Research on Service Routing Optimization Method of OTN Technology in Power Communication Network

Gao Lipo*, Kang Wei, Hao Junkui, Zhao Jianhua, Zhang Hongmei

Economic and Technological Research Institute of State Grid Hebei Electric Power Co., LTD, 050000, China

Keywords: Reliability; Optical Transport Network; Route Optimization

Abstract: With the rapid growth of the types and quantities of modern power communication networks, the reliable transmission of information has a tremendous impact on people's production activities and daily life. Based on this, the working principle and development status of optical transport network (OTN) technology are expounded. According to the typical structure and communication service characteristics of power communication network, the service routing optimization method for reliability of power communication network is studied based on OTN technology. Finally, the proposed OTN optimization method is used to optimize the service routing of a certain place. The optimization results verify the feasibility and effectiveness of the optimization method applied to the route optimization of power communication network.

1. Introduction

With the development and progress of the times, the power communication network has become an indispensable basic project for the masses of people in production and life. However, in the process of perfecting the development of the power communication network, there will be some new bad factors that interfere with its reliable operation [1]. The internal structure of the power communication network is very complicated, and routing is a very important component inside the power communication network. Whether the route design is reasonable will have a direct impact on the operation quality of the power communication network [2-3]. Therefore, the optimization design of routing has become a necessary way for power companies to improve the reliable operation of power communication networks. The power communication network adopts commonly used synchronous digital system (SDH) technology based on optical fiber communication technology, which makes the power communication network enter a new stage [4]. However, with the rapid development of science and technology and the increasing scale of the network, the information transmission capacity and bandwidth demand of the power communication network are also rapidly expanding at an explosive and exponential speed. In this context, SDH technology limitations have become increasingly prominent, and can no longer meet the rapid development of today's power communication networks [5]. When the so-called "fiber exhaustion" occurs in the fiber used for carrier transmission, DWDM-based OTN technology has emerged [6].

2. State of the Art

Optical Transport Network (OTN) is a transport network structure centered on optical channel technology and DWDM technology. It is similar to SDH, and is composed of optical splitter multiplexing, optical cross-connect, optical signal amplification and other components. The medium performs the functions of transmitting/receiving, add-drop multiplexing, and cross-connecting synchronization information [7]. The OTN transport network has two transmission modes: a two-wire unidirectional system and a single-fiber two-way system. OTN technology can improve the multiplexing degree of existing optical fibers, and can meet the increasing traffic and demand of current power communication networks [8]. OTN can multiplex multiple wavelengths on one fiber and cut the service rate and data that can be carried at different wavelengths. The formats are independent of each other, so it can meet the requirements of the power communication network for a

  DOI: 10.25236/mmmce.2019.066

variety of business support. OTN's Optical Add-Drop Multiplexer (OADM) and Optical Cross-Connector (OXC) Compared with ADM and DXC in SDH, OTN can process signals in various formats and at different rates, making the flexibility of the entire power communication network more flexible [9]. And the ability to use the optical signal to the device routing and recovery, cross-connect and other functions do not require OEO and electrical processing, improving the processing efficiency of the network [10].

3. Method for Service Route Optimization Based on Reliability OTN Technology

3.1. Factors affecting the reliability of power communication networks

The reliability of power communication networks is combined by many factors. There are two main factors affecting the service routing optimization of the reliability of the power communication network. The first aspect is that there is a certain risk in the indicators specified by the managers. Managers will involve the development of indicators in the operation of the power communication network. This link is related to the reliability of the power communication network. If the indicators set in the previous period are too high, the reliability of the power communication network will be unbalanced. When the distribution is uneven, it will pose a certain threat to the safe and stable operation of the power communication network. If the indicators set in the previous period are too low, it will hinder the service route optimization of the reliability of the power communication network, and cannot fundamentally guarantee the further development of the power communication network. In summary, the indicators set by managers should not be too high or too low. When the optimization index is selected, the average risk of the power communication network service is not correctly measured. As a result, the coverage of the risk measurement result is too small, which has a bad influence on the integrated service route calculation and design optimization of the reliability of the power communication network, so it is more needed. Coordination and cooperation of staff in relevant departments.

3.2. OTN hierarchical structure

ITu-TG.872 divides the entire OTN network level word into three layers, covering two different processing areas of light and electricity, as shown in Fig. 1 for the tiering of OTN networks.

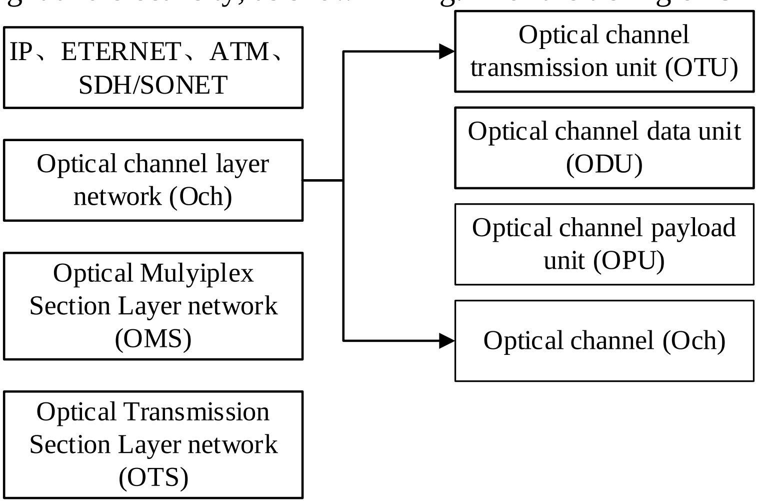

Fig.1. OTN hierarchical structure

The optical channel layer (OCh) provides end-to-end transparent optical transmission for different service signals. In this layer, there are three electrical domain sublayers, which are optical channel payload unit (OPUk) and optical channel data. Unit (ODUk) and optical channel transmission unit (OTUk). The purpose of this division is to provide a network connection function for multi-wavelength signals to accommodate multiple transmissions of multi-wavelength signals in order to accommodate multiple transmissions of multiple services at different rates. The functions of the layer network include: multi-wavelength multiplexing and multiplex section layer overhead processing, and implement management functions such as monitoring and protection of the multiplex section. The Optical Transmission Section Layer (OTS) provides signals for the optical multiplex section to provide transmission functions on different types of optical media. The functions of the OTS layer should be as follows: processing the overhead of the layer, generating/extracting the optical monitoring channel, providing adaptation of the optical channel to the physical transmission medium, and monitoring the optical amplifier and the repeater at the same layer.

3.3 Routing optimization indicators and methods

It can be seen from the above analysis that reliability is a key indicator for evaluating the service routing of power communication networks. Therefore, we consider the service reliability indicators to achieve optimal allocation of routes for power communication networks. Among them, NSGA II is the most commonly used optimization algorithm, its computational efficiency and robustness are better. The core of genetic algorithm is to adjust the relationship between each objective function, find out that each objective function can be as small as possible (or larger). The optimal solution set, the algorithm flow is as follows:

Step 1: The initial population P_0 is randomly generated. Calculate the average risk of each individual's business R_{avg} and business risk balance B_R. According to the value of the objective function, the population is sorted non-inferiorly, and the crowded distance is calculated.

Step 2: According to the non-inferior sorting and crowding distance calculation results, P_0 is selected, crossed, and mutated to obtain a new population Q_0, so that $t = 0$.

Step 3: Form a new population $R_t = P_t \cup Q_t$, calculate R_{avg} and B_R of each individual. according to the value of the objective function, sort the new population by non-inferiority and calculate the crowded distance.

Step 4: According to the results of non-inferior sorting and crowding distance calculation, select the best N individuals in the new population Rt to form a new population P_{t+1} select, cross, and mutate the population P_{t+1} to obtain a new population Q_{t+1}.

Step 5: If the termination condition is true, the genetic process ends. otherwise $t = t + 1$, jump to step 3 to continue the loop. The selection process in the genetic algorithm uses binary tournament selection. The intersection process uses a location-based hybridization algorithm, and the mutation process randomly changes the position of genes in a chromosome.

4. Case Study

4.1. Network planning

A certain power grid has jurisdiction over a certain place, two 500kV stations, 13 220kV stations, and 63 110kV stations. Three 220kV stations are planned to be put into operation in the next five years. More than 220kV and important 110kV stations meet the requirements of optical cable N-2. According to the service bearer strategy, the plan plans to transform the OTN equipment network into the power grid A of the grid. Configuring OTN equipment at 11 220kV stations, such as 500kV G station and 220kV K station, and constructing OTN backbone layer framework according to Mesh networking mode. OTN equipment is configured at 5 220kV stations such as K station, as the aggregation layer node. The ring network is built and connected to the backbone layer. The service traffic of the access layer is 622 Mb/s or less. The SDH device will continue to be used in the ring network.

4.2. Device Configuration

Considering that a large number of services need to be transferred to the ground, and the traffic volume of the 500KV G station is large, the plan plans to configure two OTN equipment in the local level, 500kV G station, and another OTN equipment in 17 stations.

4.3. Networking scheme and bandwidth allocation

According to the structure of a certain power optical cable network and SDH transmission A network, the plan plans A station, B station, C station, D station, E station, F station, G station, H station, I station, J station, K station, L Station, M station, and N station are the backbone layers. A total of 14 OTN devices are configured, and the transmission link bandwidth is 40G. The O station, P station, Q station, R station, S station, T station, and U station are used as convergence layers. A total of seven OTN devices are configured with a transmission link bandwidth of 40G. The 10G or 2.5G SDH equipment retired from the above site will be upgraded and replaced with some important 110kV site equipment in the old mode. This part is not described in detail in this document. The detailed network structure diagram shown in Fig. 2

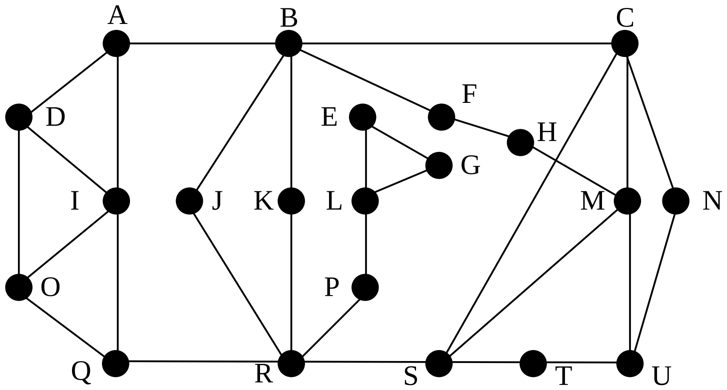

Fig.2. Backbone and convergence layer of OTN network in power supply bureau

4.4. Optimization step

In the process of transformation, it is necessary to ensure the reliable transmission of the real-time control service of the power grid. The network can be optimized and upgraded as follows: First, the above 21 OTN backbone layers and convergence layer nodes are constructed and debugged. Second, the 220kV and above services are gradually migrated to the OTN network or partially migrated to the SDH transmission B network and debugged. Third, the service migration of access sites at 110 kV and below needs to be analyzed. It is decided to directly access the OTN backbone layer or aggregation layer, or migrate to the SDH transmission B network. Finally, the OTN network backbone layer, aggregation layer, and SDH access After the entire network node is set up and debugged, the migration service is optimized and adjusted.

5. Conclusion

When evaluating the reliability of the power communication network, it is necessary to consider not only the inherent reliability of the network, but also the reliability of the power system service carried by the network from the service layer. Through in-depth study of the technical principles of OTN, this paper analyzes the OTN equipment form based on different levels of cross-technology, and combines the typical structure of power communication network and communication service characteristics, and proposes a service route optimization allocation method for OTN technology of power communication network. The results show that the proposed service route optimization allocation method considering the reliability of the power communication network can provide a scientific and reasonable auxiliary decision-making scheme for the power system communication department to arrange the service channel and the organization operation mode when the network topology is determined. The power communication network service operates in a high-reliability mode, and can provide theoretical reference for the service channel arrangement of the power communication operation department and the optimization of the network operation mode from the service level.

References

[1] Li F Y, Ding H X, Lang H. Power OTN Communications Transmission Performance Simulation Calculation. Applied Mechanics and Materials, 2014, 543-547:2488-2491.

[2] Zhao Z D, Pei M M, Xiao R J, et al. The Dispersion Research Based on its OTN Network Backbone Optical Transmission Network. Applied Mechanics and Materials, 2014, 644-650:4525-4528.

[3] Tan Y, Gu R, Ji Y. Energy-efficient routing, modulation and spectrum allocation in elastic optical networks. Optical Fiber Technology, 2017, 36: 297-305.

[4] Jiang D W, Sun Y, Li B, et al. Study of the Hybrid Optical/Electrical Wavelength Routing Approach for OTN Backbone Network. Advanced Materials Research, 2013, 804:298-301.

[5] Mezhoudi M, Chu C H K. Integrating optical transport quality, availability, and cost through reliability-based optical network design. Bell Labs Technical Journal, 2014, 11(3):91-104.

[6] Nagarajan R, Qureshi M A, Ramanna B, et al. A fault-tolerant MPLS-based control and communication network for the Lucent LambdaRouter. Bell Labs Technical Journal, 2010, 6(2):153-169.

[7] Andrae A, Edler T. On global electricity usage of communication technology: trends to 2030. Challenges, 2015, 6(1): 117-157.

[8] Chatterjee B C, Sarma N, Oki E. Routing and spectrum allocation in elastic optical networks: A tutorial. IEEE Communications Surveys & Tutorials, 2015, 17(3): 1776-1800.

[9] Rottondi C, Boffi P, Martelli P, et al. Routing, modulation format, baud rate and spectrum allocation in optical metro rings with flexible grid and few-mode transmission. Journal of Lightwave Technology, 2016, 35(1): 61-70.

[10] Assis K D R, Peng S, Almeida R C, et al. Network virtualization over elastic optical networks with different protection schemes. IEEE/OSA Journal of Optical Communications and Networking, 2016, 8(4): 272-281.