transmit power of any relay. The source-to-relay and the relay-to destination paths are separately estimated.

B. SNR AND SER ANALYSIS

The SNR of MRC output is

$$\gamma = [|A|^2+\Sigma|B_i|^2]/N_o \quad i=1, 2 \quad (5)$$

can be transformed as follows:

$$\gamma = \gamma_1+\gamma_2 \quad (6)$$

$$\gamma_1=|A|^2/N_o=P_1|h_{sd}|^2/N_o \quad (7)$$

$$\gamma_2=\Sigma|B_i|^2]/N_o= \sum_{i=1}^{2} \gamma i \quad (8)$$

$$\gamma_i = \frac{1}{N_o} \; \frac{P_1 P_{r,d}|h_{s,r}|^2|h_{r,d}|^2}{P_1\,|h_{s,r}|^2 + P_{r,d}\;|h_{r,d}|^2 + N_o} \quad (9)$$

γ_1 is the SNR of MRC output formed by signal's transmitting from source node to destination node. γ_i is the SNR of MRC output formed by signal's transmitting through the relay-assisted channel. *n* is the total number of relay nodes. γ_2 is the total SNR of all relay links. γ_i can be tightly upper bounded as

$$\gamma_i<\tilde{\gamma}_i= \frac{1}{N_o} \; \frac{P_1 P_{r,d}|h_{s,r}|^2|h_{r,d}|^2}{P_1\,|h_{s,r}|^2 + P_{r,d}\;|h_{r,d}|^2 + N_o} \quad (10)$$

which is the harmonic mean of two exponential random variables $P_1|h_{s,r}|^2/ N_o$ and $P_{r,d}\;|h_{r,d}|^2/ N_o$. If we approximate the SNR $\gamma = \gamma_{sd} + \sum_{i=1}^{2} \gamma_i$ [5].The conditional SER of AF cooperation systems with MPSK modulations can be given as follows.

$$P_{psk} \approx \frac{1}{\pi} \int_0^{\frac{(M-1)\pi}{M}} \exp\left(\frac{-b_{psk}}{\sin^2\theta}\gamma\right) d\theta \quad (11)$$

we obtain the SER formula of AF cooperation systems in terms of MGF *M*(s). *M*(s) is MGF of the output SNR defined as *M* (s)=E{e^{sx}} ,where E{.} denotes the statistical expectation of a particular random variable.

$$f_{MPSK}\left(M, M(s)\right) = \frac{1}{\pi} \int_0^{\frac{(M-1)}{M}} M\left(\frac{-g_{MPSK}}{\sin^2\theta}\right) d\theta \quad (12)$$

III. EXPERIMENT AND RESULT

The performance of Amplify and Forward protocol is analyzed when direct link is used for transmission of signals, when single relay is used and when two relays are used and all signals are combined at receiver. Matlab 7.8 software platform is use to perform the experiment.

This is done by taking different values of shape parameter i.e. m=1 and m=2. The graph shows that BER is reduced when single relay is taken as compared to direct link. The performance also improves when two relays are taken as compared to single relay. Thus, for m=1, the direct link, when single relay and when two relays are used for transmission of signals and all signals are combined at receiver. For m=2 , the direct link, when single relay and when two relays are used for transmission of signals and all signals are combined at receiver.

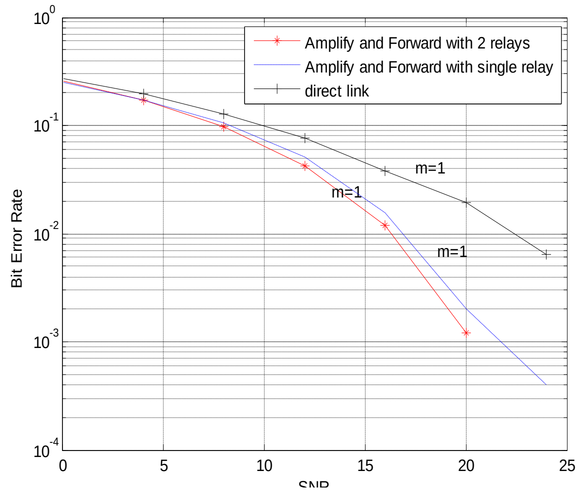

Fig. 2 AF Cooperative communication protocol for direct link, with single relay, with two relays for m=1.

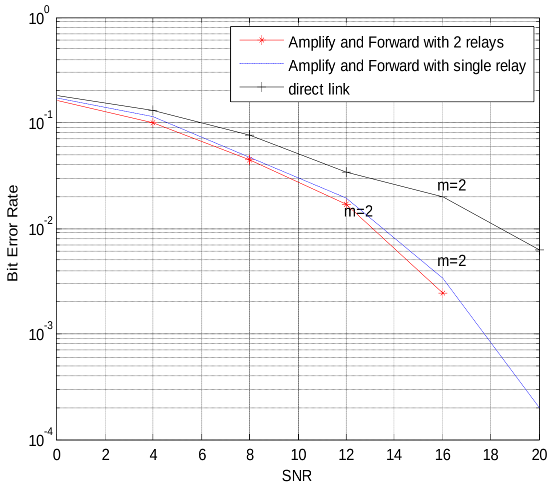

Fig. 3 AF Cooperative communication protocol for direct link, with single relay, with two relays for m=2.

(i) Simulation Parameters

Parameter	Value
Signal to Noise Ratio	0-15(varying)
Number of symbols	5000
Modulation technique	QPSK
Channel used	Nakagami-m channel
Shape parameter, m	1,2
Controlling spread, Ω	2

IV. CONCLUSION

In this paper the performance of AF cooperative communication systems is investigated. It is observed that when two relays are used instead of single relay, there is a reduction in bit error rate. In future, this performance may be compared with DF (Decode and forward) to analyze the performance of both AF and DF two relaying protocol.

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