An Investigation of DAF Protocol in Wireless Communication

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Abstract - *Cooperative communication can be considered as a promising technology to significantly increase the data rate along with the coverage area of a wireless network, which aims to achieve spatial diversity via the cooperation of user terminals in transmission without requiring installation of multiple transceiver antennas. This paper is bothered with the performance of differential amplify-and-forward (D-AF) relaying for multi-node wireless communications over time-varying Rayleigh attenuation channels. A first-order auto-regressive model is employed to characterize the time-varying nature of the channels. Supported the second order statistical properties of the wireless channels, a new set of combining weights are projected for reception at the destination. Expression of pair-wise error probability (PEP) is provided and used to get the approximated total average bit error rate (BER). It's shown that the performance of the system is said to the auto-correlation of the direct and cascaded channels associated an irreducible error floor exists at high signal-to-noise ratio (SNR). The new weights cause a more robust performance when put next to the standard combining scheme. Technique is administrated in numerous situations to support the analysis.*

Key Words: Cooperative communication, D-AF, BER, SNR, MRC etc...

1. INTRODUCTION

In wireless communications, multipath propagation could be a severe variety of interference that leads to loss of data. The employment of diversity techniques will excuse the signal loss. In diversity techniques, redundant signals are transmitted over independent methods (distributed in time, frequency, and space) and combined at the receiver to gather diversity gain. Spatial diversity techniques (e.g. multiple antennas) are particularly attractive because they will be simply combined with time, frequency or code diversity, while not touching the performance gain. Unfortunately, the employment of multiple antennas can be impractical in mobile devices due to the limitation of size. The separation distance between collocated antennas ought to be longer than a half-wavelength to form all channels independent (at most slightly correlated), and so the preparation of extra antennas eventually will increase the dimensions of mobile devices. This drawback is often mitigated even while not the utilization of multiple antennas by using cooperative diversity. A virtual antenna system is often shaped using multiple nodes to appreciate distributed spatial diversity. In cooperative diversity technique, the "relay" node, assists the communication from the "source" to the "destination".

2. BACKGROUND

The direct communication, single-user or point-to-point communication is the process of communication from a single source to a single destination (Fig 1). User-cooperation is feasible whenever there's a minimum of one extra node willing to help in communication. The only and oldest type of user-cooperation is probably multi-hopping, that is nothing however a sequence of point-to-point links from the supply to the destination (Fig 1 shows two-hop communication). Regardless of what the channel, there's some attenuation of the signal with distance that makes long-range point-to-point communication impractical. This drawback is overcome by replacement a single long-range link with a sequence of short-range links; wherever at every intermediate node there's a booster or repeater to boost signal quality. Multi-hopping was formed regarding identical time as smoke and drum signals, thus we have a tendency to do not attempt to put a time stamp on that.

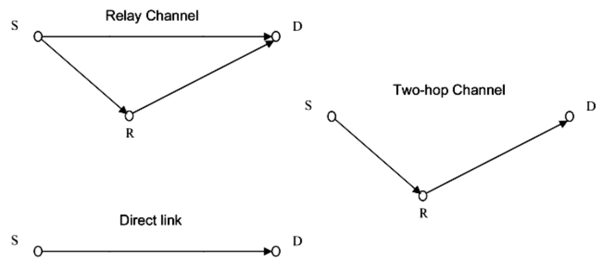

Fig 1: Direct, Two-hop and Relay Communication

More recently, the three-terminal relay channel (depicted in Fig 1) was introduced by van der Meulen, [1-2]. In his original work, van der Meulen discovered higher and lower bounds on the capacity of the relay channel, and created many observations that led to improvement of his ends up in later years. The capacity of the final relay channel remains unknown, however the bounds discovered by van der Meulen were improved considerably by cover and El Gamal, 1979[3]. Within the interim, Sato, 1976[4] conjointly checked out the relay channel within the context of the acknowledgement system. Notably, an in depth review of results on many channels that are necessary to network information theory was printed in van der Meulen, 1977[5]. The review summarized the progressive at that point; however our understanding of relaying has improved significantly since then. Several of the researchers work on necessary contributions [6-9] of the age that contributed to the understanding of user-cooperation.

Cooperative communication is one among the quickest growing areas of analysis, and it's likely to be a key enabling technology for economical spectrum use in future. The key plan in user-cooperation is that of resource-sharing among multiple nodes in a very network. The explanation behind the exploration of user-cooperation is that disposition to share power and computation with neighboring nodes will cause savings of overall network resources. Mesh networks give a vast application space for user-cooperation methods to be enforced. In conventional communication networks, the physical layer is barely accountable for act data from one node to a different. In distinction, user cooperation implies a paradigm shift, wherever the channel isn't only one link however the network itself. This chapter summarizes the elemental limits realizable by cooperative communication, and conjointly discusses sensible code constructions that carry the potential to succeed in these limits.

As mentioned earlier, Cooperative Communications help in improving the system reliability. Cooperative Diversity can be defined as a form of space diversity [9]. Some of the popular cooperatives techniques are Amplify and Forward and Decode and Forward [10-12]. In the former method, the relays receive the information, amplify the signal and forwards again to the destination, whereas in the later method, the relays completely decode the original signal, encode again and then transmit to the destination. Since the relays also send the original signal, these methods are called repetition based cooperative algorithms. It is also clear that this method causes a decrease in bandwidth, as the nodes require separate channels within the limited bandwidth.
Distributive Space Time Coding (DSTC) [13] can be used to realize cooperative diversity to prevent the bandwidth limitations. As mentioned in [14], DSTBC is a distributed form of STBC i.e., a replica of the information is shared among the cooperating nodes for transmission. Since we are dealing with DSTBC and cooperative diversity, we consider a single relay system and emphasize these methods.

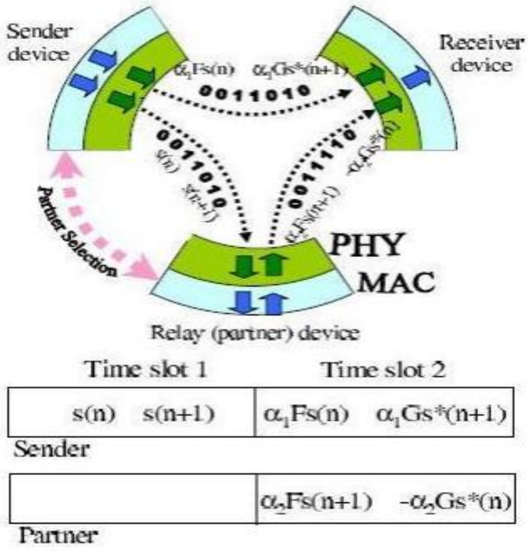

Fig. 2: Single channel based cooperative communication using DSTC [15]

A single channel based cooperative communication using DSTC is shown in fig 2. The system consists of a sender, a relay and a destination. During the first time slot, the transmitter sends two symbols, s(n) and s(n+1) to the relay (* denotes conjugate of the symbol, α_1 and α_2 are the real coefficients which are related as $\alpha_1^2 + \alpha_2^2 = 1$ [15], [16]). During the second time slot, the sender and relay cooperatively transmit the blocks. F and G are the coding matrices used to encode the signals. These space-time encoding matrices are orthogonal in nature. Hence they can be transmitted by the sender and relay at the same time and thereby improving the reliability of the communication as well [15].

3. SYSTEM MODEL

The wireless relay model under consideration is shown in Fig 3. It has one source, R relays and one destination. The source communicates with the destination directly and also via the relays time.

Here every node has a single antenna, nodes form half duplex, i.e., each node can either send or receive in any given time. The channels from the source to the destination (SD), from the source to the i^{th} relay (SR_i) and from the ith relay, i = 1,.... , R, to the destination (R_iD) are shown with $h_0[k]$, $h_{SR_i}[k]$ and $h_{R_id}[k]$ respectively, where k is the symbol time. A Rayleigh fading model is assumed for each channel. The channels are spatially uncorrelated and changing continuously in time. The auto-correlation value between two channel coefficients, which are n symbols apart, follows the Jakes' fading model.

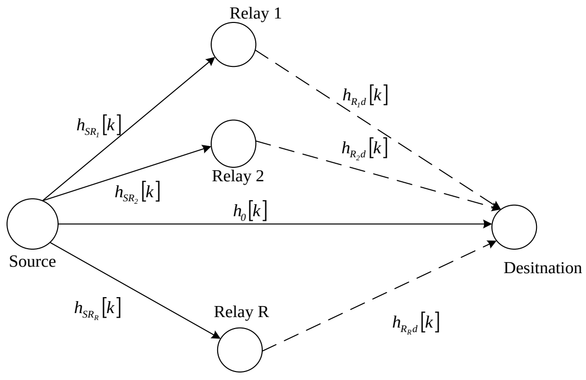

Fig 3: The model of wireless Relay

Let $v = \{e^{j2\pi m/M}, m = 0,....,M-1\}$ denote the set of M-PSK symbols. At time *k*, a group of $log_2 M$ information bits is transformed to $\upsilon[k] \in v$. Before transmission the symbols are enclosed differentially as:

$$S[k] = \upsilon[k]S[k-1], \qquad S[0] = 1 \tag{1}$$

In phase I, the symbol $\sqrt{P_0}\,S[k]$ is transmitted by the source to the relays and the destination, where P_0 is the average source power. The received signal at the destination and the ith relay are:

$$y_0[k] = \sqrt{P_0}\,h_0[k]S[k] + w_0[k] \tag{2}$$

$$y_{SR_i}[k] = \sqrt{P_0}\,h_{SR_i}[k]S[k] + w_{SR_i}[k] \tag{3}$$

Where, $w_0[k]$, $w_{SR_i}[k]$ are the noise component of the destination and noise component of ith destination.

The received signal at the ith relay is then multiplied by an amplification factor A_i, and forwarded to the destination. The amplification factor can be either fixed or variable. A variable A_i needs the instantaneous CSI. For D-AF, in the absence of the instantaneous CSI, the variance of the SR channels (here equals to one) is utilized to define the fixed amplification factor as [9]–[12]:

$$A_i = \sqrt{\frac{P_i}{P_0 + 1}} \tag{4}$$

Where, P_i is average transmitted power of the ith relay. So the corresponding received signal at the destination is

$$y_i[k] = A_i h_{R_iD}[k] y_{SR_i}[k] + w_{R_iD}[k] \tag{5}$$

Where $w_{R_iD}[k]$ is noise component at destination, now from (3) and (5) we get

$$y_i[k] = A_i\sqrt{P_0}\,h_i[k]S[k] + w_i[k] \tag{6}$$

Here, $h_i[k] = h_{SR_i}[k]h_{R_iD}[k]$ is the gain of the equivalent double-Rayleigh channel.

4. PERFORMANCE ANALYSIS

In this section a typical multi-node D-AF relay network is simulated in different channel scenarios and for the case that all nodes are mobile (the general case). In all simulations, the channels $h_0[k]$ $\{h_{SR_i}[k]\}_{i=1}^{R}$ and $\{h_{R_iD}[k]\}_{i=1}^{R}$ are generated individually which is discussed in previous chapter. Based on the normalized Doppler frequencies of the channels, three different conditions are considered:

(I) All the channels are fairly slow fading,
(II) The SD and SR channels are fairly fast, while the RD channels are fairly slow,
(III) The SD and SR channels are very fast and the RD channels are fairly fast fading.

The normalized Doppler frequencies of the three scenarios are shown in Table 1. The values in the table can be translated to different vehicle speeds of communication nodes in typical wireless systems. For example, in a system with carrier frequency f_c = 2 GHz and symbol duration T_s = 0.1 ms, the corresponding Doppler shifts for the SD channel would be around $f_D = f_{sd}/T_s$ = 50, 500, 1000 Hz, which would correspond to the speeds of $v = cf_D/f_c$ = 25, 270, 540 km/hr, respectively, where c = 3×108 m/s is the speed of light.

Table 1 covers a wide practical range of situations occurs, from very slow to very fast fading, and these situations can be applicable in present and future wireless applications.

Table 1: Three Simulation Conditions

	f_{SD}	f_{SR_i}	f_{R_iD}
Condition I	0.005	0.005	0.005
Condition II	0.05	0.05	0.005
Condition III	0.1	0.1	0.5

In each condition, binary data is differentially encoded for M=2 as DBPSK constellations. Here in this simulation consider block-by-block transmission is conducted in all conditions. The amplification factor at the relay is fixed to $A_i = \sqrt{\frac{P_i}{(P_0+1)}}$ to normalize the average relay power to P_i. The power allocation among the source and relay is such that $P_0 = \frac{P}{2}$ and $P_i = \frac{P}{2R}$, where P is the total power consumed in the network.

Note that, due to the way the variance of all AWGN components and channel gains is normalized to unity, the total power P also has the meaning of a signal-to-noise ratio (SNR). At the destination, the received signals are first combined with the proposed weights so that the minimum Euclidean distance detection can then be carried out. The simulation is run for various values of the total power in the network.

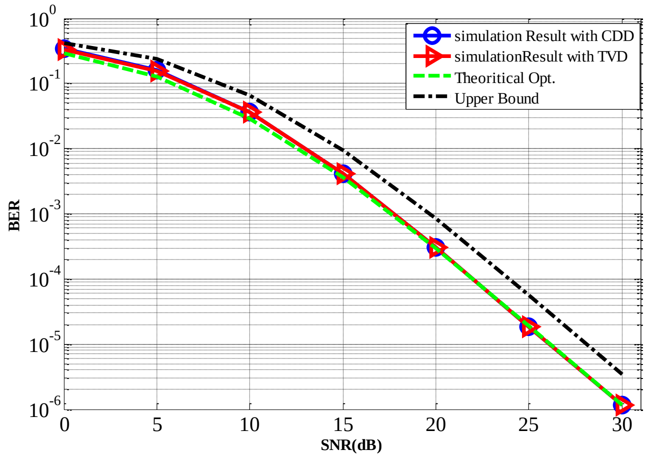

Fig 4: Theoretical and Simulation results of DAF relaying with Two Relay in condition I using DBPSK

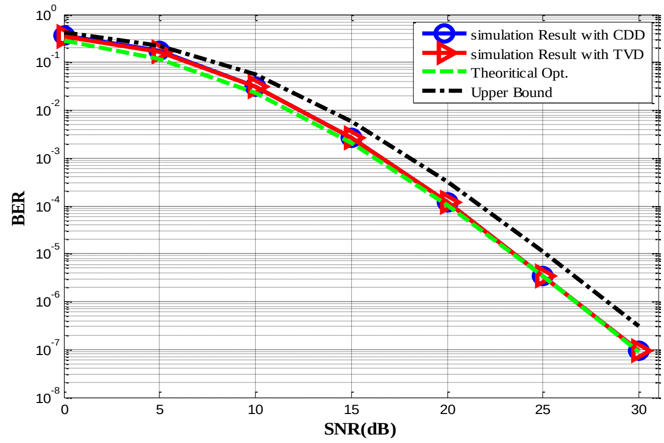

Fig 5: Theoretical and Simulation results of DAF relaying with Three Relay in conditional I with using DBPSK

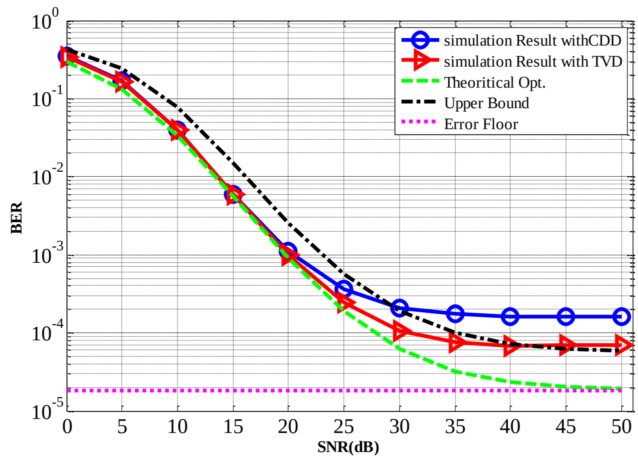

Fig 6: Theoretical and Simulation results of DAF relaying with Two Relay in condition II using DBPSK

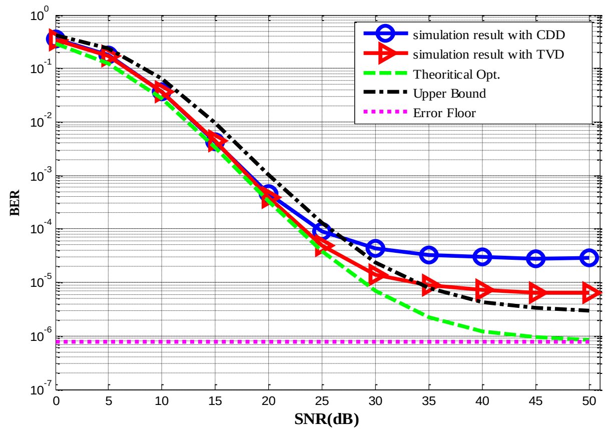

Fig 7: Theoretical and Simulation results of DAF relaying with Three relay in condition II with using DBPSK

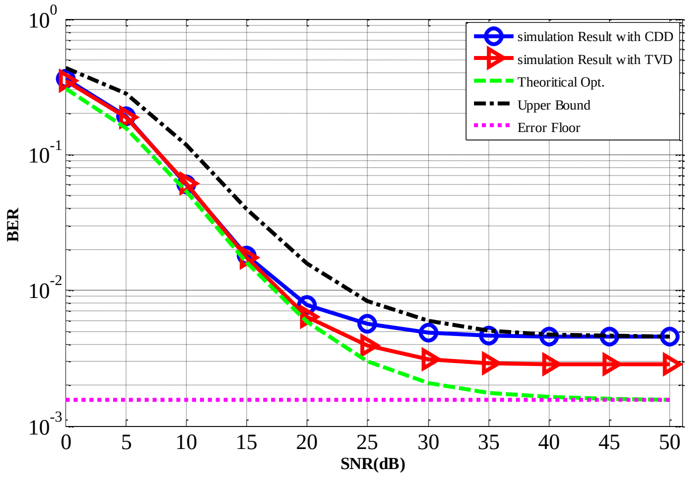

Fig 8: Theoretical and Simulation results of DAF relaying with Two relay condition III using DBPSK.

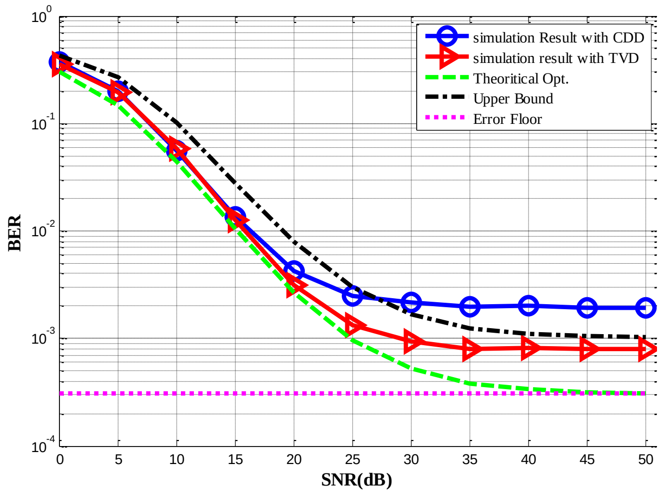

Fig 9: Theoretical and Simulation results of DAF relaying with Three relay condition III with using DBPSK.

5. CONCLUSION

The performance of multi-node relaying system is described in this paper. Differential M-PSK modulation is used with amplify-and-forward method to perform the work in time varying channel. The channel is related to auto-correlation values, the new combining weight at destination was provided. The whole work is simulated in MATLAB environment. The result is verified in two and three relay operation. It was shown that the error performance depends on the fading rates of the direct and the cascade channel. the proposed work support with simulation in different conditions and depicts the proposed combining gains lead to a better performance over the conventional weight.

REFERENCES

[1]. van der Meulen, E. C. (1968). Transmission of information in a T-terminal discrete memoryless channel. PhD thesis, Dept. of Statistics, University of California, Berkeley.

[2]. van der Meulen, E. C. (1971). Three-terminal communication channels. Advanced Applied Probability, 3:120–154.

[3]. Cover, T. M. and El Gamal, A. A. (1979). Capacity theorems for the relay channel. IEEE Trans. Inform. Theory, 25:572–584

[4]. Sato, H. (1976). Information transmission through a channel with relay. The Aloha System, University of Hawaii, Honolulu, Tech. Rep.

[5]. van der Meulen, E.C. (1977). A survey of multi-way channels in information theory: 1961-1976. IEEE Trans. Inform. Theory, 23:1–37.

[6]. Slepian, D. and Wolf, J. (1973). Noiseless coding of correlated information sources. IEEE Trans. Inform. Theory, 19:471–480

[7]. Gaarder, N. T. and Wolf, J. K. (1975). The capacity region of a multiple-access discrete memoryless channel can increase with feedback. IEEE Trans. Inform. Theory, 21(1):100–102.

[8]. Cover, T. M. (1972). Broadcast channels. IEEE Trans. Inform. Theory, 18:2–14.

[9]. Cover, T. M. (1975). An achievable rate region for the broadcast channel. IEEE Trans. Inform. Theory, 21(4):399–404.

[10]. J. N. Laneman, G. W. Wornell, and D. N. C. Tse, "An efficient protocol for realizing cooperative diversity in wireless networks," in Proc. IEEE Int. Symp. Information Theory, Washington, DC, June 2001.

[11]. Yi Zhao, Raviraj Adve and Teng Joon Lim, "Improving Amplify-and-Forward Relay Networks: Optimal Power Allocation versus Selection", in IEEE International Symposium Information Theory, 2006.

[12]. Andreas Meier, Dr John Thompson, "Cooperative Diversity in Wireless Networks", Erasmus Project at the University of Edinburgh, March 2004.

[13]. Pallavi Mannar Mannan, "Framework for the Design and Implementation of Software Defined Radio Based Wireless Communication System", MS Thesis, University of Akron, December 2005.

[14]. Sangman Moh, Chansu Yu, Seung-Min Park, Heung-Nam Kim and Jiwon Park, "CD-MAC Cooperative Diversity MAC for Robust Communication in Wireless Ad Hoc Networks" ICC 2007.

[15]. Chansu Yu, Sangman Moh, "A Cooperative Diversity-based Robust MAC Protocol in Wireless Ad Hoc Networks", IEEE Trans. on Parallel and Distributed Systems.