Research on the Whole Model Splicing Problem of the Provincial and Regional Power Grid Based on Dispatching and Control Cloud

Na Pan1, Zheyu Wang1, Shenjie Wang1, Haonan Niu1, Zi Wang2, Zhicheng Xu1
1State Grid Tianjin Electric Power Company, Binhai Power Supply Branch, Tianjin, 300450, China
2State Grid Tianjin Electric Power Company, Tianjin, 300010, China
*Corresponding author’s e-mail: na.pan@tj.sgcc.com.cn

Abstract. With the increasing expansion of power grid scale and the increasing complexity of power grid structure, the integration of power network is becoming more and more obvious. The existing real-time model of power network can no longer meet the requirements of network analysis and calculation. In order to improve the accuracy of online analysis and application function of power grid, a whole model splicing method of the provincial and regional power grid is proposed, and the modeling method of boundary equipment, boundary splicing method and processing of boundary T connection lines are studied. By applying the whole model splicing scheme on Tianjin Power Grid, and validating the result, the method can improve the accuracy and rationality of the result for whole model splicing of the provincial and regional power grid, at the same time meet the requirements of various network analysis and calculation.

1. Introduction
With the development of power grid dispatching automation system, the third-generation power grid, which is mainly characterized by large-scale renewable energy power acceptance and intelligence, has become the development trend of future power grids[1]. The power grid dispatch operation mode is gradually transformed and upgraded from "analytic dispatch" to "intelligent dispatch". Cloud computing technology is a brand-new service model that has developed rapidly in recent years. Compared with traditional service models, cloud computing technology has the characteristics of ultra-large scale, virtualization, high reliability, versatility, high scalability, and on-demand services, which is an ideal solution for the transformation and upgrading of power grid dispatching operation mode. For power system cloud computing technology, many scholars have carried out related application research[2-4].

Real-time power grid model is the basis of online analysis software, the existing models usually adopt three methods: local part model, external network equivalent model and whole model regular distribution[5]. In the local part model, the influence of neighboring power grids is ignored, which can meet the requirements of local model analysis, but the calculation error of the boundary line is relatively large. In the external network equivalent model, the influence of the boundary line on the calculation results is considered, but there are still large errors when the power flow of the power grid changes greatly. There is a large delay in the regular distribution of the whole model, and the data cannot be synchronized in real time, which affects the real-time calculation function of online analysis.
With the increasing expansion of power grid scale and the increasing complexity of power grid structure, the independent control system model of each region can no longer meet the current network analysis and calculation requirements. The three existing power grid models will affect the accuracy of online analysis results, resulting in the low practicability of online analysis software, which cannot meet the needs of integrated analysis of large power grids. If the existing model is used, it will inevitably bring great difficulties to network analysis and calculation, and affect the accurate calculation of network analysis applications and the accurate perception of the global state of the power grid. Therefore, we need to study the problem of power grid whole model splicing, realize the online analysis function of power grid whole model based on cloud computing, and improve the online analysis ability of power grid.

According to the plan of the State Grid Corporation of China, By the end of the "Thirteenth Five-Year Plan", a production control cloud with flexible resource allocation, unified data application planning, centralized and intelligent functions and services will be built, referred to as the dispatching and control cloud. So we can complete the construction of "State Grid cloud", which is composed of enterprise management cloud, public service cloud and production control cloud[6].

In this paper, the whole model splicing problem of provincial and regional power grid for the analysis and calculation of regulatory cloud network is studied, a whole model splicing scheme of provincial and regional power grid is proposed, the modeling method of boundary devices in the whole model splicing process, the boundary splicing schemes under different conditions, and the processing methods of boundary T connection, \( \pi \) connection and complex connection are studied. By applying the scheme to the whole model splicing of Tianjin Power Grid, the accuracy and rationality of the scheme are verified.

2. The structure of the dispatching and control cloud
The dispatching and control cloud adopts national and provincial hierarchical deployment methods to form a "1+N" overall structure. In order to adapt to the "unified management, hierarchical scheduling" scheduling management model, the dispatching and control cloud adopts a unified and distributed hierarchical deployment design, forming a two-level deployment of the national branch leading node and each provincial collaborative node, which together form a complete dispatching and control cloud system. Based on the entire network model, the leading node provides complete model services, data services and business applications, and each collaborative node provides related business services based on the province's complete model and on-demand external network model. This physically distributed and logically centralized operation mode can achieve the purpose of improving the co-processing capability, information support capability and global resource sharing capability of the multi-level control system[5].

Each dispatching and control cloud node is composed of three levels: infrastructure layer (IaaS), platform service layer (PaaS), and application service layer (SaaS). Each cloud node adopts a unified standard system[5]. IaaS focuses on the sharing of computing resources. By establishing computing resource pools, storage resource pools and network resource pools, consumers can obtain services from a complete computer infrastructure through the Internet. IaaS focuses on the sharing of computing resources. By establishing computing resource pools, storage resource pools and network resource pools, consumers can obtain services from a complete computer infrastructure through the Internet. PaaS focuses on services, providing services on a server platform or development environment. SaaS focuses on services, providing software program services through the network. Among them, PaaS is the focus of regulating cloud construction. According to the characteristics of regulating business, the PaaS layer can be divided into three platforms, namely model data cloud platform, operation data cloud platform and real-time data cloud platform. The model data cloud platform realizes the synchronization, storage, management and service of the whole business model; the operation data cloud platform realizes the collection of all-business operation data and operation events, and establishes a big data platform through data cleaning, extraction, and labeling, so as to realize long-term data storage, management and service; the real-time data cloud platform
synchronously collects real-time grid data, realizes the unified construction of real-time grid models, and realizes synchronous replication and on-demand tailoring services of real-time grid models according to application needs. The overall structure of each dispatching and control cloud node is shown in Figure 1.

3. The whole model splicing method of the provincial and regional power grid
Based on the model data cloud platform to realize the whole model splicing of the power grid model and graphics of the provincial power dispatch system and the regional power dispatch system. In addition to providing the entire network model data for the provincial model cloud platform, this model also provides the integration work of the entire network topology model, graphic ID conversion, external network equivalent load, and boundary overlapping lines. The whole model splicing method of the provincial and regional power grid is shown in Figure 2.

3.1. Boundary equipment modeling
In the process of splicing the provincial power grid model, the line is selected as the boundary device separating the internal and external networks. The boundary of provincial and regional power dispatch is generally set on the 110kV outlet line of 220kV substations; the boundary of regional and regional power dispatch is generally 110kV or 35KV connection lines. As shown in Figure 3.
In the process of boundary equipment modeling, at least one level of buffer network should be built when the regional power dispatch establishes the external network model, including local station and at least one level of external station. The station and line endpoint of this side are modeled according to the actual situation, and the connecting equipment of the line endpoint of the opposite side can be modeled in two cases: In the detailed modeling of the external network, the connecting device at the end of the opposite line is the bus, as shown in Figure 4. In the simplified modeling of the external network, the connected equipment at the end of the opposite line is the equivalent load, as shown in Figure 5.

Figure 3. The schematic diagram of the boundary

Figure 4. The detailed modeling of the external network

Figure 5. The simplified modeling of the external network

3.2. Boundary stitching

In the process of model splicing, the line is used as the boundary, the provincial and regional dispatching models are cut and spliced through the boundary table, and the boundary equipment ID, connection point ID and equipment measurement ID are replaced, so as to complete the whole model splicing of provincial and regional power grid. According to the modeling situation of boundary equipment, it is divided into two cases: line boundary splicing and load boundary splicing.
3.2.1. Line boundary splicing. The line boundary splicing is applied to the detailed modeling of external network, the splicing process is shown in Figure 6.

In Figure 6, line A is the main line and line B is the auxiliary line, after splicing, keep line A in the line table, delete line B, and replace the station on the other side of line A with station 4. In the line endpoint table, retain endpoint 1 and endpoint 4, delete endpoint 2 and endpoint 3, and replace the line that endpoint 4 belongs to with line A. In this way, station 1 and station 4 can be spliced together through line A.

3.2.2. Load boundary splicing. Load boundary splicing is applied to the simplified modeling of the external network, the splicing process is shown in Figure 7.

In Figure 7, the opposite side of station 1 adopts simplified modeling method, the connected equipment on the opposite side is equivalent load 1, and line A is the main line. After splicing, reserve line A in the line table, replace station 3 corresponding to line A with station 1, reserve endpoint 3 and endpoint 4 in the line endpoint table, and replace the connection point number of endpoint 3 with the connection point number of endpoint 1 to transfer the measurement of load 1 to terminal 3. In this way, station 1 and station 4 can be spliced together through line A.

3.3. Treatment of boundary T connection

Due to the complexity of the power grid structure, many boundary lines are not directly connected point-to-point, but have T connection, π connection or more complex connection conditions. In this case, we use the method of defining T-connected virtual station for processing, and assign the T-connected virtual station to virtual area. In order to simplify the boundary model, each T-contact point in the virtual area is unified into one T-contact point for processing.

Figure 6. Line boundary splicing

Figure 7. Load boundary splicing

Figure 8. Treatment of boundary T connection

Figure 9. Treatment of boundary complex connection
4. Whole model stitching result verification

Apply this scheme to splicing the whole model of Tianjin Power Grid, splicing the graphics and models of provincial and ten regional power distributions to form a whole model of Tianjin Power Grid, and revise the spliced model through topology verification and graphic verification. After verification, this scheme can improve the accuracy and rationality of the whole model splicing results of provincial and regional power grid, and the spliced model can meet the requirements of network analysis and calculation such as regulation of cloud state estimation, dispatcher power flow, static security analysis, etc. Improve the accuracy of network analysis and calculation results, and can meet the needs of various network analysis and calculations.

5. Conclusions

According to the general requirements of the State Grid Corporation for accelerating the construction of the dispatching and control cloud, in order to improve the accuracy of the network analysis and calculation results of the dispatching and control cloud, the problem of splicing the whole model of the provincial power grid for the dispatching and control cloud network analysis and calculation is studied, and a whole model splicing scheme of the provincial power grid based on the dispatching and control cloud is given. The problems of boundary device modeling, boundary splicing and boundary T connection are studied. Through the application of the scheme, the whole model of Tianjin Power Grid is spliced, and the results of the whole model splicing are verified. After verification, the power grid model spliced by the application can meet the needs of various network analysis and calculations, and improve the accuracy of network analysis and calculation results such as state estimation, dispatcher power flow, and static safety analysis.

References

[1] Zhou X.X, Chen S.Y, Lu Z.X. (2013) Review and prospect for power system development and related technologies: a concept of three-generation power systems. Proceedings of the CSEE, 33: 1-11.
[2] Cao Y, Gao Z.Y, Yang S.C, et al. (2012) Application of cloud computing in power dispatching systems. Electric Power, 45: 14-17.
[3] Liang S.Y, Hu R, Zhou H.F, et al. (2016) A new generation of power dispatching automation system based on cloud computing architecture. Southern Power System Technology, 10: 8-14.
[4] Wang D, Qian K.J, Gao Y.D, et al. (2015) Cloud computing platform technology and its application in power grid dispatch. Power System and Clean Energy, 31: 72-78.
[5] Xu H.Q. (2017) The architecture of dispatching and control cloud and its application prospect. Power System Technology, 41: 3104-3111.
[6] Wang M, Chang N.C, Wang L, et al. (2018) Architecture of Network Analysis Service Based on Dispatching and Control Cloud. Power System Technology, 42: 2659-2665.