# Power Minimization Algorithm for Cooperative Wireless Network

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***ABSTRACT :*** *The increasing demand of data rate with limited available spectrum has motivated the researcher to find solutions which enable to cater the demands of future wireless networks. Cooperative communication is one of the solutions, which uses the cooperation of other terminals called relays to complete the communication. The node who overhears the communication cooperate with the source of information and re-transmit it towards destination is the key concept of cooperation. If many cooperators retransmit with uncontrolled power, it results in wastage of power and increased interference in the network. To achieve the fruits of cooperation, it is, therefore, very essential to choose the appropriate partner (relay) and adequate power level for all the pairs of source-relay in the network. Relay assignment and power minimization algorithm for multisource multi relay scenario is presented in this paper. The approach taken in this paper ensures that each pair of source-relay consumes minimum power, at the same minimizing the overall power consumption of the network.*



***KEYWORDS:*** co*operative communication, relay selection, power minimization,*

## I. INTRODUCTION

Cooperative communication is similar to the relay channel model to some extent but differs significantly in that each wireless user is assumed to both transmit data as well as act as a cooperative agent for another user. In other words, cooperative signaling protocols should be designed so that users can assist other users while still being able to send their own data. Cooperation leads to interesting tradeoffs in code rates and transmit power. In the case of power, it may seem that more power is required because, in cooperative mode, each user is transmitting for both itself and a partner. However, the point to be made is that the gain in diversity from cooperation allows the users to reduce their transmit powers and maintain the same performance. In the face of this trade, one hopes for a net reduction of transmit power, given everything else being constant. In cooperative communication, each user transmits both its own bits as well as some information for its partner, so it may appear that each user requires more bandwidth. On the other hand the spectral efficiency of each user improves because, due to cooperation diversity, the channel code rates can be increased. Thus, in non-cooperative communication users send directly to a common destination, without repeating for one another. In cooperative communications, independent paths between the user and the base station are generated via the relay channel. The relay channel can be thought of as an auxiliary channel to the direct channel between the source and destination. A key aspect of the cooperative communication process is the processing of the signal received from the source node done by the relay. These different processing schemes result in different cooperative communications protocols. The processing at the relay differs according to the employed protocol. Cooperative communications protocols can be generally categorized into amplify and forward and decode and forward relaying schemes.

II System Model and Problem Statement

Consider a multi-source and multi-relay network with M source nodes and N relay nodes as shown in Fig.1. [8]. Here it is assumed that, direct transmission is not possible and one source has only one partner to help for information transmission, i.e. single relay selection. The protocol used by relay is decode and forward. (DF). In this method, each source node is connected with one relay. The channels from source nodes to relays and the channels from relays to destination are unidirectional.

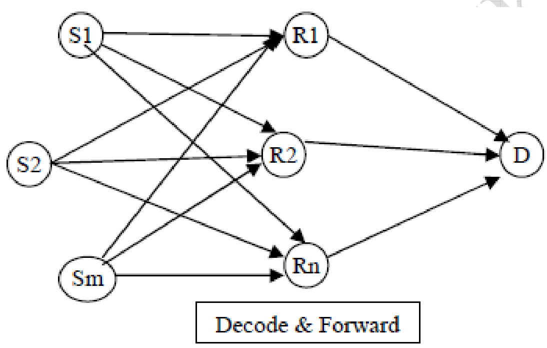



Fig.1: Wireless network with M sources and N relays

The sources are assigned to relays in such a way to minimize the total power consumption in the network. The problem of power minimization can be stated state mathematically as follows:

$$min\left(\sum_{i=1}^{M} \mathrm{P}_{s,i} + \sum_{j=1}^{N} \mathrm{P}_{r,j}\right)$$

$$\text{s.t.} \quad \mathrm{P}_{s,i} > 0, \quad \mathrm{P}_{r,j} > 0$$

$$\sum_{i=1}^{M} \mathrm{P}_{s,i} \le P_{s,max}$$

$$\sum_{j=1}^{N} \mathrm{P}_{r,j} \le P_{r,max}$$

III Proposed Algorithm

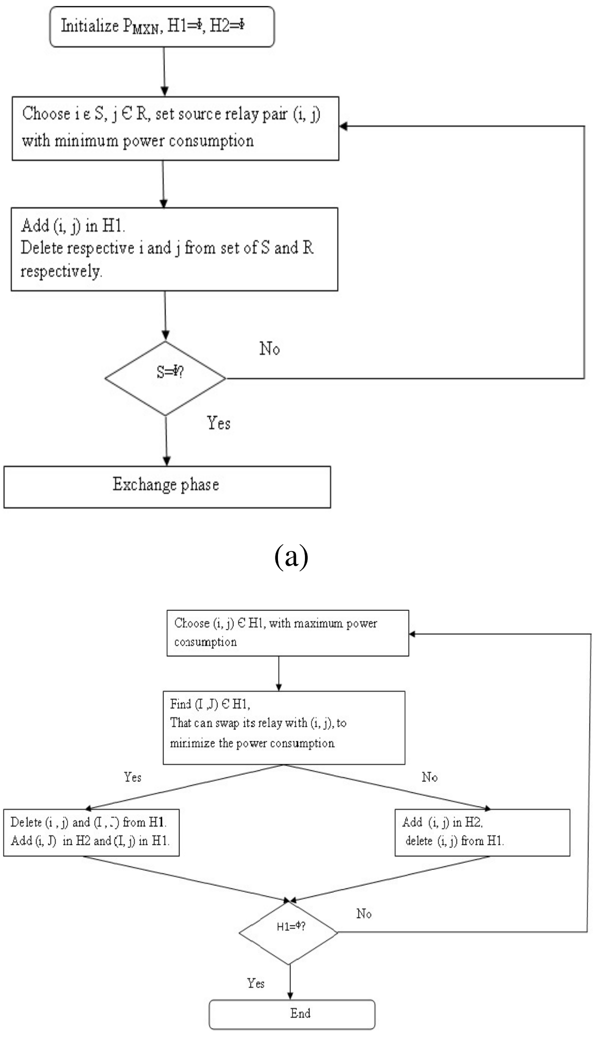
First of all, for the relay selection, power matrix is generated, in which transmission power for each source with every relay is calculated [8]. Then initialize the elements in the transmission power matrix, which can be expressed as shown below.

$$\begin{bmatrix} P_{1,1} & \cdots & P_{1,N} \\ \vdots & \ddots & \vdots \\ P_{M,1} & \cdots & P_{M,N} \end{bmatrix} \text{....[1]}$$

This algorithm can be used to select appropriate relay node in the cooperative environment in order to minimize the transmission power of source-relay pairs as well as the transmission power of the whole network. The flow chart of algorithm is shown in fig 2. Set of source nodes is denoted by S and set of relay nodes are denoted by R respectively. P1 denotes the initial relay allocation, P2 denotes the intermediate relay allocation and P3 denotes final relay allocation. The algorithm consists of three phases: Initial phase, Intermediate phase and final phase.

The relay allocation in Initial phase is known as initial relay allocation, (Fig.2) which is denoted by P1. In this phase, for one source the relay is being selected in such a way that the source-relay pair has minimum power consumption. In this way relay selection is done until all the source nodes have been allocated. The relay allocation in Intermediate phase is known as

Intermediate relay allocation, (Fig.2) which is denoted by P2. In this phase, exchange of relay is carried out M times for the power reduction. From P1 the maximum power consuming pair (i, j) is selected. Then another source and relay pair (y, z) from initial phase, which can swap the relay to get the maximum power saving, is being found. If the source and relay pair (y, z) is found, delete previous pairs from P1, and add new pairs in P2 and P1 respectively. Repeat this process until P1 is empty. The relay allocation in Final phase is known as Final relay allocation, (Fig.2) which is denoted by P3. Final phase uses a step consisting of a check to identify whether the total power consumption due to source-relay allocation in Intermediate




(a)

(b)

Fig. 2: (a) Greedy Phase (b) Exchange Phase

Phase is lesser than the corresponding power consumed in the Initial phase or not. And then relay selection is done based on the initial relay allocation or intermediate relay allocation which has lesser power consumption.

## IV Results

Simulation of this algorithm is performed in simulation tool MATLAB. In DF environment, assuming that the power allocation is already done; we consider 5 sources and 5 relays for the simulation purpose, which can be changed as per requirement later on. From the simulation of the algorithm it has been found out that, it works well in DF-DT system. In DF-DT system, Direct Transmission from source node to destination is possible in addition to the relayed transmission. In the intermediate phase when a maximum power consuming pair (i, j) in P1 swaps its relay with other pair (y,z) forming pair (i, z), then source y remains without relay. So, now it can either chose to make pair with the relay j which is left by the source i, or it can co-operate with the remaining relays in the network, or can even opt for direct transmission. The limitation with algorithm is that in case of DF system, where no direct transmission is possible, the intermediate phase allocation tends to increase the total power transmission. This is because, when pair (i, j) i.e maximum power consuming pair in P1, swaps its relay with (y, z) forming (i, z), then the source y is forced to make pair with j owing to the fact that there is no direct transmission possible and other relays are occupied by different sources. This can possibly increase the total power consumption of the source y transmission to the destination via relay j. So in order to overcome this limitation of the initial and intermediate phase, we propose a final phase which eliminates the possibility of increase in power consumption in the intermediate phase. Table 1 shows the source-relay pair & their corresponding power consumption and total power in Initial Phase. Total power in

Initial Phase is the total transmission power of the network.

**Table1: The Initial Phase relay allocation**

| Source | Relay | Power Consumption |
|---|---|---|
| **2** | **5** | **1.0714** |
| **1** | **2** | **2.9262** |
| **3** | **1** | **3.8096** |
| **4** | **3** | **14.5613** |
| **5** | **4** | **28.7848** |
| **Total Power in initial Phase=51.1532** | | |

**Table 2: The Intermediate phase relay allocation**

| Source | Relay | Power Consumption |
|---|---|---|
| 2 | 5 | 1.0714 |
| 5 | 1 | 18.9708 |
| 4 | 3 | 14.5613 |
| 3 | 2 | 16.4064 |
| 1 | 4 | 4.2566 |
| Total power in intermediate stage=55.2664 | | |

Table 2 shows the source-relay pair & their corresponding power consumption and total power in Intermediate Phase. Total power in Intermediate Phase is the total transmission power of the network. As seen from Table 1 the maximum power consuming source-relay pair is 5-4 in P1 consuming 28.7848 unit power. In intermediate phase as show in Table 2, source 5 exchanges it relay with source 3 making pair source-relay 5-1 consuming 18.9708 unit power which is less than pervious pair 5-4. But, though we succeeded in reducing power consumption of source 5, intermediate phase has unknowingly increased power consumption of source 3 from 3.8096 to 16.4064 units which in turns increases the total transmission power of the network from 51.1532 to 55.2664 units. In Fig.3, the code is run for 5 consecutive times in order to see the effect of power level of Initial Phase and Intermediate Phase; and the corresponding results have been shown in the form of Bar-graph. The careful observation (Fig 3) of the graph shows that initially in the first, third , fourth and fifth run the power in Intermediate Phase is effectively reduced but in second run, it fails to do so. The reason for this is, Intermediate phase's attempt to minimize the power consumption of maximum power consuming source relay pair by relay exchange, has increased the overall power consumption of the network. Hence Final relay selection is not made on the basis of P2, but it is made on the basis of P1 i.e initial relay allocation in initial phase. From fig.4 we observe that the power consumption in final phase never exceeds that in the intermediate Phase.

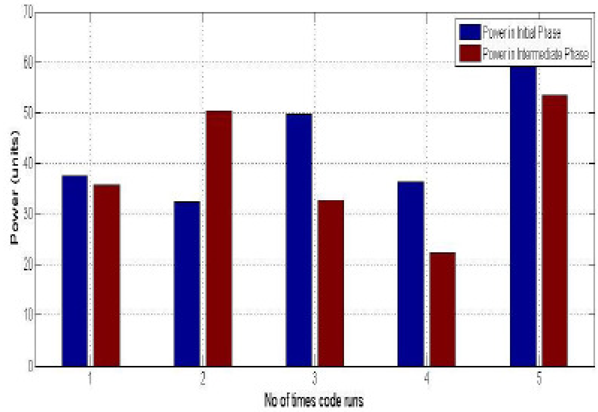



Fig.3: Power consumption in Initial phase and Intermediate phase

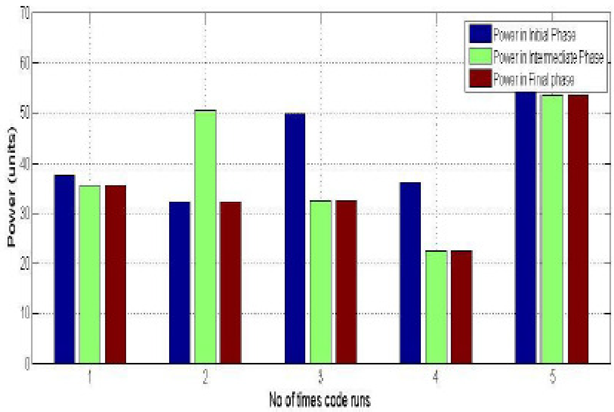



Figure 4: Power consumption in final phase

## V CONCLUSION

The diversity can be achieved by using relay along with source and destination in the network. The data is sent directly from the source to the destination or via the relay. Proper selection of the relay is a crucial task. In this, study of different relay selection techniques is done. In this paper, simulation of Greedy Exchange algorithm with limited no of sources and relays is done. This algorithm is basically used to minimize the total transmission power required to transmit the information. From the simulation results it has been concluded that, power consumption in Exchange phase is effectively reduced, but sometimes it fails to do so. Modified GAEA algorithm developed, which is an logical extension of the GAEA algorithm. This algorithms tends to minimize the overall power consumption and at the same time overcome the limitation of GAEA. The simulated results and the comparison also shows that Modified-GAEA algorithm can be effectively used for the Relay Selection in Wireless Networks and gives better and more optimized output as compared to GAEA algorithm.

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