

Design and Implementation of Function of Automatic Modeling Based on United Distribution Networks in New-generation Distribution Automation System

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Abstract—Aiming at the problem that the existing distribution automation system cannot meet the requirements of automatic modeling in united distribution networks, this paper has proposed the design and implementation of the function of automatic modeling based on united distribution networks in new-generation distribution automation system, and has formed the function of united automatic modeling using the initial network-wide equipment's model introduced by the geographic information system (GIS) or the production management system (PMS) on the platform of the new-generation distribution automation system, and then has comprehensively considered the characteristics of the architecture of united distribution networks. It mainly includes the function of united model check, the function of united model transformation, the function of united model cut, and the function of generating united model library. It has been applied to the distribution network in Suzhou, Zhenjiang and other regions, which lays a foundation for the model information required by the dispatcher to operate and control the power grid, and effectively improves the accuracy and reliability of related operations of application.

Keywords- *united distribution networks; united model library; united model check; united model transformation; united model cut*

I. INTRODUCTION

The distribution network is an important platform to support for the management of response from demand side, carrying a large number of distributed energy sources such as distributed generation and electric vehicles, and is a key link to promote to construct the smart grid and solve energy crisis [1-3]. With the continuous increase of distributed power sources, the rapid popularization of electric vehicles and the continuous increase of controllable loads, the existing architecture of distribution networks have been difficult to meet the user's requirements for the environmental protection, the reliability of power's supply, the quality of

power and the quality of service [4-6]. Therefore, many regions in China, such as Beijing, Shenzhen, have tried to break the previous planning and design of the distribution network, and carried out the planning of medium-voltage distribution networks using the concept of grid-based [7-11]. Based on the load's density of the level year of planning or the administrative level, considering factors such as the level of economic development, user's importance, the level of power's consumption, GDP, the planning of grid-based distribution network is a method that refers the grid of power's supply as the basic unit, and builds medium-voltage distribution networks as an objective architecture [12]. Combined with the actual situation, based on the guiding ideology of the planning of grid-based distribution networks, Jiangsu further has refined and summarized the method of planning in united distribution networks, that is, based on the division of areas of grid-based power's supply, according to the nature of different areas, combined with the structure of the grid of power, geographical conditions and other factors, the area of power's supply of medium-voltage distribution networks is further divided into several units of power's supply, each unit of power supply can independently undertake the task of normal power's supply in the area, and meet the reliability of the area of power's supply, reserve spare capacity to meet the requirements of future growth of the load. The method of planning in united distribution networks flexibly determines the unit of power's supply according to the nature of different areas, and follows the following principles: (1) The unit of power's supply generally does not cross natural barriers such as rivers, rivers, lakes, mountains; (2) The unit of power's supply is generally convenient for management, and does not cross administrative areas and different companies of power's supply; (3) Combined with the existing grid of power that have been formed, reasonably divide the units of power's supply, and facilitate the realization of dual power points and subsequent transformation; (4) The unit of power's supply

can be further subdivided with the development of the area for subsequent management and development.

Under the background of design and management of the planning of united distribution networks, at present, domestic distribution automation systems cannot supply the function of automatic modeling oriented to united distribution networks, which cannot meet the needs of the management of operating and controlling the grid of power, daily operation and maintenance for dispatchers in united distribution networks. In terms of basic modeling, the traditional distribution automation system mostly adopts feeder-based integrated network's modeling, that is, all equipment in the distribution network related to the network's structure is modeled in the memory to form a larger network's graph of topology. Then based on this graph, the topological network's analysis is carried out, thus the problem is the consumption of system's resource, the efficiency of low analysis and lack of localized unit topology model, it is difficult to adapt to the needs of the analysis of applications in united distribution networks.

In this paper, the authors have proposed the design and implementation of the function of automatic modeling based on united distribution networks in new-generation distribution automation system, and have formed the function of united automatic modeling using the initial network-wide equipment's model introduced by the GIS system or the PMS system on the platform of new-generation distribution automation system, and then have comprehensively considered the characteristics of the architecture of the united distribution network. Thus transforming the united distribution network into a local unitization and global integration is realized. The subsequent analysis of the application can realize the dynamic loading of the local model according to the information, reduce the resource's consumption and improve the efficiency of the topological analysis, and provide a reliable model foundation for accurate, comprehensive and efficient analysis of the application.

II. OVERALL FUNCTIONAL STRUCTURE AND CHARACTERISTICS

A. Overall functional structure

The overall functional structure is shown in Figure 1. It is composed of four functional modules, which are the function of united model check, the function of united model transformation, the function of united model cut, and the function of generating united model library.

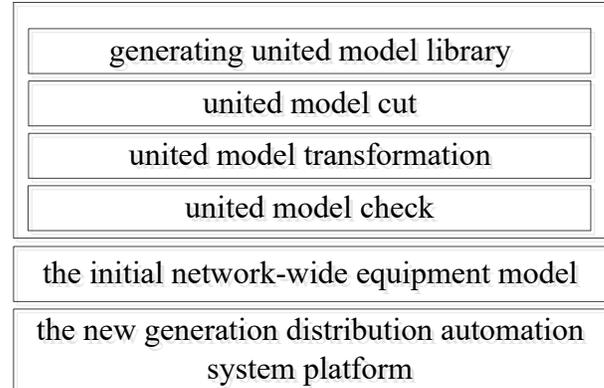


Fig.1 Overall functional architecture

The overall functional structure is based on the platform of new-generation distribution automation system. Based on the existing initial network-wide equipment's model in the feeder imported by the GIS system or PMS system, the function of united model check, the function of united model transformation, the function of united model cut, and the function of generating united model library are built. The relationship between the functional modules is shown in Figure 2.

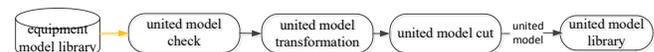


Fig.2 Relationships of functional module

The function of united automatic modeling uses the distribution network model imported by the GIS system or the PMS system to form an initial network-wide device's model in the feeder. The function of united model check is used to check the initial network-wide device's model, and unreasonable model are eliminated. The verified network-wide device's model is converted into a full-network's model by the function of united model transformation, and then through the function of united model cut, using the topological search algorithm to automatically cut the entire network model, forming a united model. Finally, the feeder model is loaded into the united model of power's supply to form a united model library featuring the unitization of power's supply in distribution networks.

B. Functional features

The function of united automatic modeling reasonably segments the large whole network's model of the distribution network and realizes local unitization, so that the subsequent analysis of application in distribution networks can realize the dynamic loading of the local united model on demand, reduce the consumption of resource and improve the efficiency of analysis.

III. FUNCTIONAL MODULE

The function of united automatic modeling provides a unit model for united distribution networks in new-generation distribution automation system, which is the basis

for the subsequent analysis and application of function of operation and control in united distribution networks.

From the top to the bottom, the model's level of the traditional distribution automation system is the administrative area, the factory station, the feeder and the opening and closing station (ring network cabinet). The model of the electrical equipment outside the station is finally contained in the feeder, the opening and closing or the ring network cabinet model. In the design of united automatic modeling in new-generation distribution automation system, a new "the partition of power's supply" model is added, which indicates that the partition of power's supply is divided according to the structure of distribution networks, and the "the partition of power's supply" model is used as a container for the united model of power's supply. The united model is added to the container of the "the partition of power's supply" model; a new "the unit of power's supply" model is added to represent the unit of power's supply divided according to the structure of distribution networks, and the "the unit of power's supply" model is used as a container for the feeder model, and the feeder model is added to the model container of the unit of power's supply. The hierarchy structure of model in united distribution networks is shown in Figure 3.

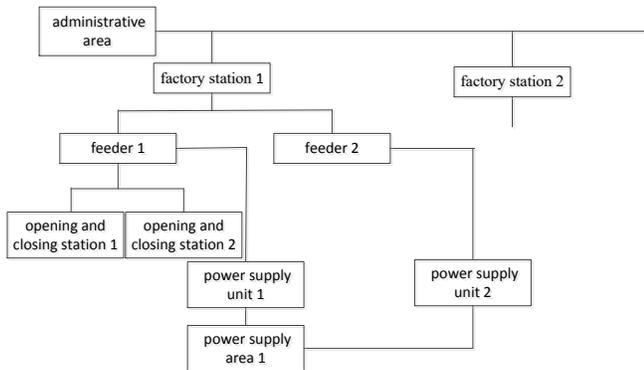


Fig.3 Hierarchical structure of model in united distributed networks

A. United model check

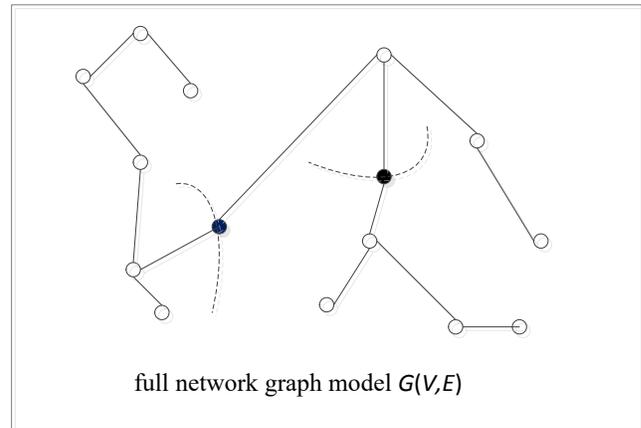
The function of united model check verifies and cleans the initial network-wide equipment's model imported by the GIS system or the PMS system, eliminates the unreasonable and ineffective models, and forms standardized network-wide equipment's model.

The method of united model check mainly includes: 1) checking the single device, checking the node's number of topological connection of a single device, and eliminating the device with illegal node's number; 2) comparing the graph with model, the relationship of topological connection of the model and the relationship of device's connection drawn on the graph are compared to check whether their relationship of connection is consistent. 3) Topological check, through topological searching, checking whether there is a

single radiating line without a transfer path or an isolated electric island without a power's supply.

B. United model transformation

The cleaned network device's model is converted into a full network's graph model $G(V, E)$ by the function of united model transformation, that is, the switch, the knife gate, the feeder segment, and the like are abstracted into the edge E , and the two endpoints are abstracted as the point V . Full network's graph model is shown in Figure 4.

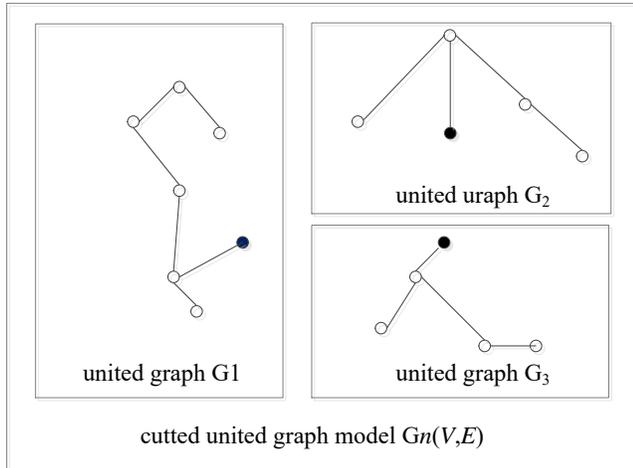


- device endpoint at the boundary of unit
- device endpoint in unit
- double-ended devices such as switches, knife gates, and feeder segments

Fig.4 Full network's graph model

C. united model cut

Using the topological search algorithm, the 10kV station outline switch and the manually designated switch outside the station (before the regional distribution network is not completely united-transformed, the unmodified part needs to be manually specified the disconnect point between the units of power's supply) as the boundary, automatically complete united model cut on the whole network's graph model, and the subgraph $G_n(V, E)$ is formed (n indicates the number of subgraph), and each subgraph represents a unit of power's supply, and the subgraph is named according to the "the region-the partition of power's supply - the serial number of the unit of power's supply", which is the name of the unit of power's supply. United model cut is shown in Figure 5.



- device endpoint at the boundary of unit
- device endpoint in unit
- double-ended devices such as switches, knife gates, and feeder segments

Fig.5 Cutted united graph model

D. Generating the library of united model

Finally, the feeder model is loaded into the united model of power's supply to form a library of united model.

IV. APPLICATION EXAMPLE

At present, the function of automatic modeling researched in this paper has been successfully applied to many new-generation distribution automation systems such as Suzhou and Zhenjiang. This function can be extended to other areas for the sharing of the field of operation and control in distributed networks and other related business areas.

Suzhou Power Supply Company took the lead in completing the united planning of distribution networks in Suzhou Industrial Park, and successfully demonstrated the application to realize united power's supply. In the context of current united management of distributed networks, the existing distribution automation system has been constructed with the feeder model as the basic unit, but it is difficult to adapt to the unitization and standardization of the unit distribution network. However, by applying the function of automatic modeling studied in this paper, it is possible to decompose the distribution network with large complexity and high complexity into many sub-units with small correlation, and in general, the application of the function of automatic modeling lays the foundation for the model information required by the dispatcher's remote operation and on-site operation, which effectively improves the accuracy and reliability of related operations. At the same time, it also reduces the intensity of the dispatcher's work and improves the efficiency of their works.

V. CONCLUSIONS

This paper has designed and implemented the function of automatic modeling based on the unit distribution network of new-generation distribution automation system, and has formed the function of united automatic modeling through the initial network-wide equipment's model introduced by the GIS system or the PMS system on the platform of new-generation distribution automation system, and then has comprehensively considered the characteristics of the architecture of the united distribution network. At present, the function has been put into operation in the dispatching centers of Suzhou, Zhenjiang and other regions. The operation results show that the system can meet the requirements of operating and monitoring the united distribution network, effectively improve the operation and management of the dispatchers in the distribution network, and realize to judge the fault of the distribution network fast and accurately, greatly improve the adaptability of the distribution network to user's operation and perception, and ensure the high reliability of the power's supply, thus bring greater economic and social benefits.

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