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Outage Analysis of Cooperative and Non-Cooperative Communication

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Abstract: ***The cooperative communication has a great applications in the past years. In this a set of nodes can form a distributed multiple-antenna system and transmit in a cooperative manner. So cooperative communication is a good technique which can avoid the attenuation of signals due to fading and path loss by providing gains. The reliability of the cooperative communication is increased by sharing information among multiple antenna. But the cooperation may introduce interferences and it will degrade the performance of the system. In this paper deriving a criterion, by analyzing and comparing the outage performances of cooperative and non-cooperative strategies. The implementation of cooperation or non-cooperation in a communication can be determine by using this criterion. The comparison is based on the outage probability due to the fixed rate of transmission.***

Keywords: Diversity gain, Outage probability, Homogeneous poisson process

1. Introduction

Cooperative communication is an effective communication using the information of different nodes. It has many importance in the past decade applications. The transmission is in a cooperative manner and is achieved by using coordination protocols. This will provide a diversity gain to combat the attenuation f signals caused due to fading and shadowing.

More efficient transmission can be obtained from the cooperative strategy. This data from different nodes transmits together. Different nodes may generate interferences. So as the network become more dense, performances will degrade. So that, its benefits applicable only in the single wireless links. For a large wireless networks large number of nodes participates and it affect the communication.

By avoiding these problems we can develop good communications. In this paper analyze and compare cooperative and non-cooperative strategy based on the outage probabilities. Then from that develop the criterion for both strategies. The effective cooperative strategy can be used in interference limited networks and a useful lower outage probability can be achieved using the non-cooperative strategy.

2. Motivation and Related Works

Alternating concurrent cooperative transmission [1] can give a solution. The medium access control(MAC) free broadcast strategy is a simple, energy efficient, low-overhead form of cooperative diversity based strategy called the opportunistic large arrays and used a received power based threshold.

The problem of joint spectrum management [2] for a set of concurrently utilizing an interference-limited wireless networks can be mathematically analysed. The overall problem is separated into two sub problems, (i) spectrum management through power allocation with given relay selection strategy, and (ii) relay selection for a given spectral profile.

The problem of joint rate control relay selection and power allocation [3] is formulated as mixed integer nonlinear problem with objectives of maximizing the sum peak signal to noise ratio of a set of concurrent video session. A global optimization algorithm based on the branch and bound frame work and on convex relaxation of non convex constraints is proposed to solve the problem. The proposed algorithm can provide a theoretical upper bound on the achievable video quality and is shown to provably converge to the optimal solution.

Throughput maximization is a key challenge in cognitive radio adhoc networks. A cross layer protocol [4] is implemented the joint routing , relay selection and dynamic spectrum allocation. Performance evaluation results show that the protocol achieves much higher throughput.

The existing system focus only local benefits of cooperative communications and neglects its possible drawbacks. It performs the communication in an interference limited networks, which is an idealised version of the problem.

3. System Model

Cooperative strategy is an effective one to reduce the attenuation and fading of the signals. The analysis takes the optimal centralized algorithm and sub optimal distributed algorithms have been proposed to achieve excellent performances.

The system model consider a large wireless networks. The nodes in this area are distributed and frequency and time are synchronized. The slotted ALOHA protocol is used so that they transmits independently. The basic diagram for the system model is shown in figure 1.

In the system model signal is transmitted from the source node to the destination node. Relays are placed between the source and destination nodes. The relays are used to get

better transmission. During the transmission there is an interference from the source node to the other destinations.

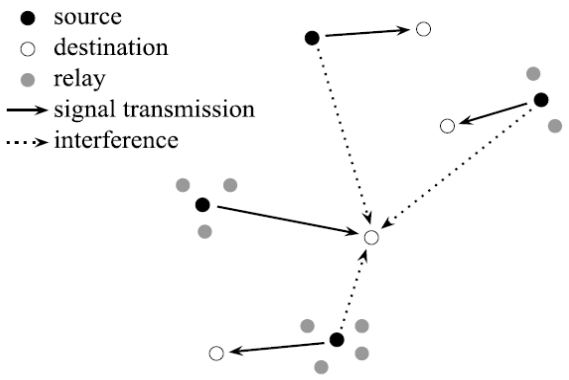

Figure 1: System Model

The analysis is carried out by taking the two strategies, cooperative and non-cooperative. From the outage probabilities the criteria is derived.

3.1 Non-Cooperative Strategy

For the analysis first taking the non-cooperative strategy. In this as the name indicates, there is no cooperation between the nodes. Each node transmits independently. Here assuming the sources form a homogeneous poisson process with intensity λ on the plane. The parameter λ depends on the density of the node and statistics of incoming data.

The large scale path loss and small scale fading is considered to measure the strength of the received signal. Power-law path loss and Rayleigh fading model is considered. The instantaneous received signal power is measured by $P_t G\left(\frac{d}{d_0}\right)^{-\alpha}$ (1)

where, d is the distance between the source and the destination, P_t is the transmitted power, G is random variable in Rayleigh fading, d_0 is the reference distance and α is the path loss exponent. In the ALOHA protocol several interference can come. So that the received signal may get disturbed with noise. Also all the sources have the same transmit power. The received interference power can be calculate with the h_i channel from i^{th} interference to a location x at the destination as,

$$P_I(x) = \sum_{x_i \in \Pi} P_t |h_i|^2 = \sum_{x_i \in \Pi} P_t G_i \|x_i - x\|^{-\alpha} \quad (2)$$

Here $\|.\|$ represents the Euclidean distance and Gi characterizes fading effects .

In this paper the performance is measured from the outage probability. To find the outage there is threshold for the SINR, γ_{th} .

$$\gamma_{non} = \frac{P_t G d^{-\alpha}}{P_I + P_N} \quad (3)$$

Here a baseline strategy is taken and P_N is the noise power. The outage probability is

$$P_{out}^{non} = P_r\left(\gamma_{non} < \gamma_{th}\right) \quad (4)$$

The closed form expression will be

$$P_{out}^{non} = 1 - \exp\left(\frac{-\gamma_{th} P_N}{P_t d^{-\alpha}} - A_\alpha \lambda d^2 \gamma_{th}^{\frac{2}{\alpha}}\right) \quad (5)$$

$$\text{Where, } A_\alpha = \frac{2\pi^2}{\alpha \sin\left(\frac{2\pi}{\alpha}\right)} \quad (6)$$

The exponent in (5) has 2 parts , noise part and the interference part.

3.2 Cooperative Strategy

In the cooperative strategy the transmission is in a cooperative manner of the nodes. The nodes arranged in the same way as the general case. Here a time domain two phase protocol is employed. That means the time slot is divided into two and there is two phases.

In the first phase the source node transmits and the relay listen to the transmission. In the second phase the relay decode the message and forward it to the destination.

Similar to the non-cooperative strategy the source and destination uses same power Pt. The two phases generates interferences. The interference power in the first phase at a location x is

$$P_I^1(x) = \sum_{x=\pi} P_t G_t \|x_i - x\|^{-\alpha} \quad (7)$$

The received interference power at second phase is given by

$$P_I^2(x) = \sum_{x=\pi} k_{v,i} P_t G_i \|x_i - x\|^{-\alpha} \quad (8)$$

Here $k_{v,i}$ represents the relays in the interfering vicinity.

The SINR for the cooperation is γ_{CO} and is given by

$$\gamma_{co} = \frac{P_S}{P_N + P_I} \quad (9)$$

Here Ps is the signal power. Then the outage probability is

$$P_{out}^{co} = P_r\left(\gamma_{co} < \gamma_{th}\right) \quad (10)$$

4. Simulation Results

The results of the analysis are shown in the simulation results. Two dimensional homogeneous poisson process is used to approximate large networks. The path loss exponent is set to 4 and noise power is 1 . the threshold SINR is set to be 0Db.

The outage and received signal power is shown in fig.2. the cooperative strategy is analyzed with different values of k. As the SNR increases the outage probability decreases.

The fig 3. Shows the variations of outage probability as the increase in the interfering sources. As the intensity of interfering sources increases the outage probability increases.

Same for both strategies.

The fig 4 deviations of success probability as the increase in the distance between source and destination. The large distance cause to decrease the success probability. In both cases it decreases. But the success probability of non-cooperative strategy decreases slowly.

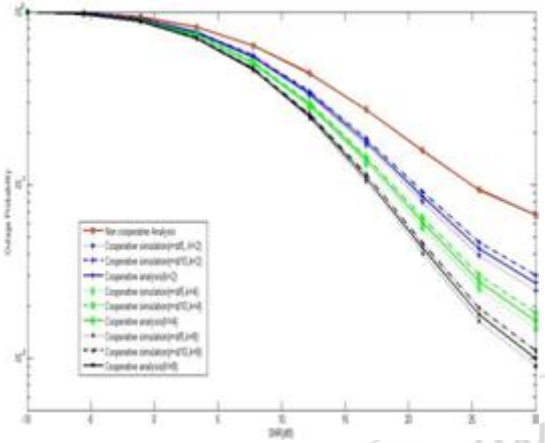

Figure 2: Outage probability versus the SNR(dB)

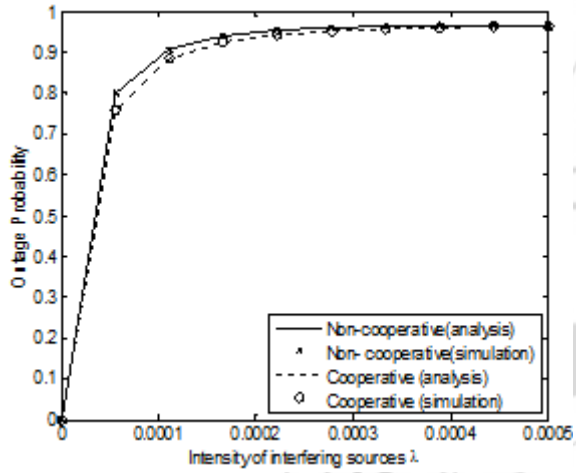

Figure 3: Outage probability versus intensity of interfering sources

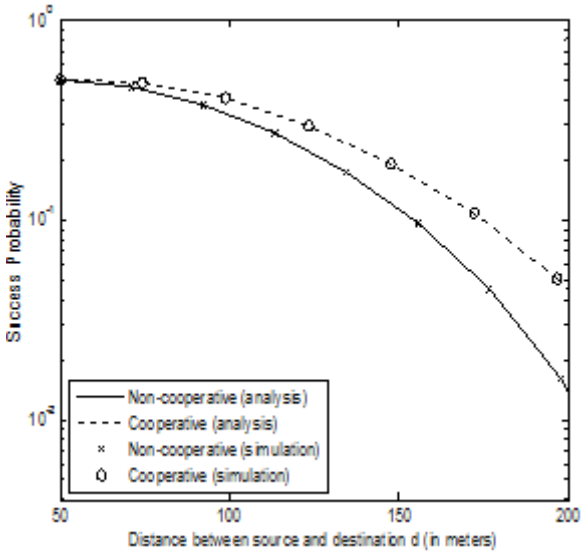

Figure 4: Asymptotic behavior of success probability as the distance increases

5. Conclusion

The paper analyzed the performances of cooperative and non-cooperative strategies. The performance is analysis is based on the outage probability. From that derived a criterion which determines the reliable strategy for the network. From that we can say for larger network the interference dominates and by using the non-cooperative strategy a lower outage probability can be obtained. The cooperative strategy can give a better performance in small networks with less interferences. This paper analysis uses a fixed rate transmission. In future you can perform these analysis withot the fixed transmission. Then the performance can be compared using the outage capacity.

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