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An Energy-Efficient Dual Hop Cooperative Relay Model With Best Relay Selection

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Abstract:*Cooperative transmission obtains the spatial diversity gains created by sharing antennas of terminals in wireless networks mainly to overcome the channel impairments and provide high data rates. In this paper, we present end to end BER performance of dualhop wireless communication model equipped with multiple Decode and Forward relays withthe best relay selection. Orthogonal space time block coding is applied at the source terminal. Best relay is selected based on the end to end channel conditions to minimize the energy requirements. We compare the BER performance using best relay selection with the BER performance of single relay. And also, outage probability of the best relay is equivalent to the outage probability when all relays take part in thetransmission.*

I. INTRODUCTION

Dual hop transmission is a technique by which the channel from source to destination is split into two shorter links using a relay [4]. It is an attractive technique when the direct link between the base station and the original mobile terminal is in deep fade or heavy shadowing or there is no direct link between source and destination.On the other hand transmission diversity is advantageous on a cellular base station, it might not be practical for other scenarios. Especially due to cost, size or hardware limitations, a wireless device may not be able to support multiple transmission antennas. In order to overcome this limitation a new form of diversity technique, the cooperative diversity (named so as it comes from user cooperation) has been introduced by [8, 9, 11, 14]. In ad-hoc network when one user is transmitting information to a remote terminal, other users nearby also receive it and transmit the signal to the destination. This process results in multiple copies of same signal from independent fading paths at the destination and brings diversity.

Depending on the nature and the complexity of the relays cooperative transmission system can be classified into two main categories; regenerative and non-regenerative systems. In regenerative systems, relay fully decodes the signal that went through the first hop. Then retransmits the decoded version to the second hop. This is also referred to as decode- andforward or digital relaying[5]. On the other hand, non-regenerative systems use less complex relays that just amplify and forward the incoming signal without performing any sort of decoding. It is called amplifyand- forward [9] or analog [15] relaying. The performance of both systems has been well studied in [3, 4, 5, 7].

Moreover, choosing the minimum number of relays for reducing cooperation overhead and saving energy without performance loss is an important concern. There are various protocols proposed to choose the best relay among a collection of available relays in literature. In [16], the author proposed to choose the best relay depending on its geographic position, basedon the geographic random forwarding protocol proposed by [18, 17]. In [2], the author proposed opportunistic relay based on the instantaneous channel conditions. This single relay opportunistic selection provides no performance loss from the perspective of diversity-multiplexing gain trade off, compared to schemes that rely on distributed space time coding [14].

The paper is outlined as follows: section 2 introduces channel model. Best relay selection protocol is described in section 3. Section 4 derives the Probability Density Function (PDF) of the received SNR per bit and analyzes the BER performance of the best relay followed by the outage behaviour of the best relay. Simulation results are presented in Section 5 and finallysection 6 presents conclusion and future work.

II. CHANNEL MODEL

A wireless dual hop network where a number of relay nodes are placed randomly and independently is considered. The direct link between source and destination may be blocked by some obstacles so that relays can communicate with both end points. In our model, the source equipped with two transmit antennas and each relay node has a single antenna which can be used for both transmission and reception. All transmissions are assumed to be half duplex and therefore a relay station cannot transmit and receive at the same period. During the first hop source broadcasts symbols, the relays listen and during the second hop relays forward the decoded version of the received signal to destination.

Weassumethatchannel remains constant during two hops with Rayleigh fading as in Figure 1.Source has no channel information and uses OSTBC. Each transmit antenna use same power $\sigma_s^2 = \frac{P}{t}$ where P is the total transmission power andt is number of antenna at base station t=2.

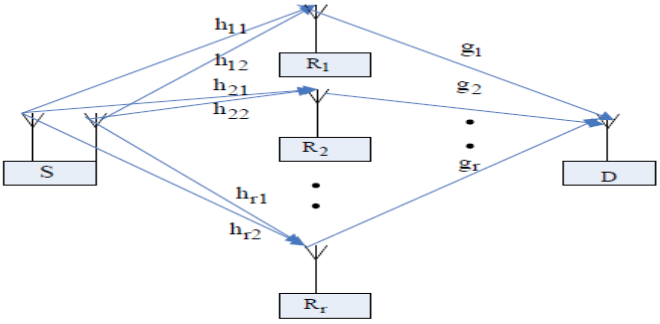

Figure 1: Dual hop cooperative relay model

For two transmit antenna, transmission matrix is defined by X=$\begin{pmatrix} X_1 & -X_2^* \\ X_2 & X_1^* \end{pmatrix}$ where X_1 and X_2 are complex symbols to be transmitted and * denotes the complex conjugate.We assume there are r relays and number of transmit antennas at source is 2. For first hop, Channel matrix is given by H_{SR}=$\begin{pmatrix} h_{11} & h_{12} \\ \vdots & \vdots \\ h_{r1} & h_{r2} \end{pmatrix}$where$h_{ij}$is channel gain between the i^{th} relay and j^{th} transmission antenna of source.i=1,2,...r and j =1,2 We assume that each element of $H_{SR}$is independent and identically distributed complex Gaussian random variable with zero mean and β_1 variance.So, Channel matrix for each relay can be represented asα_i=(h_{i1} h_{i2}) for i=1,2….r And for second hop, g_i= Individual relay to destination fading amplitude

III. BEST RELAY SELECTION

In single relay selection only one opportunistic relay transmits the received signal to destination. In previous work opportunistic relay is defined considering distance toward source or destination [17] or considering the channel condition [2]. The selectionis not efficient since communication link between transmitter and receiver located at same distance have enormous difference in terms of received signal due to fading and shadowing. In this paper, we consider all relays can listen to each other. After monitoring the instantaneous channel condition each relay broadcast the information to each other. If relays are hidden from each other destination decides which is the most opportunistic relay and broadcast it to relay station.

Let α_{si} and α_{id} denote the total channel power from source to i^{th} relay and i^{th} relay to destination respectively. Both α_{si} and α_{id} describe the quality ofthe wireless path between source to relay and destination to relay. They are calculated by following equations

$$\alpha_{si}=|h_{i1}|^2+|h_{i2}|^2+\ldots$$
$$\alpha_{id}=|g_i|^2$$

α_{id} is the fading amplitude from relay to destination. Since the two hops are both important for end to end performance, each relay calculates corresponding h_i based on two decision rules.

Rule 1: $h_i=min\{ \alpha_{si},\alpha_{id}\}$

Rule 2: $h_i=\frac{2}{\frac{1}{\alpha_{si}}+\frac{1}{\alpha_{id}}}$

The relay i that maximizes function h_i is one with the "best" end to end path between initial source to destination.After being selected as the best relay it relays signal to destination. In this paper it is assumedthe destination have perfect channel information available for decoding the received signal.

IV. BER ANALYSISAND OUTAGE PROBABILITY

In our channel model during the first time slot, the source transmits while all the relay nodes listen and during the next time slot the best relay is selected which transmits signal to destination. The end to end SNR through selected relay $i$is given by

$$\gamma = \max_{i\in 1,\ldots r} (\min(\gamma_{si}, \gamma_{id}))$$

where γ_{si} and γ_{id} are the instantaneous SNR of the S-Rand R-D link, respectively.The selection of the best relay is done by order statistics.We obtain weaker link between the first hop and the second hop of each relay node i.e, with largest SNR.We assume S-R and R-D link have the same average channel gain.

Probability density function of γ is given by [1]

$$f(\gamma) = 2rf(\gamma^*)(1 - F(\gamma^*))(2F(\gamma^*) - F(\gamma^*)^2)^{r-1}$$

where pdf $f(\gamma^*) = \frac{1}{\gamma^*}\exp(-\frac{\gamma^*}{\bar{\gamma}^*})$ and cdf $F(\gamma^*) = 1 - \exp(-\frac{\gamma^*}{\bar{\gamma}^*})$ of Rayleigh distributed random variable.

Finally pdf of γ is obtained by $f(\gamma) = \frac{\exp(-\frac{\gamma^*}{\bar{\gamma}^*/2})}{\bar{\gamma}^*/2}\left(1 - \exp(-\frac{\gamma^*}{\bar{\gamma}^*/2})\right)^{r-1}$ and further expanded through binomial expansion as $f(\gamma) = \sum_{i=1}^{r}(-1)^{r-1}\binom{r}{i}\frac{2i}{\bar{\gamma}^*}\exp\left(-i\frac{2\gamma^*}{\bar{\gamma}^*}\right)$

Above pdf expression can be used to evaluate error performance for any modulation techniques.BER for BPSK modulation scheme is given by

$$P_{BPSK} = \frac{1}{2}\int_0^\infty erfc(\sqrt{\gamma})f(\gamma)d\gamma = \frac{1}{2}\int_0^\infty erfc(\sqrt{\gamma})\sum_{i=1}^{r}(-1)^{r-1}\binom{r}{i}\frac{2i}{\bar{\gamma}^*}\exp\left(-i\frac{2\gamma^*}{\bar{\gamma}^*}\right)d\gamma$$

Outage Probability:

Mutual information between source and relay nodes *i=1,2,….r* in first hop is given by

$I_{i1} = \frac{1}{2}\log(1 + \Omega_{i1}SNR)$ where $\Omega_{i1} = \frac{|h_{i1}|^2 + |h_{i2}|^2}{2}$, Ω_{i1} is exponential distribution.

Mutual information in the second hop $I_{i2} = \frac{1}{2}\log(1 + \Omega_{i2}SNR)$

Probability density functions of Ω_{i1} and Ω_{i2} are

$$f(\Omega_{i1}, \lambda_1) = \lambda_1 e^{\Omega_{i1}\lambda_1},\ f(\Omega_{i2}, \lambda_2) = \lambda_2 e^{\Omega_{i2}\lambda_2}$$

So the capacity of network for relay *I* isminimum of the mutual information of this two hops.

$$C(\gamma_i) = \min(I_{i1}, I_{i2})$$

We are selecting the best relay based on end to end channel condition. Maximum capacity of the entire network depends on mutual information of the best relay as

$$I = \max_{i\in|1,..,r|}(\min(I_{i1}, I_{i2}))$$

$$= \max_{i\in|1,..,r|}(\min(\frac{1}{2}\log(1 + \Omega_{i1}SNR), \frac{1}{2}\log(1 + \Omega_{i2}SNR)))$$

So network capacity $C(\gamma) = I$ .Outage probability P_{out} is defined as the probability that instantaneous capacity $C(\gamma)$ fall below outage capacity C_{out} .

$$P_{out} = \Pr(C(\gamma) < C_{out})$$

$$P_{out} = \Pr(\max_{i\in|1,..,r|}(C(\gamma_i) < C_{out}))$$

Due to channel assumption, we have $P_{out} = \prod_{i=1}^{r} P_{out}^{i}$ where $P_{out}^{i} = \Pr(C(\gamma_i) < C_{out})$

$$P_{out}^{i} = \Pr(\min((\frac{1}{2}\log(1+\Omega_{i1}SNR), \frac{1}{2}\log(1+\Omega_{i2}SNR)) < C_{out})$$

$$= \Pr(\min((\Omega_{i1}, \Omega_{i2}) < w)), \ where \quad w = \frac{2^{2C_{out}} - 1}{SNR}$$

Then by order statistics [18], $\Pr(\min(\Omega_{i1}, \Omega_{i2}) = 1 - e^{-(\lambda_1+\lambda_2)\frac{2^{2C_{out}}-1}{SNR}}$

Thus $P_{out}^{i} = 1 - e^{-(\lambda_1+\lambda_2)\frac{2^{2C_{out}}-1}{SNR}}$ Finally, we substitute this value to obtain outage probability P_{out}

V. SIMULATION RESULTS

In this section, we discuss about simulation results of BER performance and outage behavior. We consider BPSK constellation for 2 transmit antennas equipped at source in slow Rayleigh fading channel. Simulation are performed one for decision rule 1 and another for decision rule 2 in NS2 environment. We can see that the performances are nearly the same for both cases in Figure 2.

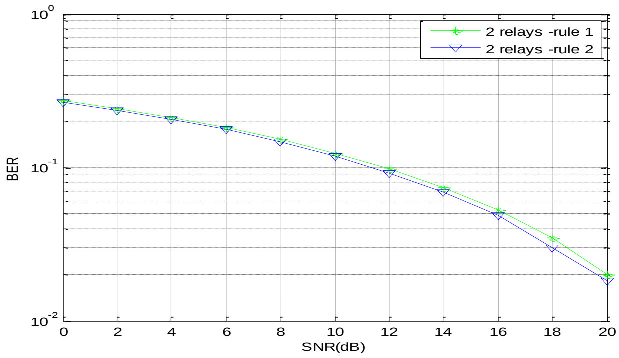

Figure 2:BER vsSNR

We have performed simulation with relays r= 2,3,5 and 7. BER performance of the best relay among a set of relays is always better than the BER performance of single relay shown in Figure 3.It is also shown that the better BER performance can be achieved by adopting more relay nodes.The single relay selection can reduce receiver complexity and at the same time will increase the network coverage.Figure 4 show the outage performance of the best relay compared to single relay for outage capacity C_{out}=.5bps/Hz. Outage probability decreases with increase in number of relays. By adopting more relays better outageperformance can be achieved.

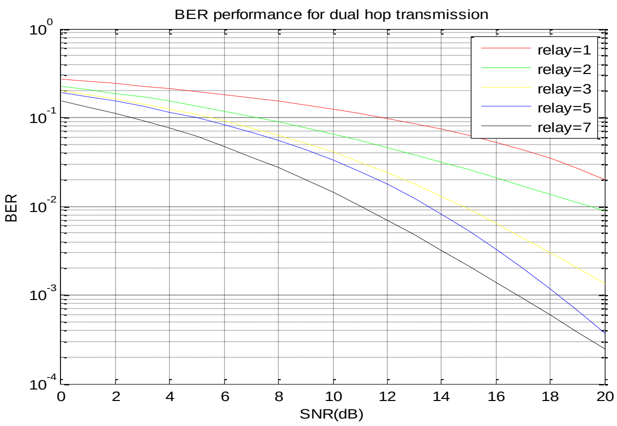

Figure 3:BER vs SNR

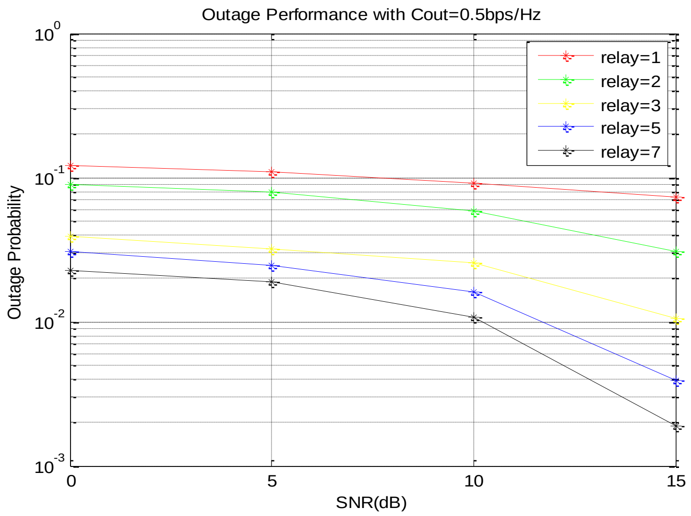

Figure 5:P_{out} vs SNR

VI. CONCLUSION

In this paper, an end to end BER analysis and outage performance of dual hop cooperative model by selecting the best relay based on the instantaneous channel conditions is presented. Both BER performance and outage probability can be improved by adopting more relays. However the outage performance of the best relay is equivalent to the outage behavior when all relay nodes participate in the second hop. In future, we can extend it to multi-hop transmission for covering long distance.

REFERENCES

[1] Balakrishnan N. and Cohen A., *Order Statistics and Inference: Estimation Methods*, AcademicPress, 1991.

[2] Bletsas A., Khisti A., Reed D., and Lippman A.,“A Simple Cooperative Method Based on Network Path Selection,” *Computer Journal ofIEEE Journal Selected Areas Communications*, vol. 4, no. 2, pp. 159-163, 2005.

[3] DaConne, C., Il-Min Kim'' Outage probability of multi-hop amplify-and-forward relay systems” IEEE Transactions on Wireless Communications, Volume:9 , Issue: 3 ,March 2010

[4] M Elkashlan, PL Yeoh, N Yang, TQ Duong, C Leung, “A comparison of two MIMO relaying protocols in Nakagami-*m* fading”. *IEEE Trans. Vehicular Technol*., 1416–1422 ,2012

[5] Ahasanun Nessa, Qinghai Yang, and Kyung-sup Kwak,” Performance Analysis of Two-Hop Cooperative MIMO Transmission with Best Relay Selection in Rayleigh Fading Channel”, *The International Arab Journal of Information Technology, Vol. 8, No. 1, January 2011*

[6] Qi, J., Aissa, S. ; Alouini, M ,“Dual-hop amplify-and-forward cooperative relaying in the presence of Tx and Rx in-phase and quadrature-phase imbalance”, *Communications, IET Volume:8 , Issue: 3* , Feb 2014

[7] Jinlong Wang, Yuzhen Huang, CaijunZhong, Fawaz Al-Qahtani, QihuiWu1 and Yunpeng Cheng,” Performance analysis of interference-limited dual-hop multiple antenna AF relaying systems with feedback delay”, *EURASIP Journal on Wireless Communications and Networking* , 2013

[8] FS Al-Qahtani, J Yang, RM Radaydeh, H Alnuweiri, “On the capacity of two-hop AF relaying in the presence of interference under Nakagami-*m* fading”. *IEEE Commun. Lett.*, 19–22 ,2013

[9] C Zhong, H Suraweera, C Yuen, A Huang, Z Zhang, “Outage probability of dual-hop multiple antenna AF relaying systems with interference”. *IEEE Trans. Commun.*, 108–119 ,2013

[10] Laneman J. and Wornell G., “Distributed Space-Time Coded Protocols for Exploiting Cooperative Diversity in Wireless Networks,”*Computer Journal of IEEE Transactions onInformation Theory*, vol. 50, no. 2, pp. 2415-2525, 2003.

[11] Nabar R., Bölcskei H., and Kneubühler F., “Fading Relay Channels: Performance Limits and Space-Time Signal Design,” *Computer Journal ofIEEE on Selected Areas in Communications*, vol. 22, no. 6, pp. 1099-109, 2004.

[12] Papaulis A. and Pillai S., *Probability, Random Variables and Stochastic Process*, McGraw Hill,2006.

[13] Proakis J., *Digital Communications*, McGraw Hill, 1995.

[14] Sendonaris A., Erkip E., and Aazahang B., “User Cooperation Diversity Part I and Part II,” *Computer Journal of IEEE Transactions onCommunications*, vol. 51, no. 11, pp. 1927-1948, 2003.

[15] Yanikomeroglu H., “Fixed and Mobile Relaying Technologies for Cellular Networks,” *inProceedings of Second Workshop Applications Services Wireless Networks*, France, pp. 75-81,2002.

[16] Zhao B. and Valenti M., “Practical Relay Networks: A Generalization of Hybrid-ARQ,” *Computer Journal of IEEE Selected AreasCommunications*, vol. 23, no. 1, pp. 718-723, 2005.

[17] Zori M. and Rao R., “Geographic Random Forwarding (Geraf) fr Ad hoc ad Sensor Networks: Multihop Performance,” *ComputerJournal of IEEE Transactions on Computer*, vol. 2, no. 4, pp. 337-348, 2003.

[18] Zori M. and Rao R., “Geographic Random Forwarding (Geraf) for Ad hoc and Sensor Networks: Energy and Latency Performance,” *Computer Journal of IEEE Transactions on Mobile Computing*, vol. 2, no. 4, pp. 349-365,2003.