

INTELLIGENT DISTRIBUTION NETWORK ANALYSIS AND INFORMATION ARCHITECTURE DESIGN

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ABSTRACT

From the background of intelligent distribution network construction, this paper introduces the definition of intelligent distribution network and its features, such as intelligent substations, power distribution and power real-time monitoring, marketing and distribution integration, two-way communications, smart meter, etc.. This paper introduces the basic operational capacities that distribution network should have, and gives the definition and goal of each sub-capacity. This paper focuses on the information architecture design and data interactions of intelligent distribution network, and gives an example for analysis. Finally, this paper makes technique suggestions on the construction of distribution network and its route.

INTRODUCTION

STATE GRID Corporation of China (SGCC) accord to the actual grid situation in China, creatively put forward the development strategy of constructing "a unified strong and smart grid", and the target is to build a strong and smart grid with information technology, automation, interactive features, UHV grids is the backbone grid of which, and with the coordinated development of grid at all levels [1-2]. Experimental work of a strong intelligence network has been gradually carried out. In the aspect of distribution automation, the technology of power distribution system and distribution management system as the technical basis for intelligent power distribution automation has made considerable progress in our country after nearly a decade of development. The distribution automation technology practical guide of SGCC has been completed. Distribution management system already covered the construction of GIS, PMS, OMS, WMS, DSCADA and FA system, CMS, and enterprise resource planning ERP system interface in some cities, and the public support platform for efficient processing of the distribution production operations is initially constructed. In addition, SG186 platform and production management system PMS system of SGCC has laid a good technology foundation for carrying out the construction of intelligent distribution network of technology transformation next step.

From the background of intelligent distribution network construction, this paper introduces the definition of intelligent distribution network and its features, such as intelligent substations, power distribution and power real-time monitoring, marketing and distribution integration, two-way communications, smart meter, etc..

This paper introduces the basic operational capacities that distribution network should have, and gives the definition and goal of each sub-capacity in detail. This paper focuses on the information architecture design and data interactions of intelligent distribution network, and takes the data exchange between the substation and the control dispatching center as an example.

1 DEFINITION OF INTELLIGENT DISTRIBUTION NETWORK AND ITS CHARACTERISTICS

The basic characteristics of strong smart grid is to reflect informationization, digitization, automation and interaction in technology, and to reflect group oriented, intensive, lean and standardization in management. As an important component of smart grid, intelligent distribution network will show new features. The new characteristics of smart distribution grid can be divided into two major aspects. One aspect is grid infrastructure, including primary and second electrical equipments and related information system; the another aspect is service operation, mainly refers to the daily operation and information flow of distribution enterprises' production, marketing, dispatching and the backstage management and so on.

(1) Intelligent substation. Primary and second electrical equipments are completely intelligent, electrical equipment operation is programmed, the information among substations can be completely shared and achieve real-time interaction, the acceptance of the higher level control centre's dispatching is intelligent.

(2) Distribution and electricity real time monitoring. The realization of collection, transmission and control of distribution network's real-time information, and the automatic diagnosis, fault isolation and restoration based on integrated second system smart distribution terminal, intelligent customer terminal, intelligent primary equipment

(3) Integration of marketing and distribution. Realize the integration of electric power distribution management and electric marketing, and realize the cooperation management of distribution, metering, marketing service and other business in an integrated platform.

(4) Two-way communication. Rapid, bidirectional communication infrastructure can meet the different communication demand of electricity distribution and services, such as smart meters, sensor, switch to the communication of embedded system, substation / feeder automation system, master station.

(5) Smart meter. The intelligent user terminal, realizes

the two remote functions, and can make the distance call and modify the configuration, support time division measurement, provide technical support for electric power retail. Two-way communication function, not only to replace the basic functions of meter reading, but also can control electrical equipment through the meter under the user authorization, such as forgot to turn off the lights, turn off the air conditioning etc. before leaving home, can be remote controlled. It can open washing machine, disinfection cabinets and other equipments, can also give the car battery charging in valley period. Smart meters can help customers make more saving, lower carbon "electricity using plan", smart meters will list a number of data such as electric green index, energy consumption analysis, details of time division electricity price and so on. Customers can see the real-time electricity using through the meter, including air conditioning, air purifiers and other electrical appliances etc., and make timely adjustment.

2 SERVICE CAPABILITY OF INTELLIGENT DISTRIBUTION NETWORK

2.1 Real-time monitoring capability

Real-time monitoring capability includes running state monitoring, equipment management, the electric operation management, accident treatment, global voltage control, frequency control, harmonic management, non conventional energy management capacity. It can do automatic analysis and calculation of electrical distribution system line loss, and provide line loss analysis, line loss query, line loss monitoring, power management, analysis of loss reduction, non reactive power optimization, grid operation mode optimization etc. for all types of customers. Calculation of distribution network can provide the equipment efficiency optimization methods to decrease network loss, normal modes, and the network maintenance optimization mode analysis, fast transfer mode of failure mode. The position data of fault prediction helps to allocate working group to the distribution network in the affected areas. Similarly, intelligent terminal meter provides diagnostic data to accelerate the repair speed, improve the service level through remote fault identification of the distribution network location. The dispatcher can grasp the overall situation of power grid operation and equipment conditions, and correctly make control operation to maintain the safe operation of the power system and achieve good power quality, can quickly, decisively with anomalies and accidents to avoid the accident range expand.

2.2 Automatic measurement management capability

Automatic measurement management capability can effectively predict the response to demand growth and reduce electricity steal. Smart meters are installed in the

home or business district. They help to realize time division electricity price through the power consumption data collected at different time with the smart meter [3]. Intelligent Home Furnishing based on smart distribution network not only can realize remote control, can also achieve energy saving. Residents can read electrical equipment's electricity cost information from the terminal screen electricity consumption any time, so as to know the overall residential electricity cost, help to balance the distribution network load. In addition, smart meters installed in distribution network can also help locate electricity power steal occasions, so as to reduce the losses of enterprises.

2.3 Distribution network analysis capability

Distribution network analysis capability includes equipment life analysis and distribution network design optimization ability. The equipment life analysis includes the determination of distribution network component life and maintenance way determination when network is fault, such as when the distribution network component is failure in a similar form, can realize the condition assessment through data mining, and make pattern analysis based on historical use state.

Distribution network optimization capability can reduce the operation cost of the distribution network through the user load model analysis, can help the power supply enterprise avoid line transformation not necessary, and improve the distribution network reliability. Through the real-time monitoring of the fault current, the operating personnel can realize isolation of fault area and operation mode changes, thereby to reduce network loss, enhance system security.

2.4 Remote asset monitoring and control capability

Remote asset monitoring and control capabilities [3] can prolong the life of distribution network assets, and improve customer service through the fault prediction. Intelligent distribution network telemeters to provide real-time state detection, can provide detailed device state information, and help the operator to determine when the equipment will fail. Intelligent distribution network not only provides the data to predict and help prevent problems, but also provide accident recall, enables the control center accurately send engineers to fault location. Remote sensor can monitor whether the distribution network operation and distribution network capacity is consistent, and give operator warning timely when the component are beyond the optimization range. The sensor can find the problem at the beginning when distribution network fault occur through detection, such as transformer insulation deterioration caused by long time overheating. Based on the feedback of these sensors, the control center can adjust the structure of distribution network to reduce the endangered the safety of equipment load, or notify the site operation personnel

to handle. Data from the sensors can also be used to optimize the repair plan and update equipment.

2.5 IT support capability

Information system of intelligent distribution network should provide the communication infrastructure and information technology support to dispatching and operation business, including long-term information technology planning, application system construction management, daily maintenance management, as well as real-time technical support to the various application systems operation. Supervisory control and data acquisition (SCADA) [4] objects include distribution line under bad running environment, the primary equipment and distribution terminal, which need to have very high reliability. SCADA functional covers high, low voltage distribution network, the IP based SCADA, can large-scale cross communication network support sensors, smart meters and remote personal digital

assistant (PDA) use, and help the working group equipped with PDA digital map get the information coming from the control center ,then to facilitate the realization of management of mobile operation. The geographic information system (GIS) with fast positioning function, can quickly determine the position of the fault equipment, arrange repair [5-7], and shorten the time to failure. The information system of intelligent distribution network can help to support the establishment of IT strategic objectives, make the step-by-step implementation plan of IT construction, design IT management system.

3 INTELLIGENT DISTRIBUTION NETWORK ARCHITECTURE DESIGN AND DATA INTERACTIVE RELATIONSHIP

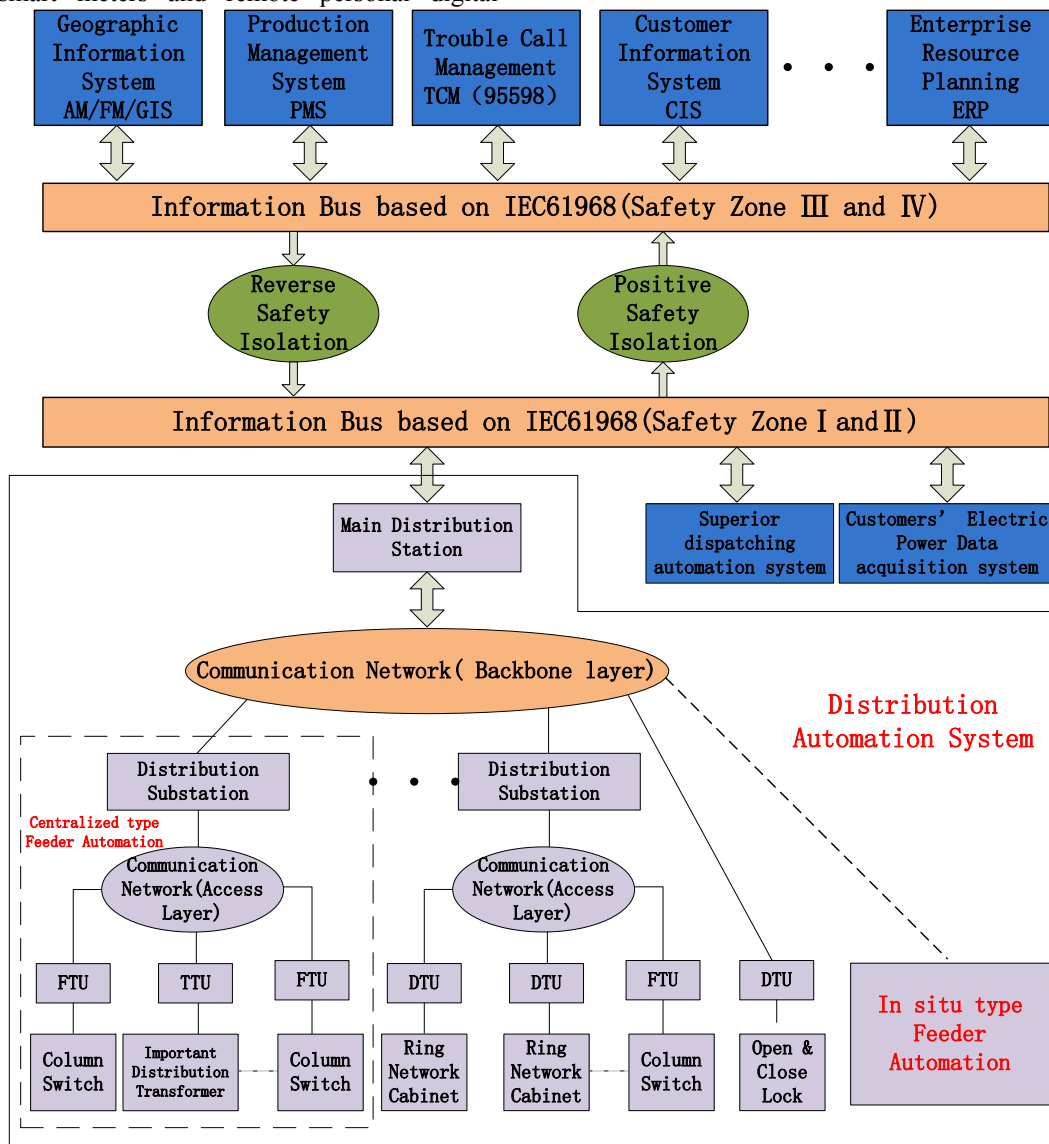


Fig1 Intelligent distribution network overall information architecture diagram

Information architecture design of intelligent distribution network should be able to meet service capabilities needs referred before. IT architecture management should realize the service capabilities under the advanced IT overall framework mode, including the application architecture, integrated architecture, data architecture and infrastructure. The main contents include the application in different levels, technical architecture component and architecture management content and relationship. Data integration is integration of business data based on the integration of business systems, reduce the data redundancy, and improve the efficiency of data. Data exchange provides a unified data sharing and exchange platform, improve the sharing of public data and application consistency, efficiency and availability. Application of data realize data requirement to make statistical analysis and assessment supervision through the data warehouse, and provide auxiliary decision, supervision report and management support and data analysis through data extraction, transformation and loading (ETL). Data management implement the data layout and data standards, to improve the data quality and data security, meet the data management needs through the establishment of data control tissue integrity and process. Data exchange platform establishes a unified data exchange standard, specifies data transmission protocol and application interface standard, establishes and apply loosely coupled data exchange mechanism, and provide a unified data exchange channel for data exchange.

Data exchange in three main ways: (1) the real time

exchange. It is mainly suitable for the real-time data exchange, such as model, equipment status updates, operation ticket, plan data etc. (2) Mass exchange, is mainly suitable for the data exchange that real-time requirement not high, such as electricity charge data. (3) The database synchronization is mainly suitable for the direct replication of data between databases, such as other database make data replication to the data warehouse.

Take the data exchange between the substation and the control dispatching center as an example. The typical application systems are: (1) SCADA / FA system, which can automatically receive and store real-time data acquisition, and give real-time control issued instructions to the RTU equipment. (2) The equipment monitoring system, which can automatically receive, process and analysis the device status information. (3) WAMS / WAMAP system, which can automatically receive and store dynamic data of PMU. (4) The protection and analysis system, which can automatically receive and analyze status and actions information of the secondary device, output protection setting and security strategy adjustments. (5) Real-time fault analysis and trouble analysis systems, which can receive and analyze the fault recorder information in real time. (6) Intelligent Operation System, which can generate intelligent operation votes, and issue to the substation. (7) Dispatching telephone system, which can achieve interoperability and digital voice recording based on the digital dispatching telephone system. This paper analyzes the business specific data types between the substation and the control dispatching center.

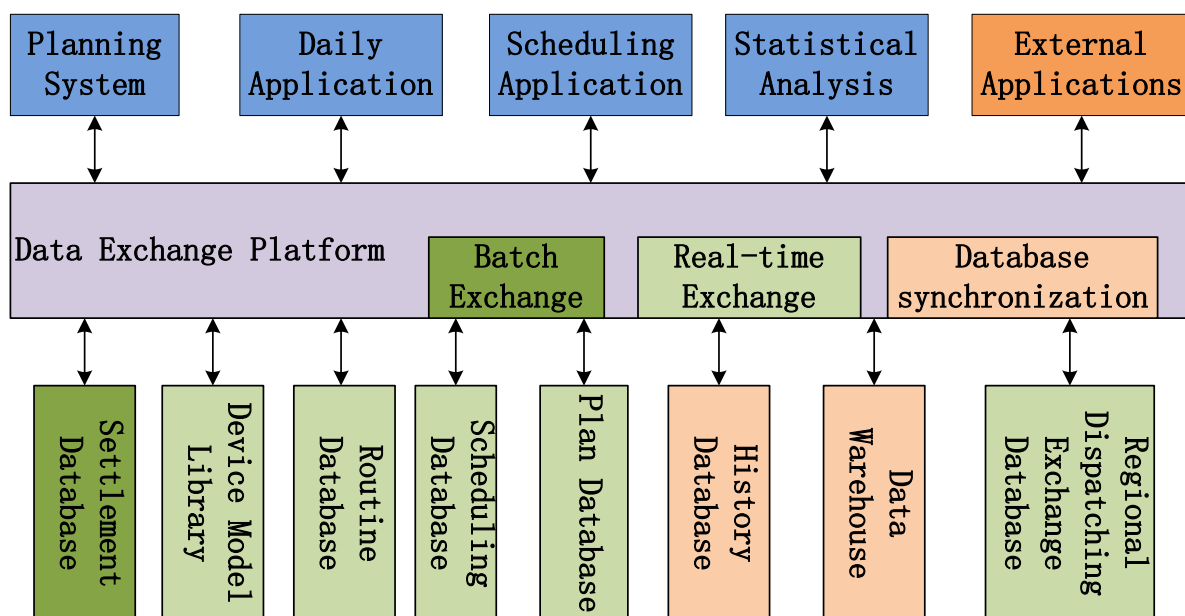


Fig2 Region scheduling data exchange platform

Table 1 The business data between substation and dispatching center

Information flow	Typical application system
Primary electric equipment data acquisition (substation →ADC)	
Real-time electric quantity: RTU collect primary electric equipment data, and transmit to the SCADA system	SCADA/HIS
Equipment state monitoring: use sensors to collect primary electric equipment state data, transmit to the equipment state monitoring system	Equipment state monitoring system
PMU data: PMU collects phase transient information, transmit to WAMS system	WAMS System
Secondary equipment data acquisition (Substation →ADC)	
State and action information: Protect substation collects and transmit to the dispatching center's protection analysis system	Protection analysis system
Fault recorder: Recorder data transmits from the station fault wave recorder system to the dispatching center real-time fault analysis system	Real-time fault analysis system and fault research center
Real time control (ADC→equipment) EMS transmit real time control command through SCADA to the RTU	SCADA
Dispatching instruction (ADC→ substation master control)	
Dispatching telephone: notify master control staff in substation dispatching station	Dispatching telephone
Operation order	Intelligent operation order
Protection setting	Protection analysis system

4 CONCLUSION

From the development trend of intelligent distribution network technology, the future network exists as energy internet to a certain extent. The concentrated energy (including nuclear power, hydropower, thermal power, gas power generation, photovoltaic generation and large-scale wind electric field) and distributed energy

resources (including distributed generation and energy storage system etc.) will be in harmonious coexistence. Electricity generation, transmission, transformation and using will coordinate with each other more. Energy will be able to flow efficiently and orderly bidirectional in the power grid, the basic carrier of which mainly rely on the energy storage system, and acts as energy "coupler", "balance" and "buffer" among electricity power generation, transmission distribution and using.

Therefore, we need to strengthen the strong network of distribution network construction, and analyze the operation characteristic of the energy flow, information flow and business flow in future distribution network. Design intelligent distribution network technology architecture, make scientific research to meet technical equipment requirement in various development stages, strengthen the technical evaluation and standardization construction, promote the combination of production, local pilot, and gradually promote, with strong network as the carrier, the intelligent network as a breakthrough,

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