

# Optimization Design of Computer Network Reliability Based on Genetic Algorithms

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With the acceleration of the process of information society, not only the user's computer communication networks is increasing, but also the rapid expansion of computer communication network connecting regional scale and network connections. Network reliability optimization of network design is a classic problem. Due to the complexity of the network reliability with the number of network nodes increases exponentially, it takes too much time to accurate calculation takes. It appears genetic algorithms, neural network, fuzzy neural network intelligent algorithm for solving this problem provides a new ideas and approaches. Due to the complexity of the network reliability with the number of network nodes increases exponentially, we want accurate calculation takes too much time, not even the result. Meanwhile, in order to make a better search algorithm performance, the paper also introduces the concept of co-evolution according to the schema theorem. The introduction of the test group, using a test group to retain better pattern, while the interaction between test groups and reconciliation group, thereby achieve the common purpose of evolution. Finally, the proposed algorithm simulation comparison, the results show that the algorithm has good convergence and search results.

## 1. Introduction

Computer communication network reliability concepts appear in the 1970s due to the rapid development of communications technology (Balog, 2007). Optical fiber technology, computer network technology, making the network function of growing, promote research computer communication network reliability problems continue depth direction (Putha and Sahoo, 2012).

With the acceleration of the process of information society, not only the user's computer communication networks is increasing, but also the rapid expansion of computer communication network connecting regional scale and network connections (Bureerat, 2013). Due to a computer communication network is widely used in enterprises and institutions (Liu, 2015). Important areas of banking, transportation, communications, industrial, defense, computer communication network powerful complexity of its structure or not is directly proportional (Ali, 2013).

In order to ensure the system work safely and reliably, theoretical research focused on the need for other indicators to optimize the design of the network reliability and improve network reliability based on the optimization of the system, such as the link cost, maintenance cost, delay, obstruction (Mohan, 2012). Rate and response time in practical application, the designer in the construction of the network system (Karaboga and Zhang, 2014).

The main consideration is two aspects: performance and investment cost of the network due to network systems are generally costly, and therefore costs are often become a network topology design is a very important constraint (Gandomi, 2013). Currently, for most networks, as long as the small improvement of its topology design, you can save a certain amount of cost, "by re-optimizing the system performance without reducing, the application of new ideas, new technology, you can get considerable cost savings (Montalvo, 2014).

Based on a comprehensive study it has been proposed based on genetic algorithm computer communications network reliability analysis and optimization. To discuss the establishment of the reliability of the model and reliability analysis in theory, to provide the necessary engineering applications security service strategy, and network reliability study multi-objective optimization, in order to establish optimization algorithm based on the

method of construction of intelligent computer communication network reliability purposes, to give a specific implementation cases. Due to the complexity of the network reliability with the number of network nodes increases exponentially, which is a NP problem, you want accurate calculation takes too much time. Based on previous research on genetic algorithm is proposed based on the improved heuristic algorithm, genetic algorithm strong global search ability, with some of the local search strategy, to overcome the shortcomings of traditional methods at the same time has made good effect.

## 2. The related theory and method

### 2.1 Algorithm for computing network reliability

Complete state enumeration method is to calculate the reliability of the network the most common and easiest way (Afonso and Gandomi, 2013). The main idea is: according to the requirements listed envoy network during normal operation of the S event occurs, all possible mutually exclusive events  $B_i$ ,  $i=1,2,\dots,n$ . Then S can be expressed as (Nguyen, 2014):

$$AS(k) = A_1 \times A_2 \times \dots \times A_k \quad (1)$$

Therefore, the network reliability:

$$\Pr(S) = \sum_{i=1}^n \Pr(B_i) \quad (2)$$

For a given graph  $G(V, E)$  on each side there are two states: running or failure. If your network has old edges, then it would have  $2E-1$  states. For larger networks, with the increase in the number of edges, the number of states increases exponentially, so complete state enumeration method is only suitable for small computing network reliability (Yang, 2012).

Such methods are mainly seeking network in accordance with the principle of inclusion-exclusion formula combinatorial mathematics reliability. Let  $A_m$  is the talk events. By the inclusion-exclusion principle known,  $A_1, A_2, \dots, A_m$ . The probability that at least one event is:

$$\begin{aligned} \Pr(G) &= \Pr\{A_1 \cup A_2 \dots \cup A_m\} \\ &= \sum \Pr\{A_i\} - \sum \Pr\{A_1 A_2\} + \dots + (-1)^{m+1} \Pr\{A_1 A_2 \dots A_m\} \end{aligned} \quad (3)$$

The topology of the network and the principle of inclusion-exclusion formula combining the introduction of the concept of free p circle graphs prove the inclusion-exclusion principle of two-terminal reliability of the formula not just destructive items and networks p circle diagram No-one correspondence, giving an inclusion-exclusion principle can be obtained directly in the formula is not destructive term formulas:

$$\Pr(G) = \sum_i (-1)^{n_j - v_i + 1} \Pr(G_{a_i}) \quad (4)$$

Wherein, J represents a network of non-G circle diagram, n, v denote the network G vertices and edges. This result makes the principle of inclusion and exclusion algorithm simplified.

### 2.2 The basic principles of genetic algorithms

Genetic Algorithm (GA) is a draw on natural selection and genetic mechanisms of thinking global random search algorithm. It is the solution of the problem might POPULATION, put every possible solution seen as individuals within a population, running the algorithm in the whole population random search space, according to a certain assessment strategies for each individual evaluation, constantly using the selection, crossover and mutation of these three genetic operators, the problem of evolving solution until an optimal solution .GA execution process was shown in Figure 1.

GA basic elements including structure, population initialization code, select Options, genetic operations (crossover and mutation), the objective function and fitness function design, the termination condition selection. Among them, selection, crossover and mutation three operations is the core of genetic algorithms, Options are selected or eliminated based on individual fitness function value in the size of the parent to ensure that the direction of optimal search algorithm; crossover operator is the main method to produce new individuals, which determines the global search ability of GA; mutation operation is to generate new individual helper method, which determines the local search ability of GA.

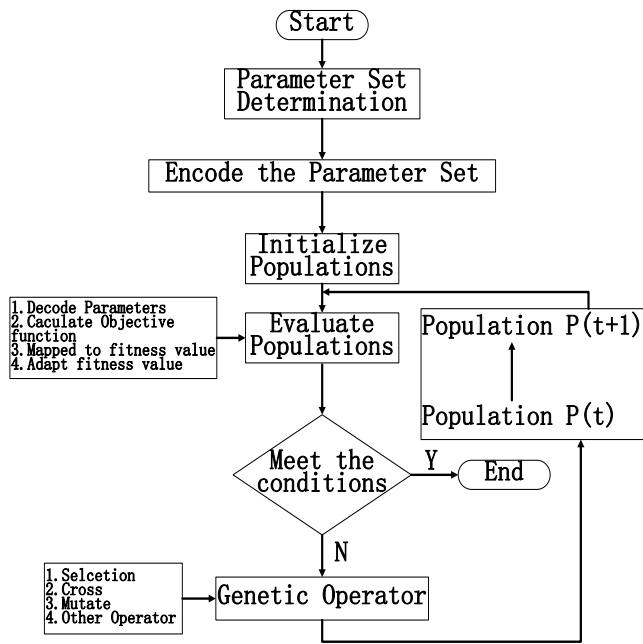


Figure 1: GA execution process

### 3. Experiments and results

#### 3.1 The impact of network topology analysis

Congenital factor programming computer communication network topology belong to computer communication networks, but also affect the reliability of computer communication network practice shows that: different application areas, different levels of scale computer communication networks must have different network topologies, otherwise improve computer communication network reliability is just empty talk. impact analysis of computer communication network topology of the computer network reliability of this chapter to be studied core interconnection network topology is the main connection computer communication networks between the components, which can be used diagram, graph theory is the study and therefore the most powerful mathematical tool interconnection network performance.

Connected graph any edge or a node failure will bring down the network. Despite the low cost of such a computer communication network, but from the reliability point of view to consider its small fault tolerance, reliability is poor. For more important computer communications networks, not the use of such a computer communication network topology network topology bus structure shown in Figure 2 (a), the network topology star structure shown in Figure 2 (b), in addition to there is a ring network topology, as shown in Figure 2 (c).

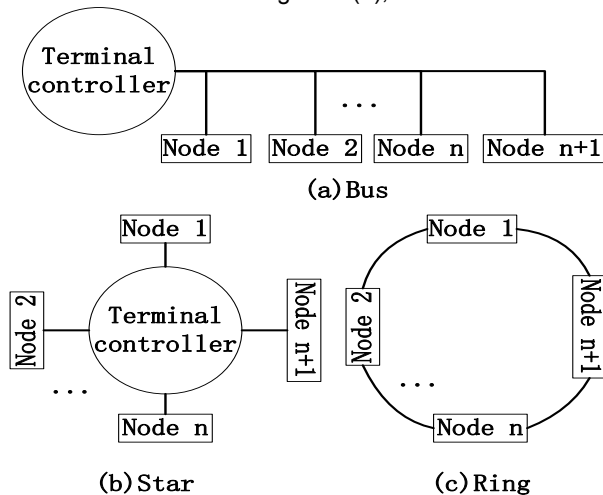


Figure 2: Computer network topology of the communication network

### 3.2 Multi-objective optimization

Significance of multi-objective optimization problem is to find problems one or more solutions to enable designers to accept all of the target value. Therefore, it is considered the single objective optimization problem is a multi-objective optimization problem in a special case, the various departments in the engineering, production management and national defense building society the problem encountered by most multi-objective optimization problem. for example, in the design of computer communication network backbone, to consider how to make the general cost delay as small as possible, reliability and survivability to be as large as possible, which optimization is a three indexes can be said that multi-objective optimization problem in real life is abundant, and even everywhere.

General mathematical form of multi-objective optimization problem as follows:

$$\begin{cases} V - \min \{F(x)\} = \min \{f_1(x), f_2(x), \dots, f_m(x)\}^T \\ \text{s.t.} \quad g_i(x) \leq 0 (i=0,1,2,\dots,m) \\ \quad \quad h_i(x) \geq R (i=0,1,2,\dots,m) \end{cases} \quad (5)$$

Let optimization system parameters (variable) have n parameters for optimization constitute selected (variable) set x:

$$X = \{(x_1, x_2, \dots, x_n) | x_i \in R, i=1, 2, \dots, n\} \quad (6)$$

X is the solution space optimization problem in which a set of parameters:

$$x(k) = \{x_1(k), x_2(k), \dots, x_n(k)\} \quad (7)$$

Evaluation of optimization problem set performance indicators with m constituting performance indicators set H:

$$H = \{h_1, h_2, \dots, h_m | h_k \in R, i=1, 2, \dots, m\} \quad (8)$$

### 3.3 Application of genetic algorithms in computer communications network reliability optimization

In this paper, include a computer network reliability optimization simulation example calculation. Computer network nodes  $N = 6$ , the computer network node reliability constraint constant  $\alpha = 2$ ,  $\beta = 2$ , the number of iterations for the genetic manipulation 100, computer network link cost matrix C, and computer network reliability matrix R, respectively As follows:

$$C_0 = \begin{bmatrix} 0 & 5 & 8 & 12 & 14 & 7 \\ 5 & 0 & 9 & 4 & 8 & 11 \\ 8 & 9 & 0 & 5 & 10 & 9 \\ 12 & 4 & 5 & 0 & 3 & 7 \\ 14 & 8 & 10 & 3 & 0 & 6 \\ 7 & 11 & 9 & 7 & 6 & 0 \end{bmatrix} \quad (9)$$

$$R_0 = \begin{bmatrix} 0 & 0.98 & 0.95 & 0.99 & 0.999 & 0.96 \\ 0.98 & 0 & 0.97 & 0.988 & 0.996 & 0.99 \\ 0.95 & 0.97 & 0 & 0.96 & 0.95 & 0.988 \\ 0.99 & 0.988 & 0.96 & 0 & 0.93 & 0.92 \\ 0.999 & 0.996 & 0.95 & 0.93 & 0 & 0.96 \\ 0.96 & 0.99 & 0.998 & 0.92 & 0.96 & 0 \end{bmatrix}$$

Genetic algorithm according to flow and flow adjustment algorithm genetic algorithms, simulated gradually solved. When the genetic manipulation of the number of iterations is 100 times, the simulation process is terminated. The simulation solved a minimum cost of 45 computer network links, and to ensure that the computer maximum network reliability is 0.875.

If the network is slightly more expensive than the average delay, then  $W_c = 0.8$ ,  $W_d = 0.2$ ,  $W_r = 0$ , optimal results are shown in Table 1; the results showed that the central node: 1,2, converted into the tree structure has three sides, They are: (3,1), (1,2), (2,4), 3,1,3,3,1,2,2,2,2 workstation.

Table 1: Performance Indices Under different Weights and Optimized result by GA

Weight	Network Cost	Reliability	Cost Satisfaction	Reliability Satisfaction	Synthetical Satisfaction
$W_c=W_r=W_d=1/3$	601	1	0.995	1	0.984
$W_c=W_r=0.5, W_d=0$	609	0.9354	0.974	0.962	0.995
$W_c=0.8$	541	0.9137	1	0.935	0.996

Through the above analysis shows that under these conditions the reliability of different weights, can get a better satisfaction can be said that these multi-objective optimization algorithm combined genetic and after, in the shortest possible time to find a satisfactory solution can be successful high reliability and low cost to solve the NP problem, and resolve quickly implement topology optimization computer communication network.

#### 4. Conclusions

Due to the complexity of the network reliability with the number of network nodes increases exponentially, we want accurate calculation takes too much time, not even the result. It appears genetic algorithms, neural network, fuzzy neural network intelligent algorithm for solving this problem provides a new ideas and approaches. Due to the complexity of the network reliability with the number of network nodes increases exponentially, we want accurate calculation takes too much time, not even the result. It appears genetic algorithms, neural network, fuzzy neural network intelligent algorithm for solving this problem provides a new ideas and approaches. Meanwhile, in order to make a better search algorithm performance, the paper also introduces the concept of co-evolution, according to the schema theorem, the introduction of the test group, using a test group to retain better pattern, while the interaction between test groups reconciliation group, thereby achieve the common purpose of evolution.

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