Business Method Allocation Method Based on Power Communication Network Reliability

Jun Qi[1,a,*], Shuo Cheng[1], Liangliang Yu[1], Rongkun Zhou[1] and Dongfang Zhang[1]

[1]State Grid Liaoning Electric Power Supply Co., LTD. Information & Telecommunication Branch, Shenyang, 110006, Liaoning, China
a. qij0427@163.com
**corresponding author: Jun Qi*

Keywords: Power communication network, reliability, average risk, risk equilibrium, routing optimization, non-dominated genetic algorithm.

Abstract: According to the typical structure of power communication network and features of power communication service for smart grid, a service routing allocation optimization algorithm is proposed based on the reliability of power communication network. Taking service average risk degrees and service risk balancing degrees as reliability evaluation indexes of power communication network, the algorithm used non-dominated sorting genetic algorithm (NSAGII) for communication service routing optimized allocation. Business information entropy was adopted as optimization function. Finally, quantum genetic algorithm was used to solve the multi-constrained routing problem. With bandwidth constraints added to process of fitness evaluation to control direction of each business flow path, the business path set of maximum information entropy value of current network was worked out. Simulation result showed that, network business under the algorithm based on entropy distribution was relatively well-distributed, business traffic was effectively controlled and network resource optimization and network load balance were realized.

1. Introduction

The power communication network is the second physical network of the power system, which bears the business needs of power grid companies' production scheduling, operation management, and enterprise information management. Its safety and reliability directly affect the safe and stable operation of the power grid. Scholars at home and abroad in the power system reliability A lot of results have been obtained in the research on the reliability of communication networks. At present, the reliability research of power communication networks mainly focuses on the optimization of communication network topology and the reliability of the network structure itself. Literature [1] proposed a balance based on the importance of nodes For network topology optimization algorithms, literature [2] proposes an optimization method for fiber optic cable routing that considers the capacity demand relationship and the sharing of fiber optic cables, and literature [3] proposes a method for evaluating the vulnerability of electric power communication networks based on complex network theory. None of these literatures are from the business level. Assess the reliability of power communication networks.

Considering that the electric power communication network and electric power communication business are developing day by day, the connection with the power grid is also closer. Literature [4] pointed out that researching the overall business reliability of the electric power communication network is important to guide the daily business planning and design of the electric power communication operation department and optimize the network operation mode Adjustments and other aspects are of great significance, and reliability evaluation indicators such as business importance, average risk of the entire network business, and business risk balance are proposed. Evaluation measures of the reliability of the power communication network based on the business network's risk balance are established. Indicators, evaluation models, and solution methods. The literature was developed in the context of a given business channel (routing). There was no research on ways to improve business reliability. Based on the business risk assessment indicators proposed in [5], the business was studied. Routing optimization distribution method. The research found that routing optimization distribution using network business risk balance as an evaluation index has limitations, and the routing allocation method with the smallest network business risk balance is not necessarily the optimal route allocation method in practical situations. This article takes the business risk balance and average business risk as the power communication network.The reliability assessment index of the company uses multi-objective genetic algorithms to optimize the distribution of business routes, and provides a theoretical reference for the reliability assessment of power communication services and the optimization of network operation methods from the business level.

2. Uniform Distribution Algorithm for Power Communication Network Services

Expert scoring links in traditional power business importance evaluation are highly subjective, and there are differences in the evaluation results given by different expert groups, which may lead to inconsistent evaluation results of business importance, which will affect various network performance analysis based on business importance. In order to eliminate this effect, it is necessary to find objective factors that can replace subjective factors of experts to describe the mutual importance between businesses[6].

Considering the actual situation of multiple services transmitting at the same time, under the objective functions of delay, bandwidth, and bit error rate, etc., the optimal unicast path of a certain service is solved in a single way and the interaction with other services is ignored. The routing algorithm cannot better uniformly distribute services and optimize network resources[7]. To this end, this paper proposes a routing algorithm that uniformly distributes overall network services based on entropy. It focuses on solving the global service path set suitable for network distribution. At the same time, using the index to measure the uniformity of network services as the objective function, the transformation from a multi-objective optimization problem to a single-objective optimization problem has played a direct and maximum optimization role. The set of optimized business paths is performed in two steps. The delay requirement is to obtain the set of available paths for each service, followed by the service information entropy as the objective function and the link bandwidth as the constraint condition, and the quantum genetic algorithm is used to select the service path that makes the network most uniformly distributed for each service. The process is as follows[8].

1) Select the set of available paths that meet the delay requirements of the corresponding service. According to the delay requirements of the power service, find all available paths that meet the requirements of the transmission service. $x=\{s,i,j,d\}$ Represents the original node s To the destination node d Path, because the source and destination nodes selected for the same service

are different, the selected path is different.When different services are transmitted under the same source and sink node, the selected service path is also different. X_{hk} The first h Service of source and sink node pairs k One available path to get the set of available paths for the corresponding services of all source and sink node pairs Z .

2) Qubit encoding and decoding.

After obtaining all the path sets that all the corresponding services meet the delay requirements, how to choose the available path set that is most suitable for the distribution of network services is the most critical thing[9].

The genetic quantum algorithm (GQA) uses a qubit-based encoding method, that is, a qubit is used to store and express a gene, and the qubit can be arbitrarily superposed in the two states of 0 and 1. This genome contains all Possible information. A quantum chromosome consisting of n qubits can be described as α with β Representing the probability amplitudes of the qubits in the 0 state and 1 state, and $\alpha^2+\beta^2=1$ The chromosome can express 2n state information at the same time. In order to calculate the fitness function, the coding chromosome needs to be decoded, and the binary individuals are converted to decimal to get the specific path set.

Perform a quantum measurement operation on the encoded chromosome, randomly generating a number between 0 and 1, if the number is greater than $|\alpha_r|^2$, then x_r is 1, otherwise it is 0. The length is n Binary string $p=\{x_1,x_2,x_3 \ldots x_n\}$.

3. Simulation Analysis

3.1. Building a Network Topology

In order to verify the effectiveness of the algorithm, Matlab2013a simulation platform was selected. Based on the IEEE 30-node test system for networking, the network model reference [10]. The network topology is shown in Figure 1, which includes 26 nodes and 38 links. The numerical values on the road in turn indicate the link number and the actual distance between the two nodes. Among them, node 25 is the provincial dispatch center, number 26 is the regional dispatch center, numbers 4, 15 and 23 are 500kV substations, and number 6 is the convergence node. The rest are 220kV substations.

As shown in Figure 1, there are N1 to N5 scheduling in the network at a certain period of time. The data network service request must pass N6. It can be decomposed into 2 sub-service requests, which are N1 to N6 and N6 to N5 dispatch data network services. The maximum number of operations is 300 times. As can be seen from the figure, when it runs to about 100 generations The proportion of the number of Pareto optimal solutions in the population is basically maintained at about 35%.

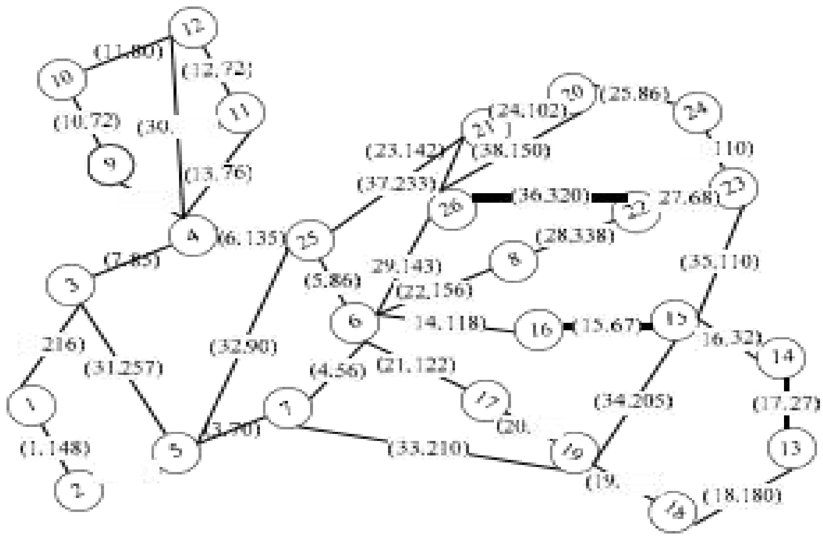

Figure 1: Topology of communication network of the IEEE 30-bus test system.

3.2. Algorithm Flow

For a certain service, delete the path that does not meet the delay requirement, and then add the link bandwidth constraint in the fitness evaluation process to remove the path that does not meet the bandwidth constraint.

3.3. Routing Optimization Algorithm Flow Using nsgaII

1) Randomly generate an initial population P0. Calculate the average business risk Ravg and business risk equilibrium BR of each individual; according to the values of these two objective functions, non-inferiorly rank the population and calculate the crowding distance.

2) According to the calculation results of non-inferior ranking and crowding distance, select, cross, and mutate P0 to obtain a new population Q0, let t = 0.

3) Form a new population $Rt = Pt \cup Qt$, and calculate the individual population Ravg and BR; based on the values of these two objective functions, non-inferior sorting of the new population is performed to calculate the crowding distance.

4) According to the results of non-inferior ranking and crowding distance calculation, select the best N individuals in the new population Rt to form a new population Pt + 1; select, cross, and mutate the population Pt + 1 to obtain a new population Qt + 1.

5) If the termination condition holds, the genetic process ends; otherwise t = t + 1, skip to step.

The selection process in the genetic algorithm uses binary tournament selection, the crossover process uses position-based hybridization algorithms, and the mutation process randomly changes the position of 2 genes in a chromosome. Compares the uniformity of the overall network business. The dispatch center and each plant There is business transmission between stations, and there is also business transmission between each substation. In order to simplify, the above business is classified according to the previous classification, and some node business related information is listed.

Randomly select the network service distribution at time t. It can be seen that a small number of links (Articles 5 and 6) carry too many services. These two links are exactly the links connected to the dispatch center. On this basis, Compare business routing and business traffic distribution under various routing algorithms.

Not all 1-to-1 services in the power communication network. It may be 1-to-N (1 starting point, N-terminating points), N-to-1 (N starting points, 1 termination point), or multiple nodes executing sequentially (Starting from a starting node, passing through multiple intermediate nodes in sequence, and finally reaching the terminating node), etc. At this time, the service request can be broken down into multiple sub-service requests.

4. Conclusions

When evaluating the reliability of the power communication network, not only the inherent reliability of the network must be considered, but also the reliability of the power system services carried by the network should be analyzed from the business level. The business route optimization considering the reliability of the power communication network proposed in this paper. The distribution method can provide scientific and reasonable auxiliary decision-making schemes for the power system communication department to arrange business channels and organizational operation methods in the case of the determined network topology, so that the power communication network business runs in a highly reliable manner. In the process, the effects of delay and network node congestion on the reliability of power communication networks require in-depth analysis and research.

Acknowledgments

This work was financially supported by Science and Technology Project of Liaoning Province Electric Power Company Limited (2019YF-65).

References

[1] Peng X, Deng D, Cheng S, et al. Key technologies of electric power big data and its application prospects in smart grid [J]. Zhongguo Dianji Gongcheng Xuebao/Proceedings of the Chinese Society of Electrical Engineering, 2015, 35(3): 503-511.

[2] XUE Shengjun, HU Minda, XU Xiaolong. Fairness- optimized resource allocation method in cloud environment [J]. Journal of Computer Applications, 2016, 36(10): 2686-2691.

[3] FENG Yazhou, YUE Dong. Design and implementation of distributed retrieval system for massive power video [J]. Computer Technology and Development, 2016, 26 (12): 186-189.

[4] LI Congying, WANG Ruigang, YU Jinliang. Design and implementation of distributed text retrieval system for big data [J]. Computer and Digital Engineering, 2016, 44 (12): 2426-2430.

[5] Chengchang Z, Huayu Z, Jianchang L, et al. Massive data analysis of power utilization based on improved K-means algorithm and cloud computing[J]. Journal of Computer Applications, 2018.

[6] Wang Z Q, Li H L. Research of Massive Web Log Data Mining Based on Cloud Computing[C]// Fifth International Conference on Computational & Information Sciences. 2013.

[7] ZHOU Dibin. Research on ten million of high dimensional data real- time retrieval by Multi- GPUs[J]. Bulletin of Science and Technology, 2013, 29 (1):118-123.

[8] LI Pengfei, LIU Chunyu, HAI Jun. Real- time streaming controllable clustering algorithm for correlated big data in cloud computing environment [J]. Science Technology and Engineering, 2018 (7): 185-190.

[9] LIN Nan, SHI Weihang. Web database security index based on multi- layer space fuzzy subtractive clustering algorithm [J]. Computer Science, 2014, 41 (10): 216-219.

[10] HU Leijun, PANG Songtao, ZHU Jiong, et al. FPGA- based big data K-means algorithm optimization [J]. Electric Power Information and Communication Technology, 2016, 24 (8):1-6.