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Performance analysis of Inter-Relay Cooperation on the performance of FSO Systems using DF, AF and FF Algorithms.

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ABSTRACT

In this work, we study the impact of inter-relay cooperation on the performance of Decode-and-Forward (DF), Amplify-and-Forward(AF) and Filter-and-Forward(FF) cooperative Free Space Optical (FSO) communication systems with the help of any number of relays. The idea of inter-relay cooperation (IRC) was introduced very currently where the relay-relay links are activated for further increasing the performance of the system. The aim is to calculate the outage probability and power margin.It is a tendency to gift an asymptotic analysis that is effective for coping with the quality of IRC with an absolute number of relays and for explanation the network conditions under that implementing IRC in any of its variants is beneficial for enhancing with the help of diversity order of the FSO system. Itcan derive the diversity orders that can be achieved over the composite channel with any number of relays.

Keywords: Relay, Free Space Optical (FSO), Inter Relay Co-operation (IRC).

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INTRODUCTION

Cooperative Free Space Optical (FSO) communications promptly designed into a well established field of research .A large number of contributions investigated the cooperative FSO communication techniques as efficient distributed solutions for mitigating the turbulence-induced fading that severely put down the performance of FSO links. Several variants of the cooperative solutions were examined comprising the association of parallel-relaying and serial-relaying techniques with Amplify-and-Forward (AF), Decode-and-Forward (DF) and Filter-and-Forward (FF) transmission strategies. In this context, all-optical solutions or solutions that involve all conversion were ideated with either all-active or selective relaying schemes that can be enforced in the by using channel state information (CSI) respectively. Numerous performance measures were utilized for quantifying the gains with respect to communication factors including the bit error rate(BER), the outage probability, probability density function (PDF) and power margin. Furthermore, a wide variety of fading models were adopted including the exponential, the lognormal, the gamma-gamma and MIMO models.

While the all-active parallel-relaying systems correspond to a two-phase solution based on sequential source-destination(source-relay followed by relay-destination) communications, the idea of inter-relay cooperation was designed for such systems where the relays cooperate with each other before there transmission phase towards the destination that increases the fidelity of signal reconstruction at the relays and eventually boosts the performance of the cooperative FSO network. In this context, the solution corresponds to a three-phase source-relay, relay-relay(inter-relay)[1]-[2], and relay-destination cooperation strategy. The conditional Bit Error Rate (BER)[3] and the optimal power allocation strategy were derived for any number of relays. A two-relay system was analysed in the absence and presence of Channel State Information (CSI). Two variants of the inter-relay cooperation strategy were proposed and their outage probabilities and power margin were derived over gamma-gamma fading channels.

In this work, we extend the outage probability analysis with two relays to an arbitrary number of relays in the presence or absence of CSI. We derive the exact outage probability, power margin and the diversity orders that can be achieved by the two variants IRC1 and IRC2 where IRC is implemented in the forward and forward-backward directions based on the relays present. This contribution of the paper resides in a comprehensive analysis on the utility of inter-relay of FSO cooperation. In this context, we highlight the conditions under which IRC1 or IRC2 can improve the outage probability of a particular FSO network[4]. In the last case, the comparison between IRC1 and IRC2 depends on the state of the inter-relay links as well. We propose a technique for analytically comparing IRC1 and IRC2 under this scenario with three algorithms[5] based on the number of relays.

SYSTEM MODEL:

Consider a relay-aided FSO communication system where N relays are assumed to be present in the vicinity of a source node S, destination node D and relay node R. The relay nodes correspond to independent communication entities that are initially deployed for ensuring FSO connectivity between different locations. In case if the nodes have no information to communicate, they can serve as relays for assisting source S in its communication with destination D. This constitutes a major advantage of cooperative FSO systems where no additional infrastructure needs to be deployed. In what follows, the relays will be denoted by R1, . .,RN. For simplicity of notation, source Sand destination D will be denoted by R0 and RN+1, respectively.

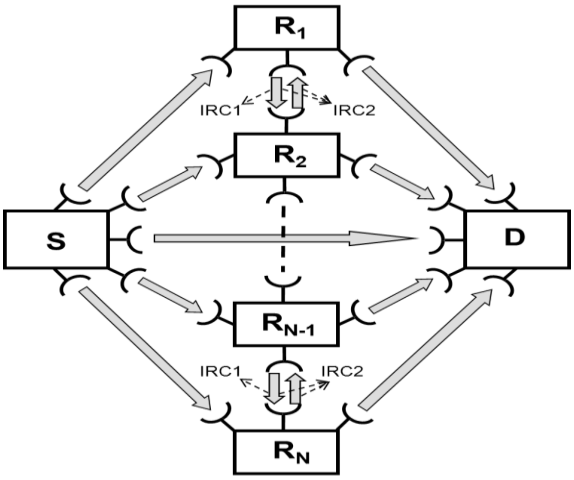


Fig 1: FSO relay-assisted transmission with N inter-connected relays

We will view and compare the three following cooperation strategies: the No Inter-Relay-Cooperation scheme(NIRC), One-way Inter Relay Cooperation scheme (IRC1), and Two-way Inter Relay Cooperation scheme (IRC2). It is worth noting that all of these schemes can be enforced in the absence of CSI at the destination from the source and the relays that renders them suitable for simple non-coherent communications based on Intensity-Modulation and Direct-Detection (IM/DD)[7]. This inter-relay cooperation strategy is based on the DF relaying scheme. In this context, the input is first decoded at each relay followed by a re-encoding/retransmission phase. The first step involves optical-to-electrical conversion while the second step involves electoral-to-optical conversion.

1) NIRC: In NIRC, Source first transmits the information message to Destination and the relays and, at a second time, the relays retransmit this message to Destination [8].
2) IRC: For the IRC schemes, after the first communication level, the relays inter-cooperate with each other to increase the fidelity of the reconstructed symbols before the retransmission phase to Destination. This inter-relay cooperation can be realized either in unidirectional or in bidirectional manners resulting in two variations of this strategy; namely, IRC1 and IRC2.

(i): For IRC1, each relay retransmits the message from the source to the next relay (if any) [8]. In other words, the decision at Rn will be based on the signals received from Source and Rn−1 (if any).

(ii): For IRC2, forward-backward inter-relay cooperation is envisaged where the decision at Rn will be based on the signals received from Source, Rn−1,….., Rn+1 (if any) to the destination.

CHANNEL MODEL:

The parameter for the inter-relay cooperation can be written as follows

$$\alpha_{i,j} = [\exp(0.49\sigma_{R,i,j}^{2}/(1 + 1.11\sigma_{R,i,j}^{\frac{12}{5}})^{7/6}) - 1]^{-1} \quad - (1)$$

$$\beta_{i,j} = [\exp(0.51\sigma_{R,i,j}^{2}/(1 + 0.69\sigma_{R,i,j}^{\frac{12}{5}})^{5/6}) - 1]^{-1} \quad - (2)$$

where

$\sigma_{R,i,j}^{2}$= $1.23C_n^2 k^{7/6} d_{i,j}^{11/6}$ is the Rytov variance

For individual links the diversity order can be derived as

$$\alpha_{i,j}=\frac{\varepsilon_{i,j}^{2}(\alpha_{i,j}\beta_{i,j})^{C_{i,j}}T(\alpha_{i,j}-C_{i,j})}{(A_{i,j}I_{i,j}^{(l)})^{C_{i,j}}T(\alpha_{i,j})T(\beta_{i,j})}\, b_{i,j} \quad - (3)$$

where $b_{i,j}$=1/($\varepsilon_{i,j}^{2}$-$\beta_{i,j}$)

for N=3, the system outage probability can be written as

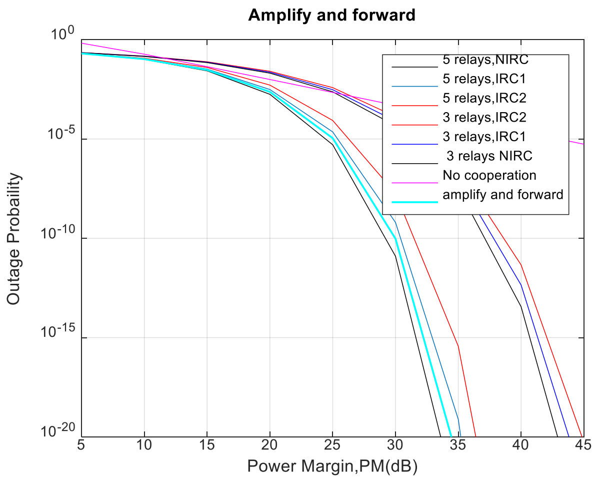
$$p_{out}=p_{0,4}[q_{0,1}q_{0,2}q_{0,3}Q_0+p_{0,1}q_{0,2}q_{0,3}Q_1+q_{0,1}p_{0,2}q_{0,3}Q_2+q_{0,1}q_{0,2}p_{0,3}Q_3+p_{0,1}p_{0,2}q_{0,3}Q_4+p_{0,1}q_{0,2}p_{0,3}Q_5+q_{0,1}p_{0,2}p_{0,3}Q_6+p_{0,1}p_{0,2}p_{0,3}Q_7] \quad -(4)$$

NUMERICAL RESULT:

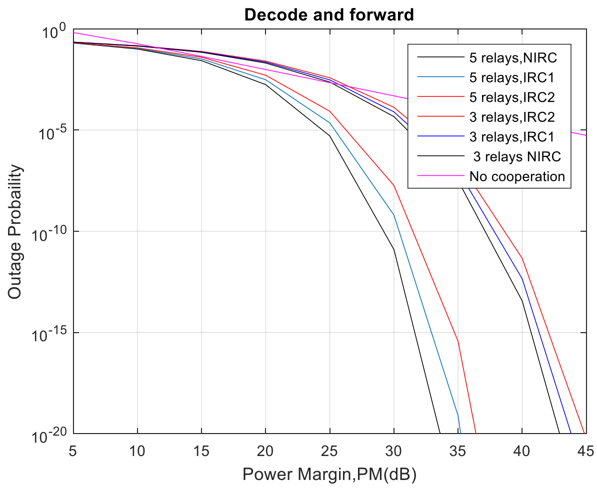
The refractive index constant C_n^2 = $1*10^{-14}m^{-2/3}$
Attenuation σ = 0.44 dB/km

The numerical result under the performance of 3-relay and 5-relay are
D = {(1, 4.2), (1.5, 3.6),–(2, 3.1)} for N = 3 and
D = {(3, 2.4), (3.3, 2), (3.6, 1.6),–(3.7, 1.5),–(3.8, 2.2)} for N = 5.

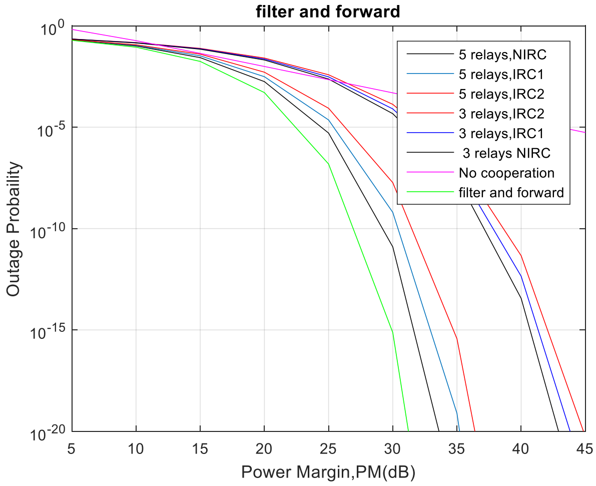
Scenario of Amplify-and-forward (AF):



Scenario of Decode-and-forward (DF):



Scenario of Filter-and-forward (FF):



CONCLUSION

The power margin can be reduced and the outage probability can be increased by using Amplify-and-Forward(AF), Decode-and-Forward(DF) and Filter-and-Forward(FF) algorithms.

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