Research on Integrated Construction Mode and Key Technologies of Regional Power Grid Dispatching System

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Abstract. This paper proposes a technical solution for the construction of an integrated system based on regional power grid dispatching system. The program is based on the principle of "economical application, resource reuse, information sharing, safety and reliability". the scheme utilizes the software and hardware platform resources in the main network dispatching automation system in operation, and uses the modular construction method to construct the function of the distribution network automation master station. The key technologies used in the construction of the integrated system are described. The regional power grid deployment integration system is the trend and direction of power grid dispatching and distribution network dispatching system construction in small and medium-sized regions, and it is an effective way to rapidly promote power grid automation construction in small and medium-sized regions. A new scheme for the construction of the main distribution network integrated dispatch control system was explored.

1. Introduction

As the construction of the smart grid continues to deepen, as the power distribution system close to the user side, it directly relates to the high-quality service level of the power grid company. The real-time monitoring of the operating status is an important means to improve the quality service, and the automation of the distribution network is higher. The degree of automation of domestic distribution networks is generally not high. There are many pilot projects in developed coastal areas and provincial capital cities, but the operation results are generally unsatisfactory. The reasons are many, one of which is the huge capital investment to make distribution automation system construction. It is impossible to start on a large scale, which limits the scope of application and makes the system unable to perform its proper performance [1-2].

At present, the construction mode of the domestic distribution automation system generally adopts the independent construction mode of the main network automation system and the distribution network automation system. A main network dispatching automation system is responsible for collecting and controlling the transmission network of 35kV and above. A distribution automation system is responsible for collecting and controlling the 10kV power distribution network. One of the root ideas of this construction mode is that due to the different control modes of the main network and the distribution network, the main network control operation is biased towards the stability of the power grid and the stability of the system power. The operating characteristics determine the main network control automation system. The amount of change state is small, the measurement and

calculation of telemetry are frequent, and the characteristics of advanced applications such as state estimation are emphasized. However, because the distribution network is directly oriented to the customer, the control operation is more focused on the power supply status of the line, so this feature determines the automation of the distribution network. The system has a large amount of change state, and the characteristics of telemetry acquisition and application are simple.[3-4].

From the point of view of this, the main network and distribution network control automation system for data collection and processing are consuming the processing power of computer equipment. When the performance meets the requirements, the data collection and processing of the primary network and the distribution network can be completed in the same system. The content of this paper is to realize the construction of the integrated system based on the regional power grid dispatching system in the small and medium-sized regional power grids with low requirements on computer equipment [5].

2. Deployment integration system construction principle

The architecture of the integrated system needs to start from the two parts of the dispatching department's grid dispatching and distribution network scheduling requirements, closely track the development of the latest technology, and has the features of functional software integration, resource sharing, and support functions. Its architecture needs to follow the service-oriented concept, using a viable, mature and effective computer and communication technology and digital means to build a safe, reliable and open integration system [6-7].

The construction of the integrated system should be adapted to the construction and development of the grid in the region. According to the structure of the grid, the condition of the equipment and the specific business needs, the appropriate construction mode should be reasonably selected. According to the current situation of economic development and load differences in the region, the equipment resources of the original automation system should be fully utilized. In principle, it should be inherited or used after appropriate transformation to build an economical and practical system.

3. Comparison of construction methods

There are two methods for the main distribution network integrated dispatch control system: The first one is that the main network and the distribution network use the same set of data acquisition and processing procedures, and collect and process the data of the main network and the distribution network. The second is to separate the main network and distribution network data acquisition and processing applications according to the modular design method, to collect and process the distribution network data, and the interaction between the main distribution network data is performed by the unified platform.

The first construction method is to collect and process the data of the main network and the distribution network at the same time. Therefore, the pre-configuration and SCADA program design is complicated and the operation efficiency is not high, and is suitable for processing data of a small power grid. Another feature is that if you want to increase the distribution function in the main network dispatch control system, you must change and replace the existing program, which has a great impact on the running system. The second construction method is independent of the data collection and processing procedures of the main network and the distribution network, and has high operation efficiency, and is suitable for adding a distribution network function in the existing main network scheduling control system, and does not cause a large impact on the original main network function. Impact is a construction method suitable for small and medium-sized or even large-scale power grids.

Table 1. Comparison table of construction methods

	Main distribution network sharing program	Main distribution network application independent
Impact on existing systems	High	Low
Program complexity	High	Low
System operation efficiency	Low	High

Pre-data access capability	2048	4096
Data storage processing capability	1000000 points	2000000 points
On-site implementation difficulty	High	Low
Data fusion	High	Low
Maintenance difficulty	High	Low
New difficulty	High	Low

The above comparison shows that the advantage of using the first method to construct the integrated distribution control system of the main distribution network is more obvious.

4. Design framework for integrated systems

Based on the second method proposed in the previous section, we chose to perform technical verification on the existing regional power grid dispatching automation system OPEN3000.

OPEN3000 system is a set of EMS system based on standardized platform developed by Guodian NARI Technology Co., Ltd. It follows the IEC61970 standard and adopts the idea of completely separating platform public services and applications, so that the system has good scalability. In addition to the traditional EMS application, the OPEN3000 has applications such as AGC and WAMS for provincial-level scheduling master stations. The platform architecture of the system provides a good foundation platform for building distribution network related functions.

4.1. Software Architecture

The software architecture of the main distribution network integrated dispatch control system is as follows. The main distribution network integrated dispatch control system uses the original main network OPEN3000 dispatch control system support platform to share the public services such as database service, real-time library service and message service. The distribution network involves procedures such as alarming and sampling for the distribution network; the SCADA application of the distribution network, the automatic processing of the feeder, and the advanced application of the distribution network. The data acquisition uses the main network acquisition and distribution network. Separate distributed acquisition, and distinguish between public network and private network. Management information area share the original WEB publishing system.

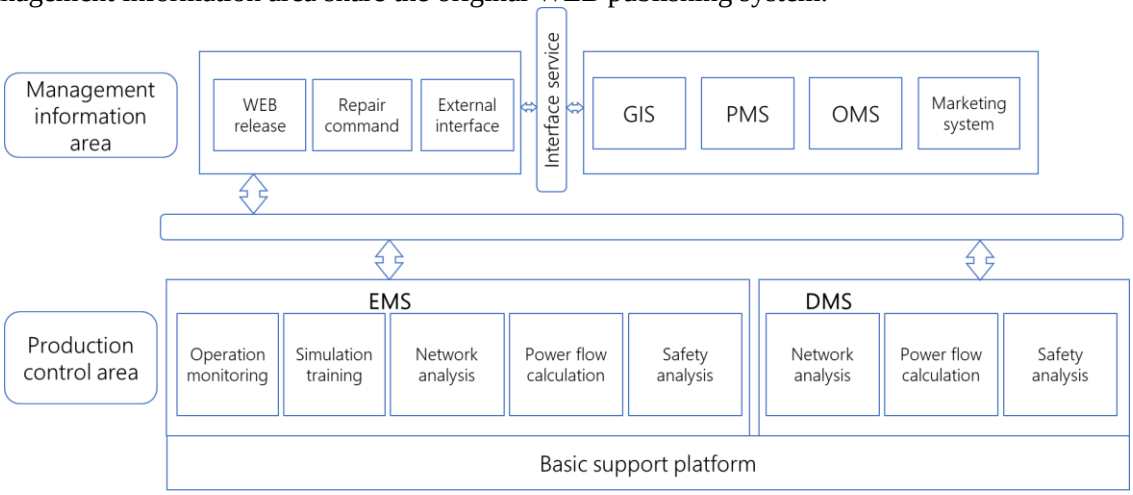

Figure 1. System software architecture diagram

4.2. Hardware architecture

The main distribution network integrated dispatch control system adopts resource reuse as the construction principle. The disk array, database server, pre-server, SCADA server, interface server and coordination workstation of the distribution network scheduling service all reuse the main network

scheduling control system equipment. According to the actual needs of the site, the new network public network data collection server is added, and the key node equipment adopts double redundancy configuration. The county adjustment side adjustment workstation reuses the county to adjust the original workstation.

The hardware structure of the main distribution network integrated dispatch control system is as follows:

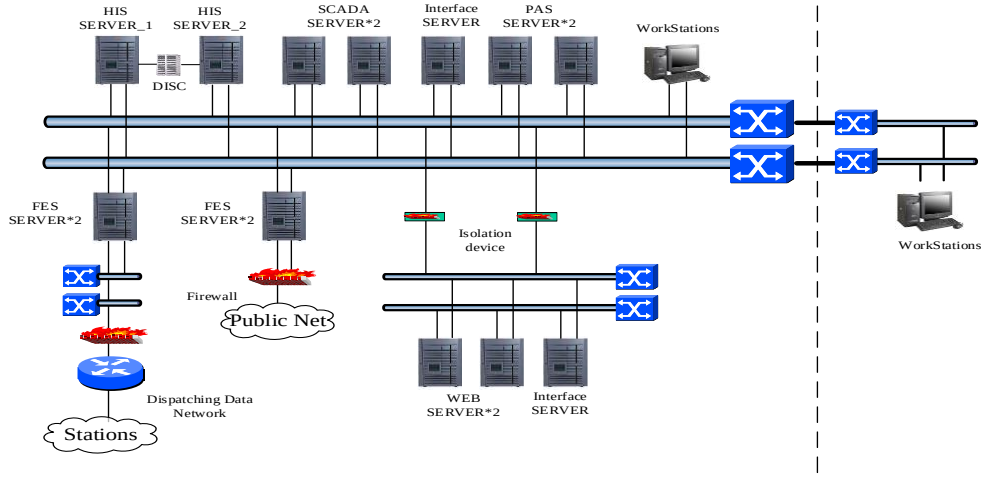

Figure 2. System hardware architecture diagram

5. Functional selection of integrated systems

As the overall design of the system is based on the principle of "economical application, resource reuse, information sharing, safety and reliability", the function selection is based on economic, practical and efficient, fully combining the actual use requirements of the regional dispatchers and the scope of dispatching services. Therefore, the extended distribution network function of the system mainly focuses on five parts of distribution network pattern management, real-time monitoring of distribution network operation, distribution network analysis, feeder fault processing and external data interaction interface. The following five parts are briefly described. .

5.1. Distribution network pattern management

In the construction of the main distribution network integrated dispatch control system, the distribution model management of the distribution network is based on the introduction of the model and the artificial improvement. After the completion of the basic pattern import, the pattern change management is performed according to the state-of-the-art transaction.

5.1.1 GIS import modeling

The main distribution network integrated dispatch control system provides the electronic wiring diagram and corresponding network model function of the special map generation system such as the single line diagram and the contact diagram of the line imported from the grid GIS platform, and the basic wiring set operation is provided on the electronic wiring diagram.

5.1.2 Manual Model Integration Modeling

The main distribution network integrated dispatch control system supports the integrated modeling of the model library, and automatically generates the static network topology model of the whole network according to the diagram of the distribution network and the corresponding model data according to the station map and the single line diagram.

5.1.3 Equipment Transaction Management

In order to meet the needs of the dynamic change management of the distribution network and reflect the dynamic change process of the distribution network model, the main distribution network integrated dispatch control system provides the functions of conversion, comparison, synchronization and maintenance of the various modes of the distribution network. Support equipment operation, non-operation, decommissioning equipment transaction, future graphics to real-world graphics conversion and process confirmation mechanism, can be coupled with the grid GIS platform's transaction process to establish an integrated device transaction management process.

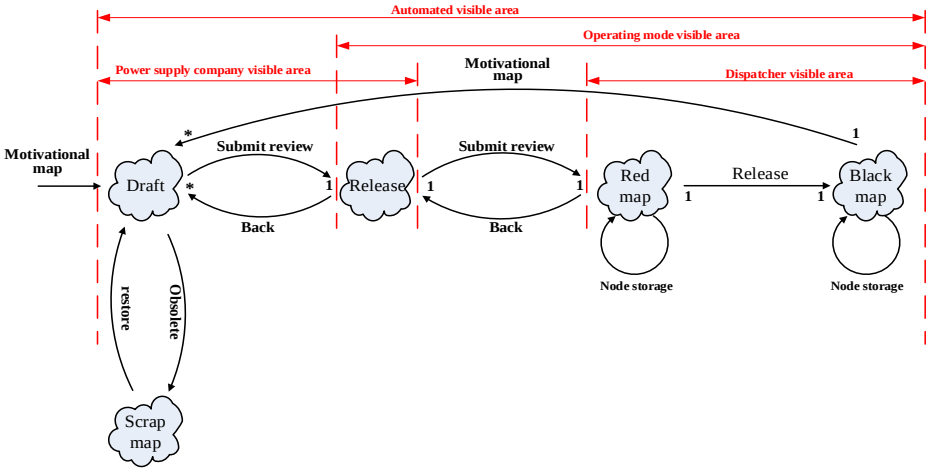

Figure 3. Schematic diagram of system data transaction flow

5.2. Real-time monitoring of distribution network operation

The real-time monitoring application of the distribution network is the technical support of the real-time dispatching service of the distribution network, which mainly includes data acquisition, data processing, data recording, terminal management, operation and control. The data collection is aimed at the scale of the distribution network data. The integrated system supports large data volume collection, can meet the real-time response needs of large data volume acquisition, and supports data collection load balancing processing. The terminal management is mainly for the comprehensive intelligent management of the current distribution terminal. It has the functions of terminal operation condition monitoring and analysis, online rate real-time statistics, etc. It supports the terminal operating condition statistics and can correctly count the distribution terminal's monthly outage time and frequency.

5.3. Distribution network analysis

The distribution network analysis application function completes the effective analysis of the distribution network operation status. The application uses the distribution network operation data and the result data provided by other application software to analyze and evaluate the operation of the distribution network to realize the optimal operation of the distribution network.

Distribution network analysis mainly includes network topology analysis, topology coloring, load transfer and other three basic practical analysis functions.

5.4. Feeder automation

The main distribution network integrated dispatch control system adopts mature and stable feeder fault processing software. When the distribution line fails, fault location, isolation and recovery of non-faulty areas are performed according to the fault information. In the automatic design of the non-faulty section of the recovery power supply scheme, the safety process is used to avoid the recovery process,

causing overloading of other lines, main transformers, etc., and avoiding the influence of human operation such as protection debugging and equipment maintenance [8, 9].

The system supports automatic and manual fault handling modes for different field terminal conditions. After the fault is processed, the entire process information of the fault processing is saved in the historical database for use in fault analysis.

6. Integrated key technology research

The regional power grid deployment integration system involves a number of key technologies in the construction process, such as communication message bus, feeder automation integrated with the main distribution network, and topology analysis of the full voltage model. This paper combines several key technologies studied in the construction of NARI OPEN3200 integration system.

6.1. Integrated system architecture technology

The integrated system architecture technology involves four parts: hardware architecture, software architecture, application coordination, and function display.

In terms of hardware architecture, the main distribution network integrated dispatch control system needs to consider the two major functions of the main network scheduling control and the distribution network scheduling control, so it has certain flexibility in the hardware architecture: the front server and the SCADA server. Main network and distribution network front-end and SCADA applications can be deployed at the same time. Applications can use cross-deployment to achieve redundant backup of applications. In the absence of a public network data terminal, the public network data collection front-end server may not be deployed.

Therefore, in some specific situations, such as the area where the main network dispatch control system has been built, the main network dispatch control system can be upgraded from the main network dispatch control system to the main distribution network integrated dispatch control system without adding any hardware servers.

In terms of software architecture, the main distribution network integrated dispatch control system uses a public support platform. The public services such as database services, real-time database services, and message services need to support the main network scheduling and distribution network scheduling at the same time; If the transformation is carried out, it is necessary to carry out the distribution network transformation of the procedures involving the distribution network in the support platform, such as alarm and sampling; expand the distribution network SCADA application, feeder automatic processing, distribution network advanced application and other functions, and data collection adopts the main network. Collecting distributed acquisitions separated from distribution network acquisition, and distinguishing between public network and private network. Management information area share the original WEB publishing system.

In terms of application coordination, since different grid scheduling models are derived from IEC61850, IEC61968, and IEC61970, respectively, it is necessary to separate the device model tables and triggers related to the main distribution network on the bottom layer of the database. The distribution network is divided into two categories: the distribution network model and the measurement model triggered by the distribution network model. After the separation of the underlying table structure is completed, considering the difference between the data collection and the distribution data collection of the main network, the distribution network front-end application (DFES) is added to enable the data collection function of the power distribution equipment. For the current situation that the data size is much larger than the data size of the main network, the pre-processing method is optimized, and the data channel is transformed from the process level to the thread-level management to improve the data access scale. Since the distribution data processing is simpler than the main network data processing, the SCADA application of the distribution network is implemented to realize the monitoring and control function of the distribution network equipment, and is completely independent from the SCADA application of the main network. The program processing method simplifies the processing flow and improves the processing speed. Messages in the main distribution

network are transmitted by different message channels when messages are exchanged, and cross-monitoring is performed only where different applications are required [10].

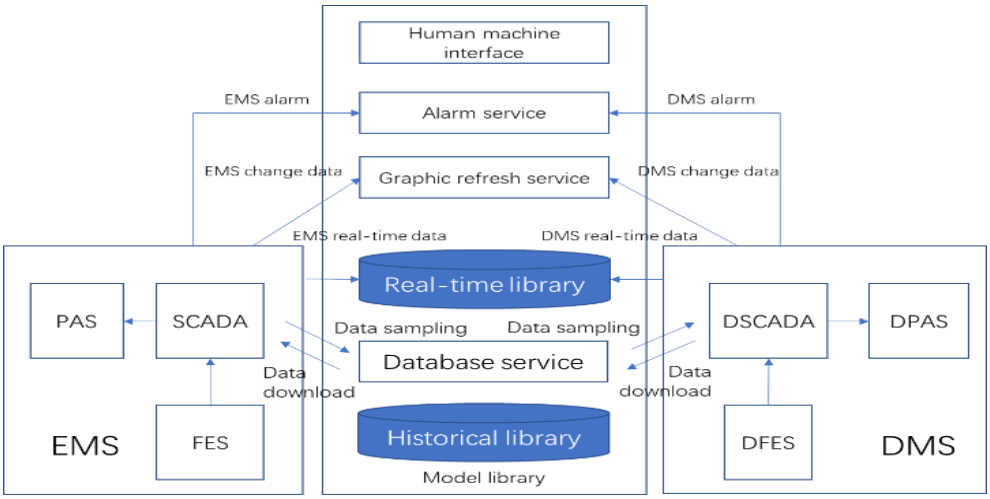

Figure 4. Scheduling integrated system application architecture

In terms of function display, the main distribution network application should establish an independent alarm system to distinguish the alarm information processing flow of different applications, and the alarm information is stored separately for unified display and application. In combination with the system responsibility area, the display information of the main distribution network alarm information is customized according to the user role (local adjustment, coordination, and county adjustment). For the sampling system, the sampling system has many sampling points and large sampling scale. It is advisable to adopt an independent processing process and separate processing from the main network sampling to improve the sampling efficiency. The graphic display distinguishes the business characteristics of different dispatching systems. The main network focuses on the plant station map, the business function starts from the plant station, and the distribution network schedule emphasizes the graph model management, the thematic map management, and the distribution network feeder automation. The system should have a system interface that integrates the main distribution network and integrates the prefecture and county, which is convenient for different identity users to operate.

6.2. Integrated analysis application technology

The grid analysis application function completes the effective analysis of the grid operation status. The main distribution network integration system uses the main distribution network operation data and the result data provided by other application software to analyze and evaluate the operation of the main network and the distribution network to achieve optimal operation.

6.2.1 Integrated network topology analysis

The network topology analysis based on the main distribution network integration system can be dynamically analyzed according to the connection relationship of the high, medium and low voltage grids and the operating state of the equipment. The analysis results can be applied to the main network monitoring, power distribution monitoring, and security constraints. Through the analysis of the electric island, the charging state of the high-medium and low-level three-level voltage grid equipment is analyzed, and the electric island is divided according to the topological connection relationship and the charging state of the main distribution network equipment. Through the power point traceability, the power supply path and power supply of the high, medium and low voltage three-level power grid equipment are analyzed to provide a topology basis for related analysis applications. Through the

operation of the main distribution network equipment listing, temporary jump connection, etc., analyze the impact of such operations on the high-middle and low-level three-level voltage network topology.

6.2.2 Integrated Topology Coloring

The main distribution network integrated topology coloring can determine the charging status of various electrical equipment of the high, medium and low three-level voltage model in the system according to the real-time status of the main distribution network switch, analyze the power supply point and the power supply path of each point, and express it in different colors. . At the same time, according to the results of topological analysis of high, medium and low three-level power grids, the operating states of grid model components of different voltage levels, such as live, power outage, grounding, etc., are dynamically displayed, and the power supply areas of different power points are dynamically displayed, and all paths of load transfer are displayed. Power supply range of different substations, etc. The fault area can be shaded according to the results of the medium and low voltage fault analysis.

6.2.3 Integrated load transfer

The main distribution network integrated load transfer analysis analyzes the impact load according to the target equipment of different voltage levels, and transfers the affected load safely to the new power supply point, and proposes a load transfer operation scheme including the transfer route and the transfer capacity. At the same time, the load information can be statistically analyzed to analyze the load and basic information of the load equipment affected by the target equipment. Through the transfer route search, the topology analysis method is used to search for all reasonable load transfer paths. Combined with the results of topology analysis and power flow calculation, the transfer load capacity and the transferable capacity of the transfer path are analyzed. It is also possible to analyze the results of the dual power supply customer transfer.

7. Summary

With the improvement of power grid planning and construction, the society has increased the requirements for power supply reliability and power supply service quality, and promoted the construction and perfection of the integration system. At the same time, the research on key technologies such as power grid dispatching, distribution network scheduling and system integration is increasing, and the development is becoming more and more mature. There are more and more cases of different modes of deployment and integration systems, and the application value of the power grid integration system is gradually emerging. At present, some typical integrated engineering cases in some parts of the country, such as Guangzhou, Guangzhou, Suzhou, and Mianyang, Sichuan, have been put into operation or are being implemented. The regional power grid deployment integration system is the trend and direction of the development of distribution network dispatching and repair scheduling in small and medium-sized areas. It is an important technical means to improve the stability, safety and economic operation of small and medium-sized power grids, and is an important guarantee for improving the quality of regional power supply services.

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