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Performance Analysis of Multi Hop Relay Network in Rayleigh Fading

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ABSTRACT: Previous work has been done in [1], [2],[3],[4], which focuses on system level description of the user concept of cooperation. It concentrates on physical layer issues, with the anticipation that any higher level overhead will be negligible compared to the gains. The type of cooperation focused on , is the cooperation of active users, i.e., users who have information of their own to send and thus do not want to simply be another user's relay. Cooperative relaying is an effective technique to combat multipath fading, improve system capacity and enhance the coverage. Initially, capacity analysis of Gaussian relay channel was comprehensively studied in [6]. For network scenario, capacity has been analyzed in [7]. Coding strategies that exploit node cooperation has been developed in [8] for relay networks. Outage probability of multi-hop amplify and forward relay system has been analyzed in [9]. In [10], closed form expressions of average bit error rate, amount of fading and outage probability have been derived for Rayleigh-fading channel where relay works in non-regenerative mode and destination performs equal gain combining. An overview of various cooperation schemes and issues related to their implementation has been discussed in [11]. Various power allocation strategies for non-generative relay network have been studied in [12]. In [13], closed form expressions of outage probability and bit error rate (BER) for binary phase shift keying (BPSK) are derived for the case where communication between source and destination is supported by multi antenna relay and both relay and destination perform maximum ratio combining (MRC) of signals in Rayleigh fading channel. Outage probability and average error rate of two-hop multi antenna relay based system for the case when relay performs selection combining (SC) of signals and destination performs MRC of signals are analyzed in [14] and [15], respectively. Closed form expressions of BER have been established in [16] for two-hop multi antenna cooperative relay network in Rayleigh fading channel. Here, destination performs selection combining of signals received from source, relay and relay performs selection or MRC combining of signal. In [17], analytical expressions of average received SNR, outage BER and channel capacity has been established for the case when source and relay are communicating with multi-antenna destination in Rayleigh fading channel. Closed form expression of outage probability has been derived in [18]; here, communication between source and destination is supported by two multi-antenna relay nodes.

KEYWORDS: Multi Hop Communication, Cooperative Communication, Relay Network, and Rayleigh Fading

I. INTRODUCTION: MULTI HOP COMMUNICATION AND RELAYING

Multi hop communication is a wireless network adopting multihop wireless technology without deployment of wired backhaul links. Traditionally, consumer wireless telecommunication services have been provided using cellular architectures where many mobile wireless terminals communicate directly with a single fixed base station with a wired connection to the public telecommunication infrastructure. Relaying systems realize a number of benefits over traditional systems in the areas of deployment, good connections, adaptability and capacity. In cooperative relay systems, system designers should be able to exploit both frequency diversity and cooperative diversity with existing techniques for flat channels need to be adapted or new techniques need to be designed.

Relay is used to receive and transmit the signal between base station and mobile user. Mobile relays can be used to build LAN between mobile users under the umbrella of the wide area cellular network. Types of Relays are:

i) Decode and Forward: Inthis relaying scheme, the relay decodes the source message in one block and transmits the re-encoded message.
ii) Amplify and Forward: In this relaying scheme, the relay sends an amplified version of received signal in the

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last time slot. Amplify and forward relaying requires less delay and less computing power.

iii) Compress and Forward: In this relating scheme, the relay quantizes the received signal in one block and transmits the encoded version of the quantized received signal.

II. LITERATURE SURVEY

Related work has been presented in [19], where authors derive expression for symbol error rate when selected relays with high contribution are allowed to participate in communication. An amplify and forward relay network has been studied in [20], where a source communicates with the user having best channel conditions through an intermediate relay that serves to multiple users. Probability density function and cumulative density functions of the received SNR at the best user in Rayleigh fading channels have also been derived. Spatial reuse of relay time-slot in interference limited channel has been analysed in [21] for amplify and forward cooperative relaying. Performance of non-regenerative cooperative relay system with selection combining at the destination over independent and non-identical Nakagami-m fading channels has been studied in [22]. Here, closed form expressions for outage probability, cumulative density function and the probability density function of received SNR have been presented. In [23], authors propose a network coding approach to cooperative diversity featuring the algebraic superposition of channel codes over a finite field. Communication over interference limited wireless networks with the help of network coding has been analysed in [24]. A new scheme for cooperative wireless networking based on linear network codes has been proposed in [25].

III. COOPERATIVE COMMUNICATION

Cooperative communication is one of the fastest growing areas of research, and it is likely to be a key enabling technology for efficient spectrum use in future. The key idea in user cooperation is that of resource sharing among multiple nodes in a network. The reason behind the user cooperation exploration is that willingness to share power and computation with neighbouring nodes can lead to savings of overall network resources. Cooperation is possible whenever the number of communication terminals exceeds two. Therefore, a three terminal network is a fundamental unit in user cooperation. The focus of our discussion will be the relay channel and its various extensions. In this regard, we first bound the achievable rates of relaying using mutual information expressions involving inputs and outputs of the cooperative nodes. The key advantages of using supportive, cooperative or space time relays in the system are:

i) Performance gains: Large system wide performance gains can be achieved due to path loss gains as well as diversity and multiplexing gains. These translate into decreased transmission powers, higher capacity or better cell coverage.

ii) Balanced quality of service: In traditional systems, users at the cell edge or in shadowed areas suffered from capacity and/or coverage problems. Relaying allows balancing this discrepancy and hence giving almost equal quality of service to all users.

Cooperative communications based on relaying nodes have emerged as a promising approach to increase spectral and power efficiency, network coverage and to reduce outage probability. Similarly, relays provide diversity by creating multiple replicas of the signal of interest. If we properly coordinate different spatially distributed nodes in a wireless system, then we can effectively synthesize a virtual antenna array that emulates the operation of a multi-antenna transceiver.

IV. RAYLEIGH FADING

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal as used by wireless devices. Rayleigh fading models have an assumption that the magnitude of a signal that has passed through such a transmission medium will vary randomly, or fade, according to a Rayleigh distribution which has the radial component of the sum of two uncorrelated Gaussian random variables. Rayleigh fading is analyzed as a reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built up urban environments on radio signals. Rayleigh fading is applied when there is no dominant propagation along line of sight between the transmitter and receiver. Rayleigh fading is reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. The requirement that there be many scatterers present means that Rayleigh fading can be a useful model in heavily built up city centres where there is no line of sight between the transmitter and

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receiver and many buildings and other objects attenuate, reflect, refract and diffract the signal. In tropospheric and ionospheric signal propagation the many particles in the atmospheric layers act as scatterers and this kind of environment may also approximate Rayleigh fading.

V. SOLUTION METHODOLOGY

Envelope is a duplicate form of a signal or we can say that replica of a signal.

$$f_{\propto}(\propto) = (2 \propto / \bar{\gamma})\ e^{\left(-\propto^2 / \bar{\gamma}\right)}$$

Where,

$\bar{\gamma}$ = Average SNR

γ = Instantaneous SNR

Probability Density Function:

$$f_{\gamma}(\gamma) = \frac{1}{\gamma}\ e^{\left(-\gamma / \bar{\gamma}\right)}$$

Cumulative Density Function:

$$F(\bar{\gamma}) = \int f_{\gamma}(\gamma) d\gamma$$

$$F(\gamma) = 1 - e^{\left(-\gamma / \bar{\gamma}\right)}$$

Outage of direct link:

$$P_{out\,(direct)} = 1 - e^{\left(-\gamma / \overline{\gamma_{sd}}\right)}$$

Outage of Source to γ_1 relay link:

$$= 1 - e^{\left(-\gamma / \overline{\gamma_{s\gamma_1}}\right)}$$

Outage of γ_1 to γ_2 relay link:

$$= 1 - e^{\left(-\gamma / \overline{\gamma_{s\gamma_1,\gamma_2}}\right)}$$

Outage of γ_n to destination link:

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$$= 1 - e^{(-\gamma/\bar{\gamma})}$$

Total Outage Probability:

$$P_{out_{relay}} = 1 - [1 - \left(1 - e^{(-\gamma/\bar{\gamma})}\right)]^{n}$$

Total Outage Probability for the signal transmission via direct link from source to destination:

$$P_{out_{direct}} = 1 - e^{(-\gamma/\bar{\gamma})}$$

Assuming selection combining at the destination to select the one best signal having highest SNR, then end to end outage:

$$P_{out_{SC}}(\gamma) = \{1 - e^{(-\gamma/\bar{\gamma})}\}\{1 - \left[1 - \left(1 - e^{(-\gamma/\bar{\gamma})}\right)\right]^{n}\}$$

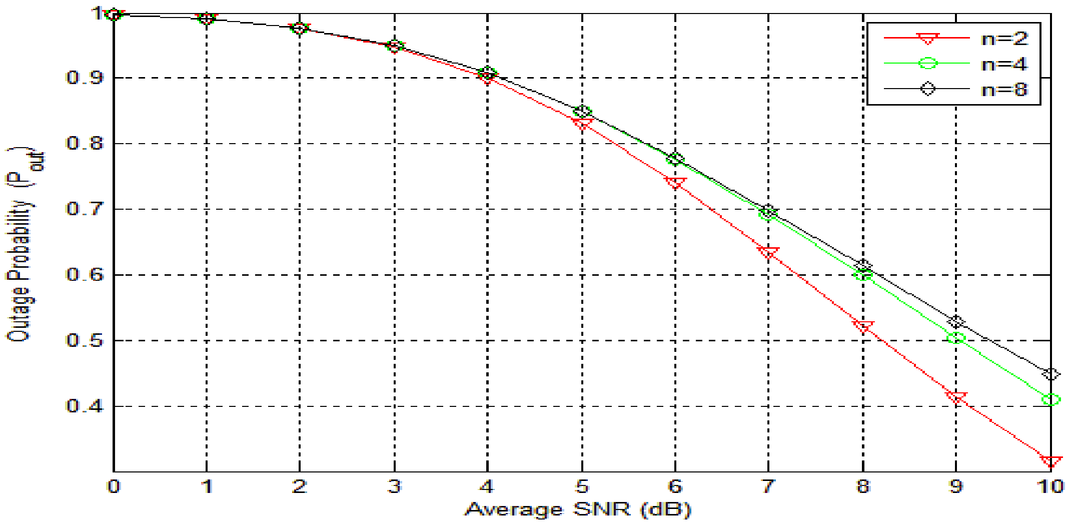

Fig 1: Graph of Outage Probability Vs. Average SNR for relay path using Selection Combining Diversity Technique.

Outage probability can be defined as the probability when the channel cannot meet certain requirement demanded by some particular application like multimedia. SNR is defined as the ratio of signal power to noise power. In selection diversity, the receiver selects branch which have highest instantaneous SNR. It is used in spatial diversity systems involving the sampling of antenna signals, and sending the largest one to the demodulator. Diversity schemes provide two or more inputs at the receiver such that the fading phenomena among these inputs are uncorrelated.

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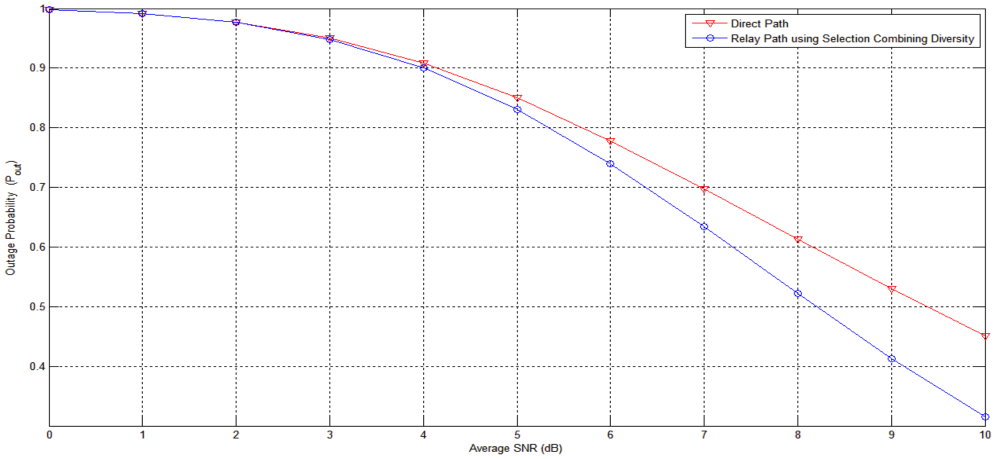

Fig 2: Comparison of Direct path and Relay path using Selection Combining Diversity. Graph of Outage Probability Vs. Average SNR. Relay path with Selection Combining diversity technique shows a better performance than direct path.

VI. CONCLUSION

As stated at the outset, the field of high-data-rate, spectrally efficient and reliable wireless communication, is currently receiving much attention. Cooperative transmission is emerging as an effective technique for combating the effects of path loss, shadowing and multipath fading. Cooperative relaying provides diversity gain, reduces outage and improves BER performance.

This model can improve the coverage area with minimal power consumption. The overall cost of the infrastructure will increase but we are focusing on its advantages and future scope for expansion of coverage areas. Further we will try to improve system performance by using other diversity combining techniques.

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