Power Allocation for Full Duplex Decode-and-Forward Cooperative Relay System

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Abstract. The 5G communication system requires higher data rates and energy efficiency. Full-duplex (FD) communications can double the spectral efficiency in ideal conditions and in full-duplex relay systems the relay node works under full-duplex mode. There is a trade off between the signal and interference at the relay node because the transmitting signal of the node can be interference signal and desired signal in different links in the system, respectively. Proper power allocation can both suppress the residual self-interference for better performance and save power of the FD system. In this paper, we propose a power allocation approximation algorithm and a power allocation method based on genetic algorithm (GA) for a FD decode-and-forward (DF) cooperative relay system with residual self-interference. The end-to-end outage probability is chosen as the criterion of power allocation problem. Both the global power constraint and individual power constraint are investigated. The approximation algorithm shows great simplicity and has better performance with high SNR. For GA algorithm, numerical results show that the proposed power allocation scheme obviously improves the performance of the FD relay system with good convergence performance.

Keywords: Full-duplex · Power allocation · Relay · Genetic algorithm

1 Introduction

Full duplex which means transmitting and receiving simultaneously in the same frequency band has become a promising technique in 5G communication [1]. It can double the spectral efficiency in ideal conditions at the side of conventional half duplex schemes. However, the most crucial issue is its strong self-interference (SI). Lots of work has been done and self-interference cancellation techniques make full duplex feasible in communication systems. In practice, the SI can not

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be eliminated completely and residual SI must be taken into account in FD relay systems [2].

In [3–5], the outage probability of full duplex decode-and-forward relay system for both dual-hop and multi-hop is derived. A new distributed FD Alamouti scheme for cooperative relay system is proposed in [6] and the outage probability and the diversity-multiplexing tradeoff are obtained. In addition, the optimization problem of power allocation for dual-hop full duplex DF relay system under power constraint conditions is solved in [7]. For full duplex decode-and-forward (DF) relay system, there is a performance tradeoff between the link from the source to the relay and the link from the relay to the destination [2]. This is because, the transmitting power of the relay node is not only the desired signal for the destination node but also the SI power for the relay node itself which degrades the performance of the link from the source to the relay. Thus, an effective power allocation strategy is necessary for performance improvement and power conservation.

In this paper, we aim at power allocation for the FD cooperative DF relay system and acquire quasi-optimal transmitting power for the nodes. Considering the FD cooperative relay system with self-interference, the outage probability of the system we derived is non-convex which is quite complex to solve through numerical methods. We use taylor expansion to obtain an approximate objective function which is easy to be optimized and it has a good performance in high SNR region. In order to get more accurate results for general conditions, we adopt GA algorithm to solve the problem. Compared with traditional search algorithms, the genetic algorithm (GA) is a global optimization technique that avoids many of the shortcomings exhibited by local search techniques on difficult search spaces [8]. Moreover, the GA has been modified for our problem as follows: (1) We introduce a penalty function to fulfill the constraint conditions and avoid local convergence. (2) Variable fitness function parameter is employed in the fitness value calculation operator which can avoid premature convergence. Simulation results show that our proposed algorithm can obtain feasible solutions with satisfying convergence performance.

The remainder of this paper is outlined as follows. In Sect. 2, we illustrate the system model of the FD relay system. And the power allocation problem is proposed and solved in Sect. 3. The simulation results are presented in Sect. 4 and the conclusion is drawn in the last section.

2 System Model

In this section, we will introduce the basic system model of the full duplex DF cooperative relay system, then derive the mathematical model of the FD system with different power at transmitting antennas. Figure 1 shows the system model of the FD relay system. It contains a source node R_0, a relay node R_1 and a destination node R_2. In FD relay mode, the received signal of relay node R_1 consists of two parts: the desired signal from source node R_0 and the self-interference signal from its own transmitting antenna. The received signal of destination node also contains two different signals: the desired signal from source node R_0 and the desired signal from relay node R_1. According to [6], the source transmission is ordered into frames and blocks. And compared with half-duplex (HD) mode, FD only needs 3/4 of half-duplex symbols. We assume Rayleigh frequency non-selective fading channel and it can be expressed as $h_{i,j} \sim CN(0, \Omega_{ij})$ where $i \in \{0, 1\}, j \in \{1, 2\}$ means the channel fading coefficient from node R_i to node R_j, and $h_{1,1}$ denotes residual self-interference of the relay node from its transmitting antenna to its receiving antenna [6]. The transmission of the cooperative scheme is divided into three phases. In the first phase, the source node R_0 transmits symbol x_1 and the received symbol at node R_1 and R_2 can be written as

$$y_{R11} = \sqrt{p_T} h_{0,1} x_1 + n_{R11}, \tag{1}$$

$$y_{R21} = \sqrt{p_T} h_{0,2} x_1 + n_{R21}, \tag{2}$$

where p_T denotes the transmit power of node R_0 in the first phase and n_{Rij} denotes the normalized AWGN at receive nodes. In the second phase, R_0 transmits symbol x_2 and R_1 transmits symbol x_1 in the meantime. The received symbol at node R_1 and R_2 can be written as

$$y_{R12} = \sqrt{p_0} h_{0,1} x_2 + \sqrt{p_1} h_{1,1} x_1 + n_{R12}, \tag{3}$$

$$y_{R22} = \sqrt{p_1} h_{0,2} x_2 + \sqrt{p_2} h_{1,2} x_1 + n_{R22}, \tag{4}$$

where p_0 and p_1 denote the transmit power of node R_0 and R_1 respectively. In the third phase, R_0 transmits symbol $-x_1^*$ while R_1 transmits symbol x_2^*, where $(\cdot)^*$ denotes the conjugate. The received symbol at node R_2 can be written as

$$y_{R23} = -\sqrt{p_1} h_{0,2} x_1^* + \sqrt{p_2} h_{1,2} x_2^* + n_{R23}. \tag{5}$$

By using the equivalent MIMO channel model, the scheme above can be expressed as

$$Y_{R2} = Hx + n_{R2}, \tag{6}$$

where $Y_{R2} = [y_{R21}\, y_{R22}\, y_{R23}^*]^T; H = [\sqrt{p_T} h_{0,2} 0;\ \sqrt{p_1} h_{1,2}\ \sqrt{p_0} h_{0,2};\ \sqrt{p_0} h_{0,2}^*\ \sqrt{p_1} h_{1,2}^*]$; $x = [x_1\ x_2]^T$; $n_{R2} = [n_{R21}\, n_{R22}\, n_{R23}^*]^T$. Then the capacity can be derived as

$$C_{FD} = \frac{1}{3}\log_2\left[\left(1 + p_0|h_{0,2}|^2 + p_1|h_{1,2}|^2\right) \left(1 + (p_0 + p_T)|h_{0,2}|^2 + p_1|h_{1,2}|^2\right)\right], \tag{7}$$

The outage probability of this scheme can be formulated as

$$P_{out} = P_{FD}(1 - P_{SR}) + P_{SD} P_{SR}, \tag{8}$$

with

$$P_{FD} = P\{C_{FD} < R\}, \tag{9}$$

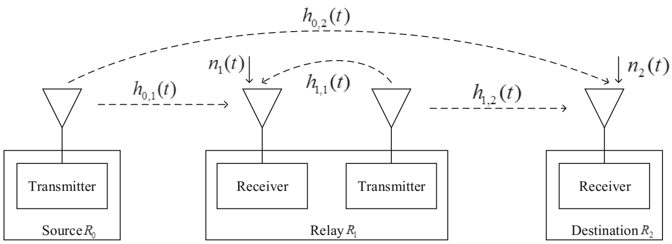

Fig. 1. System model of the full duplex DF cooperative relay system.

$$P_{SR} = P\left\{\log_2\left(1 + \frac{p_0|h_{0,1}|^2}{1 + p_1|h_{1,1}|^2}\right) < \frac{3}{2}R\right\}, \tag{10}$$

$$P_{SISO} = P\left\{\log_2\left(1 + p_T|h_{0,2}|^2\right) < R\right\}, \tag{11}$$

where P_{FD} and P_{SISO} denote the outage probability of FD cooperative and SISO mode, respectively. And P_{SR} denotes the outage probability of the source to relay link.

For Rayleigh fading channel, $|h_{i,j}|$ is Rayleigh distributed and we can express the PDF of $|h_{i,j}|^2$ as

$$f_{|h|^2}(y) = \frac{1}{\Omega_{i,j}} e^{-\frac{y}{\Omega_{i,j}}}, \tag{12}$$

Through (12) we can calculate the three parts of P_{out} as follows: The outage probability of SISO mode with transmitting power p_T can be derived as

$$\begin{aligned} P_{SISO} &= P\left\{\log_2\left(1 + p_T|h_{0,2}|^2\right) < R\right\} \\ &= \int_0^{\frac{2^R-1}{p_T}} \frac{1}{\Omega_{0,2}} e^{-\frac{y}{\Omega_{0,2}}} dy \\ &= 1 - e^{-\frac{2^R-1}{p_T \Omega_{0,2}}}. \end{aligned} \tag{13}$$

And P_{SR} can be derived as

$$\begin{aligned} P_{SR} &= P\left\{\log_2\left(1 + \tfrac{p_0|h_{0,1}|^2}{1+p_1|h_{1,1}|^2}\right) < \tfrac{3}{2}R\right\} \\ &= \int_0^\infty \int_0^{\frac{p_1}{p_0}(2^{\frac{3R}{2}}-1)y + \frac{2^{\frac{3R}{2}}-1}{p_0}} \frac{1}{\Omega_{0,1}} e^{-\frac{x}{\Omega_{0,1}}} dx \frac{1}{\Omega_{1,1}} e^{-\frac{y}{\Omega_{1,1}}} dy \\ &= 1 - \frac{1}{1+\frac{\Omega_{1,1}p_1}{\Omega_{0,1}p_0}(2^{\frac{3R}{2}}-1)} e^{-\frac{2^{\frac{3R}{2}}-1}{p_0\Omega_{0,1}}}. \end{aligned} \tag{14}$$

Because P_{FD} can not get a closed-form solution, we derive a lower and an upper bound for it. Based on $C_{FD} < \frac{1}{3}\log_2\left[1 + (p_0 + p_T)|h_{0,2}|^2 + p_1|h_{1,2}|^2\right]^2$

and $C_{FD} > \frac{1}{3}\log_2\left[1 + p_0|h_{0,2}|^2 + p_1|h_{1,2}|^2\right]^2$, the lower and upper bound for the outage probability of the FD scheme are obtained, respectively. Thus, P_{FD} can be expressed as

$$P_{FD} = P\left\{p|h_{0,2}|^2 + p_1|h_{1,2}|^2 < Z\right\}, \tag{15}$$

where $Z = 2^{\frac{3R}{2}} - 1$. Moreover, when $p = p_0$, it denotes the upper bound and when $p = p_0 + p_T$, it denotes the lower bound. Finally, the outage probability of the cooperative scheme can we written as

$$\begin{aligned} P_{FD} &= \int_0^{\frac{Z}{p}} \int_0^{\frac{Z}{p_1} - \frac{p}{p_1}y} \frac{1}{\Omega_{1,2}} e^{-\frac{x}{\Omega_{1,2}}} dx \frac{1}{\Omega_{0,2}} e^{-\frac{y}{\Omega_{0,2}}} dy \\ &= \begin{cases} 1 - e^{-\frac{z}{p\Omega_{0,2}}} - \frac{z}{p\Omega_{0,2}} e^{-\frac{z}{p_1\Omega_{1,2}}} & p\Omega_{0,2} = p_1\Omega_{1,2} \\ 1 - \frac{1}{1-\frac{\Omega_{1,2}p_1}{\Omega_{0,2}p}} e^{-\frac{z}{p\Omega_{0,2}}} - \frac{1}{1-\frac{\Omega_{0,2}p}{\Omega_{1,2}p_1}} e^{-\frac{z}{p_1\Omega_{1,2}}} & p\Omega_{0,2} \neq p_1\Omega_{1,2} \end{cases}. \end{aligned} \tag{16}$$

3 Power Allocation Algorithm

In this section, we adopt a approximation algorithm and a GA to solve the power allocation problem of the FD cooperative relay system. Our target is to minimize the end-to-end outage probability and two different constraint conditions are defined: global power constraint and individual power constraint.

3.1 Global Power Constraint and Individual Power Constraint

There are three nodes in the relay system and two of them transmit symbols. Global power constraint means the total power of the source node R_0 and the relay node R_1 does not exceed the P_{Total}. The power allocation problem which is an optimization problem can be expressed as

$$\begin{array}{ll} \min P_{out} = P_{FD}(1 - P_{SR}) + P_{SD}P_{SR} \\ \text{s.t.} \qquad p_0 + p_1 = P_{Total} \end{array}, \tag{17}$$

where P_{FD}, P_{SR} and P_{SD} are referred to (16), (14) and (13), respectively. P_{Total} denotes the total power of the system and $p_T = P_{Total}$ means the source node's transmitting power in the first phase.

Individual power constraint means the power of each node does not exceed the P_{Max}. The optimization problem can be expressed as

$$\begin{array}{ll} \min P_{out} = P_{FD}(1 - P_{SR}) + P_{SD}P_{SR} \\ \text{s.t.} \qquad 0 < p_0 \leq P_{Max} \\ \qquad\quad 0 < p_1 \leq P_{Max} \end{array}, \tag{18}$$

where P_{Max} denotes the maximum power of a single node and $p_T = P_{Max}$ means the source node's transmitting power in the first phase.

3.2 Power Allocation Approximation Algorithm

We choose the upper bound of P_{FD} as the objective function. The objective function can be written as

$$P_{out} = P_{FD}\left(1 - P_{SR}\right) + P_{SD}P_{SR}\,, \tag{19}$$

where $P_{FD} = 1 - \frac{1}{1-\frac{\Omega_{1,2}p_1}{\Omega_{0,2}p_0}} e^{-\frac{z}{p_0\Omega_{0,2}}} - \frac{1}{1-\frac{\Omega_{0,2}p_0}{\Omega_{1,2}p_1}} e^{-\frac{z}{p_1\Omega_{1,2}}}$. The objective function is consist of fraction and exponential function which make it difficult to solve. By applying taylor expansion we can rewrite the exponential function in P_{FD} as

$$\begin{aligned} e^{-\frac{z}{p_0\Omega_{0,2}}} &= 1 - \tfrac{z}{p_0\Omega_{0,2}} + \tfrac{z^2}{2p_0^2\Omega_{0,2}^2} + \cdots . \\ e^{-\frac{z}{p_1\Omega_{1,2}}} &= 1 - \tfrac{z}{p_1\Omega_{1,2}} + \tfrac{z^2}{2p_1^2\Omega_{1,2}^2} + \cdots . \end{aligned} \tag{20}$$

By substituting (20) into P_{FD}, P_{FD} can be expressed as

$$\begin{aligned} P_{FDAL}(R) &= 1 - \left(\frac{1}{1-\frac{\Omega_{1,2}p_1}{\Omega_{0,2}p_0}} e^{-\frac{z}{p_0\Omega_{0,2}}} + \frac{1}{1-\frac{\Omega_{0,2}p_0}{\Omega_{1,2}p_1}} e^{-\frac{z}{p_1\Omega_{1,2}}} \right) \\ &= 1 - \left[1 - \frac{z^2}{2p_0\Omega_{0,2}\Omega_{1,2}p_1} \right] \\ &= \frac{z^2}{2p_0\Omega_{0,2}\Omega_{1,2}p_1}. \end{aligned} \tag{21}$$

Through ignoring the 1 in the denominator of (10), we can obtain approximate P_{SR} as

$$\begin{aligned} \pi(R) &\approx P\left\{ \log_2\left(1 + \tfrac{p_0|h_{0,1}|^2}{p_1|h_{1,1}|^2}\right) < \tfrac{3R}{2} \right\} \\ &= P\left\{ |h_{0,1}|^2 < \tfrac{p_1}{p_0}(2^{\frac{3R}{2}} - 1)|h_{1,1}|^2 \right\} \\ &= 1 - \tfrac{1}{1+\frac{\Omega_{1,1}p_1}{\Omega_{0,1}p_0}(2^{\frac{3R}{2}}-1)}. \end{aligned} \tag{22}$$

Then the outage of the system can be written in a simplifying form as

$$\begin{aligned} &P_{out} = P_{FDAL}(R)(1-\pi(R)) + P_{SISO}(R)\pi(R) \\ &\approx \tfrac{z^2}{2p_0\Omega_{0,2}\Omega_{1,2}p_1} \tfrac{1}{1+\frac{\Omega_{1,1}p_1}{\Omega_{0,1}p_0}z} + \left(1 - \tfrac{1}{1+\frac{\Omega_{1,1}p_1}{\Omega_{0,1}p_0}z}\right)\left(1 - e^{-\frac{2^R-1}{p_T\Omega_{0,2}}}\right) \\ &= \tfrac{A-Kp_0p_1}{p_1(p_0+Bp_1)} + K, \end{aligned} \tag{23}$$

where $z = 2^{\frac{3R}{2}} - 1, A = \frac{z^2}{2\Omega_{0,2}\Omega_{1,2}}, B = z\frac{\Omega_{1,1}}{\Omega_{0,1}}, K = 1 - e^{-\frac{2^R-1}{p_T\Omega_{0,2}}}$. The function (23) will be the new objective function of the power allocation algorithm.

First, we consider global power constraint problem. By substituting the constraint condition $p_0 = P_{Total} - p_1$, we can get the final problem

$$\min F = \tfrac{A-K(P_{Total}-p_1)p_1}{p_1(P_{Total}+Cp_1)}, \tag{24}$$

where $C = B - 1$. It can be turn into a quadratic function optimization problem. The power allocation results are as follows

$$\begin{aligned} p_1 &= \frac{2AC + \sqrt{4A^2C^2 + 4ABKP_{Total}^2}}{2BKP_{Total}} \\ p_0 &= P_{Total} - p_1, \end{aligned} \tag{25}$$

For individual power constraint conditions, we can get

$$\begin{aligned} p_1 &= \sqrt{\frac{2AB \pm \sqrt{4A^2B^2 + 4\frac{KB^2}{A-1}\frac{A^2}{(A-1)K}}}{2KB^2/(A-1)}} \\ p_0 &= \frac{KBp_1^2 + A}{(A-1)Kp_1}. \end{aligned} \tag{26}$$

If the results beyond the scope of the constraint, the power will be set as P_{Max}.

3.3 Power Allocation Based on Genetic Algorithm

The objective function (19) reveals to be a non-convex function which is difficult to get an analytic solution. GA is a global searching algorithm with low complexity. It is an iterative procedure which mainly contains four parts: a genetic representation, a fitness function, genetic operators and control parameters. The basic structure of GA is shown in Fig. 2. In GA, each solution to the problem is coded as a fixed-length binary string which is called a 'chromosome' and every bit of the strings is called a 'gene'. A group of chromosomes are called population. For every iteration, the population produce new chromosomes and get close to the best solution gradually.

(1) Fitness value is a way to evaluate the quality of the solution which is related to the objective function and decided by fitness function. In our design, the objective function is the outage probability of the FD relay system P_{out} which is in the interval $[0, 1]$. In GA, we apply $1 - P_{out}$ as our basic fitness function. As a result, we consider larger value as better results. For the two different constraint conditions we use linear scaling (27) and exponential scaling (28), respectively.

$$f_{fitness} = b\left(1 - P_{out}\right), \tag{27}$$

$$f_{fitness} = e^{c(1-P_{out})}. \tag{28}$$

In addition, in order not to surpass the restriction of the global power constraint, we adopt a penalty function to fulfill the constraint conditions. If power of the two nodes does not satisfy the conditions in (17), the fitness value of this chromosome will shrink by (29) and be marked as a infeasible solution.

$$f_{fitness}^* = f_{fitness}\left[1 - \left(\frac{\Delta}{\Delta_{\max}}\right)^a\right], \tag{29}$$

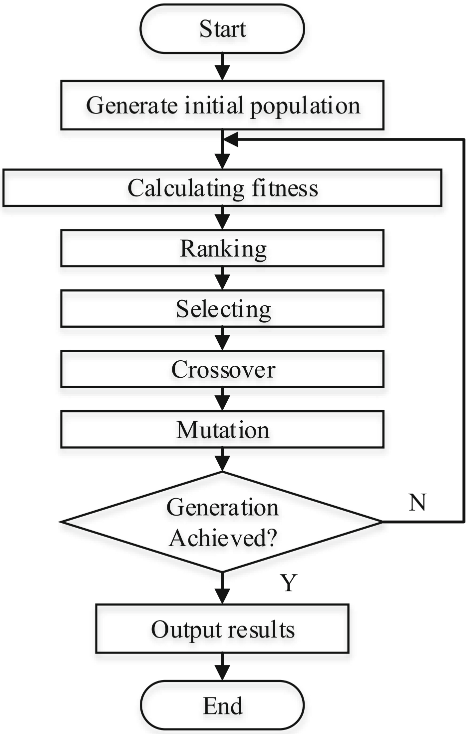

Fig. 2. The flow chart of GA.

where $\Delta = p_0 + p_1 - P_{Total}$ and $\Delta_{\max}$ is the maximum of the whole population. In this way, these infeasible solutions can be appropriately reserved for the next generation to ensure genetic diversity. Moreover, the parameter a in (29) varies with generation according to (30)

$$a = \frac{1 - a_0}{G - 1} g + \frac{a_0 G - 1}{G - 1}, \tag{30}$$

where a_0 is an initial value, G and g are total generation and current iteration generation, respectively.

(2) After finishing calculating the fitness values of the population, we will rank the chromosome and find the best one in this generation. Certainly, the chromosomes which are marked during fitness value calculation can not be chosen as the best. The best chromosomes of every generation will be recorded and the final solution is one of the best chromosomes.

(3) Selection operator has many strategies. In this paper, we employ a competition method to generate new population. Two of the chromosomes will be chosen at random, the one with higher fitness value will be one of the chromosomes in the next generation. In this way, we can keep outstanding chromosomes and maintain diversity in the meantime.

(4) Crossover operator is the core of GA which is controlled by crossover rate P_c. It chooses a pair of chromosomes and exchange some of their genes with the probability P_c. We choose single-point crossover to break old chromosomes and recreate next new population. Crossover operator balances premature convergence and diversity which is decided by P_c, and we choose two different crossover rate for different constraint conditions.
(5) Mutation operator has a parameter P_m called mutation rate. A chromosome change one of its genes with the probability of P_m and create new chromosome with new characteristic. Mutation rate should be small or GA will become a random search algorithm with low efficiency. We choose 0.1 as our mutation rate.

The five steps above are the basic components of GA's loop structure. One loop is one generation and we need 100 generations for both global power constraint and individual power constraint.

4 Numerical Results

In this section, simulation results are shown to verify the theoretical analysis and the performance of the power allocation scheme. The effect of residual self-interference are also illustrated based on simulation results. We will illustrate the parameters for the two different conditions respectively and show improvements and advantages of power allocation.

4.1 Global Power Constraint

Under the condition of global power constraint, the parameter initial value a_0 in (30) is 15 and linear scaling parameter $b = 10$ in (27). The population size is 40 and total generation of this GA is 100. The length of chromosomes is determined by precision of answers, that is, high precision needs longer chromosomes with the cost of time. Crossover rate and mutation rate are 0.85 and 0.1, respectively.

Figure 3 shows simulation results of outage probability for uniform power allocation, power allocation based on GA and approximation power allocation. We calculate three series of curves with different colors. The red one represents uniform power allocation and the blue curves are power allocation results based on GA. The black curves show performance of approximation power allocation. There are three curves in each series. They represent upper bound (UB), lower bound (LB) and simulation (S) results, respectively. It is obvious that simulation curves are in the region limited by the two bounds and it proves the correctness of the theoretical analysis above. The power allocation approximation algorithm has a poor performance when power is low but it is still better than uniform power allocation. And it will achieve a better performance in high SNR region. The GA can achieve better performance in both high and low SNR region but it has higher complexity than the approximation algorithm. Through power allocation, outage performance of this FD cooperative relay system has improved.

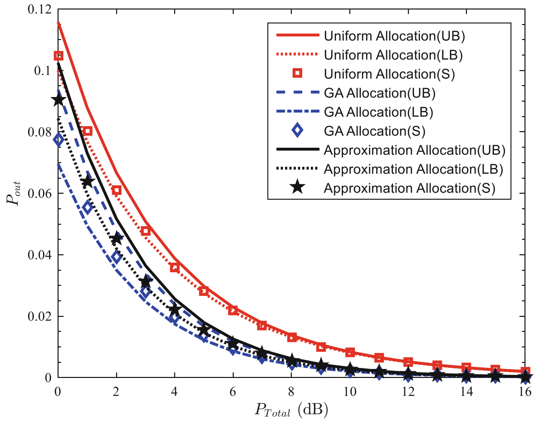

Fig. 3. Outage probability of global power constraint. ($\Omega_{0,1} = 10$ dB, $\Omega_{0,2} = 2$ dB, $\Omega_{1,1} = 8$ dB, $\Omega_{1,2} = 10$ dB, $R = 0.5$ bit/s/Hz) (Color figure online)

4.2 Individual Power Constraint

Different from global power constraint using a penalty function, we adopt exponential scaling with parameter $c = 15$ in (28). The population size is 30 and total generation of this GA is 100. Crossover rate and mutation rate are 0.75 and 0.1, respectively. Figure 4 illustrates maximum power allocation compared with GA power allocation and approximation power allocation. Different from global power constraint, approximation power allocation has a good performance with no SNR limitations and achieve similar performance as GA power allocation. The outage performance has a significant promotion and transmit power is saved in the meantime.

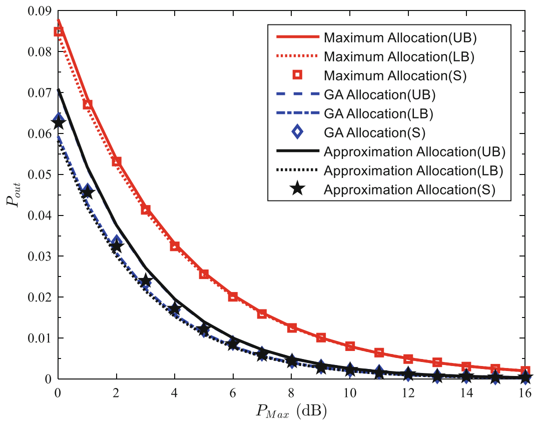

Fig. 4. Outage probability of individual power constraint. ($\Omega_{0,1} = 10$ dB, $\Omega_{0,2} = 2$ dB, $\Omega_{1,1} = 8$ dB, $\Omega_{1,2} = 10$ dB, $R = 0.5$ bit/s/Hz)

4.3 Self-interference

In Fig. 5, results of power allocation with different intensity of self-interference are illustrated. Different kind of curves represent different intensity of self-interference. As it is shown in Fig. 5, the power allocation scheme gets evident performance improvement when $\Omega_{1,1} = 8\,\mathrm{dB}$. Nevertheless, it can not achieve significant gain when the self-interference is comparatively small. This result can be explained in (8–11) where $h_{1,1}$ denotes the only interference in this system. Therefore, the power allocation scheme should be applied when there is enough self-interference.

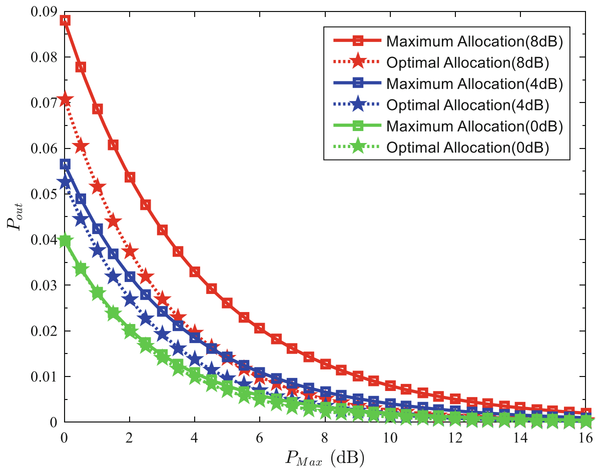

Fig. 5. Power allocation with different intensity of self-interference

4.4 Convergence of Genetic Algorithms

Figures 6 and 7 illustrate convergent performance of the proposed algorithm compared with original GA and traversal search results are regarded as optimal results.

We can clearly see that the proposed GA has a better convergence performance than original GA for individual power constraint condition. There is a premature convergence problem in original GA for global power constraint condition while the proposed GA has a good performance in both convergence and optimal value. From the results, the proposed algorithm shows superior performance for the power allocation problem. However, increasing the number of generation and population size can get further performance improvement at the expense of complexity.

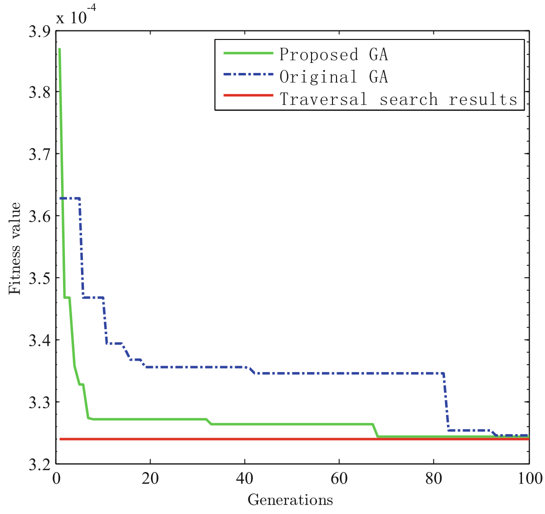

Fig. 6. Convergence of genetic algorithm for individual power constraint condition

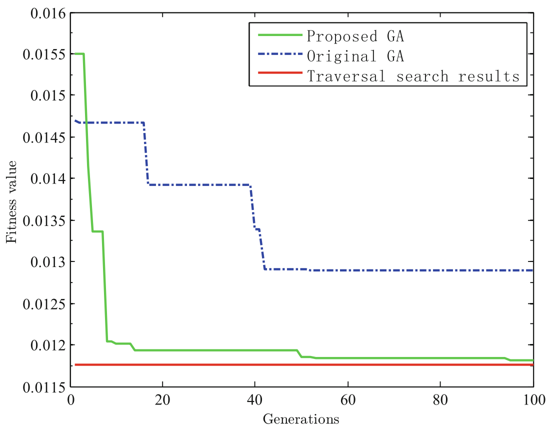

Fig. 7. Convergence of genetic algorithm for global power constraint condition

5 Conclusion

In this paper, we show a power allocation model for the FD cooperative relay system and propose a power allocation method based on GA and a power allocation approximation algorithm. Under two different constraint conditions: global power constraint and individual power constraint, we solve the optimal problem by adopting the two algorithms. Simulation results verify the theoretical analysis and show evident performance improvement. Under global power constraint, approximation algorithm has better performance under high transmitting power condition while GA has no such limitation. GA based allocation can achieve good performance under any SNR condition. Under individual power constraint, approximation algorithm is better than the algorithm based on GA for its low complexity and power allocation can also achieve energy conservation. The self-interference intensity influences the effectiveness of power allocation. When self-interference is comparatively small, there is no need to allocate power. Simulation results also show that the proposed GA has a good performance in both convergence and optimal value.

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