Computer network reliability optimization design based on genetic algorithm

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Abstract. With the rapid development of network technology, especially the development of high-speed communication network, the scale of network becomes greater, the link capacity becomes higher and the link becomes more sparse, but network reliability research is also paid more attention by people. Paper introduces the related theory of computer communication network reliability. On this basis, this paper puts forward the concrete plan of computer communication network cost model as well as computer communication network reliability model. It uses intelligent genetic algorithm to solve the computer communication network cost model and the computer communication network reliability model.

1. Introduction

Increasing with social informationization degree, people increasingly depend on a variety of network, so the network is required to provide convenient, rapid, accurate, safe, high quality service. At the same time, the scale of the network increasingly expands, as well the network connection area and length. So far, humans have developed many new large complex equipment and systems, such as the computer communication network system, communication system, automatic production line system, banking system, nuclear power plant, large aircrafts and military systems [1]. The common characteristics of these systems is a complex system structure with powerful function. System needs to be supported by sophisticated hardware and software to complete a predetermined function. It sometimes also needs the participation of people. If failure occurs in system, it will bring different degrees of damage to society, economy and environment. Therefore, one of the most important indicator of system performance is system reliability which becomes concerned research direction, therefore the study of computer communication network reliability has important theoretical significance and practical value.

In recent years, with the continuous development of the theory of intelligent optimization algorithm and extensive application research, it has become a useful tool and effective method to solve many large-scale and complex engineering practice issues [2].Using intelligent optimization method like genetic algorithm, simulated annealing algorithm, ant colony algorithm, particle swarm optimization algorithm and hybrid optimization algorithm to study the comprehensive reliability problems, especially the reliability of computer communication network optimization, the redundancy of the optimal allocation and the optimal design of the network is very effective, which can obtain a better optimization scheme than heuristic method and traditional methods.

In this paper, based on the existing study, it puts forward computer communication network reliability analysis and optimization research based on genetic algorithm to discuss the establishment of reliability model and the reliability analysis process in theory, so as to provide the necessary security services for the engineering application strategy.

2. Reliability principle and algorithm analysis of computer communication network

2.1 Reliability principle of computer communication network

The relevant domestic and foreign scholars has divided computer communication network reliability measurement into four categories: computer communication network connectivity, computer communication network survivability, damage resistance of computer communication network and effectiveness of computer communication network components under multi-mode[3]. If computer communication network works normally, the network nodes and components must provide reliable link for each user terminal. Therefore, the research of computer communication network connectivity in the related fields of reliability is widest. Computer communication network connectivity is usually measured by computer communication network reliability

(1) Computer communication network reliability: the ability of network keeping connected and satisfying the requirement of communication under specific conditions (operating mode, maintenance mode, load condition, temperature, humidity, radiation, etc.) and specific time (within 1000 hours, a quarter, etc.) is called the computer communication network reliability. It reflects the ability of computer communication network topology to support normal operation of computer communication network and is one of the important parameters of network planning, design and operation.

(2) Computer communication network reliability: the probability of the network to complete the required function under specific conditions (operating mode, maintenance mode, load condition, temperature, humidity, radiation, etc.) and specific time (within 1000 hours, a quarter, etc.) is called the reliability of computer communication network, denoted by R(t), where $R(t) = P\{T > t\}$.

2.2 The algorithm analysis of computer communication network reliability design

1. Traditional algorithm analysis of network reliability

The essence of traditional precise algorithm used in computer communication network reliability first uses the theory of graph and trees theory etc. to simplify the processing of computer network model, and then applies mathematics theory of probability and statistics, and numerical analysis to gradually solve the calculation. In the algorithm of computer communication network reliability, complete state enumeration method, sum of disjoint products approach, inclusion-exclusion algorithm, the factor decomposition algorithm and the special network algorithm and other five kinds of algorithms belong to the traditional precise algorithm. Inclusion-exclusion algorithm, the factor decomposition algorithm and the special network algorithm are developed on the basis of complete state enumeration method and sum of disjoint products approach.

2. Intelligent algorithm analysis of network reliability

Modern intelligent algorithm of computer communication network reliability is very suitable for network with many nodes and links especially for the large complex computer communication network reliability calculation.

Genetic algorithm (GA) is a kind of global random search algorithm using biological natural selection and genetic mechanism [4]. It puts the possible solutions in a group and take every possible solution as an individual. At run time, the random search is done in the whole space and continuously use selection, crossover and mutation three genetic operators according to certain assessment strategies to evaluate each individual until the solution of the problem continuously evolved so as to produce the optimal solution. The implementation process of GA is shown in figure 2-1.



Figure2-1 the implementation process of GA

Basic content of GA includes coding structure, population initialization, selection, genetic operation (crossover and variation), objective function and fitness function design, choice of termination conditions, etc. Among them, selection, crossover and variation operation are the core of the genetic algorithm. Selection chooses and obsoletes individual in the parent according to the size of fitness function value to ensure the optimal search direction of algorithm. Crossover operation is the main method to generate new individual which determines the global search ability of GA. Variation is an auxiliary method to generate new individual and determines the local search ability of GA.

GA control parameters include: population size, crossover rate and variation rate and some other GA parameters (such as the maximum number of iterations, etc.). Selection of GA parameters is vital for the final optimization results of the algorithm. At present, these parameters are decided by a large number of experimental testing methods.

3. Genetic algorithm application of computer communication network reliability optimization design analysis

 1_{N} Genetic gene expression. In this paper, it adopts the method of binary encoding to determine the gene expression with N nodes computer network shown in table 3-1.

Table 3-1 Gene expression of computer network nodes

N_1	g_{11}	•••••	g_{1n}
N_2	g_{21}		g_{2n}
	•••••	•••••	

2 Choice of fitness function. To effectively prevent the cheating occurrence in the genetic algorithm, the cost values of the individuals in the population are arranged according to the numerical size. Set the minimum one to 1 of its sort code, the maximum one as Pop-size, so the designed fitness function is shown as follows.

$$f(x) = (x-1)/(Pop - size - 1)$$
(3-1)

Where *x* is individual sort position; Pop-size is the scale of group, $1 \le x \le Pop - size$.

3 Evolutionary computation selection. In this paper, it uses wheel choice method. Its basic idea is each gene selection probability is proportional to its fitness value. For the gene with fitness value f_k , the selection probability P_k can be calculated as:

$$P_{k} = \frac{f_{k}}{\sum_{j=1}^{Pop-size} f_{j}}$$
(3-2)

4. Genetic arithmetic. For computer network node gene expression, it uses random node crossover method, which produces a random number between [1, N] to determine genetic crossover position. Each time, it can only to cross one node location. Under normal circumstances, crossover rate $P \in (0.01, 0.1)$. For instance:

Paren	t1	N_1	N_2	N_3	N_4	N_5	N_6
		010110	101100	010101	101011	100101	001110
Parent2		N_1	N_2	N_3	N_4	N_5	N_6
		010010	101100	011101	100111	100101	101110
Crossover	operate	es at node3 a	and it genera	ites new ger	neration:		
Generation1	N_1	N_2	N_3	N_4	N_5	N_6	
	01011	0 10110	0 01110	1000	11 10010	1 001110)
Generation2	N_1	N_2	N_3	N_4	N_5	N_6	
	01001	0 10110	0 01010	1001	11 10010	1 101110)

 5_{γ} Adjust algorithm steps. When the computer network node gene expression cannot accurately reflects the original computer network topology, follow these steps to achieve adjustment algorithm:

for j=1,N if gij=1 then If gji=0 then gji=1 else if gji=1 then gji=0 end for end for

6. Terminal conditions of GA. GA convergence theory illustrates the limit properties of the convergence in probability 1. The most common terminal condition is to preset the biggest genetic operation iteration or a population evolution degree to control namely the proportion between biggest fitness value in current generation and average fitness of group.

4. Summary

The rapid development of computer network, on the one hand promotes the increasing of factors on the reliability of computer network, on the other hand it puts higher requirements on computer network reliability index system. Therefore, the computer network reliability index system also needs to further improvement. The establishment of the computer network reliability model also needs to consider the randomness in actual operation, uncertainty and human objective factors.

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