Design of a practical substation equipment condition monitoring integrated system

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Abstract. Condition monitoring of substation equipment plays an important role for the safe and stable operation of power grid, aiming at the insufficient of existing condition monitoring system, a practical substation equipment condition monitoring integrated system is designed which adopts J2EE technology, SOA architecture to realize the B/S framework system, and the IEC61850 communication standard for data communication and access. This multi-functional integrated system can realize the data sharing and integrated display of all kinds of substation equipment condition monitoring and has the function of operation monitoring, fault monitoring, intelligent early warning and diagnostic analysis. The design principle, the overall technology architecture and the function of each part of this system are introduced in detail also.

Introduction

As an important part of smart power grid, Substation equipment condition monitoring is of great significance in ensuring the safe and stable operation of power grid and improving the management level of power grid [1].At present, the existing problems of power transmission and transformation equipment condition monitoring system mainly are[2,3]:1. Each state monitoring device has different function, different interface, and unified communications protocol, makes data sharing become difficult. 2. Management of monitoring data is very fragmented, system function is single, and implementation of substation equipment condition evaluation by making full use of all kinds of status information obtained from monitoring system is very difficult.3.The openness of system is limited and not suitable for secondary development. A kind of substation equipment condition monitoring system integration can realize all kinds of data sharing and has versatile functions is urgently needed.

The design principle and functional requirements of Substation equipment condition monitoring integrated application system

Design principles

As a part of the grid monitoring system, substation equipment condition monitoring integration system must take into account the compatibility and continuity of the subsequent development, so the following principles must be followed.1. normalization： The overall architecture of system should keep to the specifications of Grid Company and data access should follow the unified power grid company standard specification.2. Interaction and consistency： All the date including the collected on-line monitoring data, test data of high voltage management system, and equipment parameter data of basic parameter and safety production management information system, must be able to associate to each other and make sure which can be interacted with consistency. 3. openness： Database system must have good openness, support cross-platform transplantation and run, and module functions can be increased or decreased conveniently according to the need

System function requirement analysis

As a practical substation equipment condition monitoring integrated system, the system must meet the requirements of the following functions: 1. It can realize the sharing of data of various types of substation equipment on-line monitoring data, high voltage test management system and safety production management information system of equipment stand-books. 2. Realize the comprehensive display of condition monitoring data by various ways such as the GIS system interface and graphical interface.3. Versatile. The system should possess the function of operation monitoring, fault monitoring, intelligent early warning, diagnostic analysis, and can effectively realize monitoring and evaluations of monitoring data and the data transmission quality, subsystem or interface operation status, and has diversified alarm function.

Design of substation equipment condition monitoring integrated system

Choice of the system architecture

According to the system requirements, the existing popular software development system B/S architecture and C/S architecture [4-5] are investigated.

C/S mode is a kind of two layer structure system; the client application is installed on the client and server administration programs installed on the server. The client makes a request and the server returns the result after process. Its advantages are: 1. Applications and services are separated, system has good stability and flexibility; 2. System adopt the structure of point to point mode, safe and reliable; 3. the client and server is connected directly, response quickly. But in this mode, once the software system in server upgrade, the client should upgrade corresponding, make the system upgrade and maintenance is more complicated.

B/S mode, the browser/server mode namely. The browser software is installed on the computer of user, Service application and data is stored and installed on the server. The users implement information browsing, file transfer, electronic mail, and other services through the browser. Its advantages are: 1. Development, maintenance and upgrade is easy. When upgraded, only service application on the server should be upgraded, without having to modify browser software on the user. 2. Strong openness. 3. Easy to extend. This structure can be easily extended to large system from small system. 4. Easy to use.

At present, standard J2EE enterprise application development platform provided by SUN Company has get the favor of more and more developer [6]. J2EE architecture is divided into three levels, client presentation layer, logic layer and data management and application system, each level has good collaboration, and can meet the requirements of distributed management.

Service-oriented architecture (SOA) is a component model, it connect different functional units with good interface and contract, and make the system have good portability, scalability, and compatibility.

Considering the characteristics of power grid enterprises, the B/S structure, standard J2EE and SOA are chosen to establish the framework of system.

Choice of communication protocol

For existing substation equipment, due to the unified standard or specification, at different times, manufacturers develop their business systems alone, different data structure and technology, different communication protocols, different standards system. For example, the IEC61968 standard is widely used in the power distribution system, the IEC61970 standard is widely

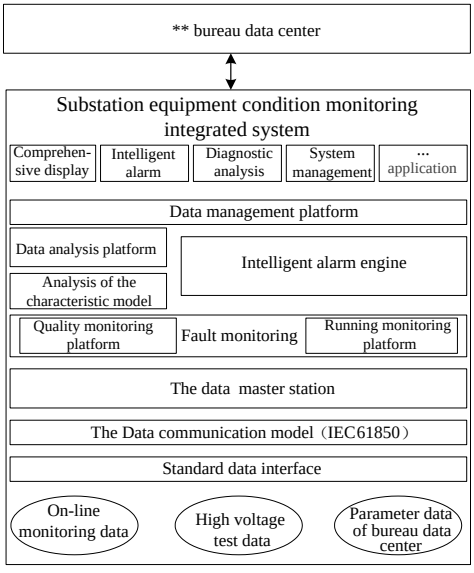


Fig.1 The overall frame of substation equipment condition monitoring integrated application system

used in dispatch center, and the IEC61850 standard is used in substation automation system. Once information sharing and interactive communication between each platform want to be achieved, unified communications protocol must be adopted[7].

Study those three agreements above, as the only international standard based on network communication platform of substation, IEC61850 standard not only absorbed the experience of IEC60870 series standard and UCA but also absorbed a lot of advanced technology at the same time, It has had a profound effect on the design of protection and control automation products of the substation automation system. And now, it is not only used in substation, but also applied between transformer substation and control center at all levels. Major power companies and research institutions at home and abroad are actively adjust their product development direction to meet the standards, to adapt to the development direction of the future.

So, our system selects IEC61850 communication protocol to realize the unified data storage and transmission format, build the multifunctional master station, simplify the structure, reduce the construction and maintenance cost, and increase the extensibility of the system.

Above all, the application system adopts J2EE technology, SOA architecture to realize the B/S framework and adopts the IEC61850 communication standard for data communication and access, make it has good stability, data sharing and good ability of second development.

The overall frame of the system

The framework of substation equipment condition monitoring integrated application system is shown in figure 1, it is made up by the data master station module, fault monitoring module(data quality monitoring platform, system operation monitoring platform), data management platform module, data analysis platform module, intelligent alarm engine module, intelligent inspection module, query statistics module, system and management module.

The system integrates all the relevant data in on-line monitoring system and high voltage test management, collects basis data based on IEC61850 standard through the data master station platform. at the same time, monitors data quality, and subsystem operation management through the quality monitoring platform and operation monitoring platform; extract and analyze the quantity of state data and characteristic data, implement primary diagnosis of equipment state through the data analysis platform; realize classification and unified warning points strategy of equipment, monitoring equipment and system operation through unified alarm engine; at last, display device status information, alarm information and diagnostic analysis Comprehensively through the data display platform, transmit data of the data master station to the higher level data center through external standard interface.

Function design and implementation of the main system

The data master station

The data master station is the unification of the data acquisition and integration, its structure is shown in figure 2. it collects data and monitors the status in the way of point to point through the TCP/IP communication and unified standardized interface; At the same time, obtains high voltage test data through the master station and high voltage test data management system interface; gets bureau parameter data and real-time data, transmits the monitoring data and the analysis data to the data center

The analysis platform of Data and characteristic.

Fig.2 The data master station platform

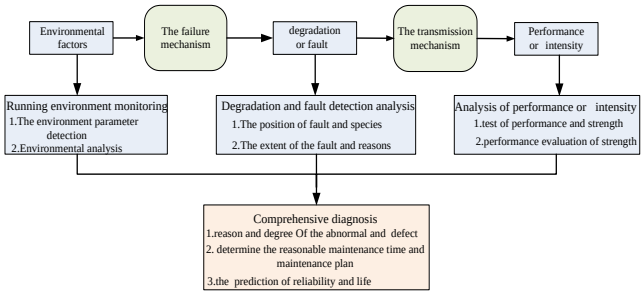
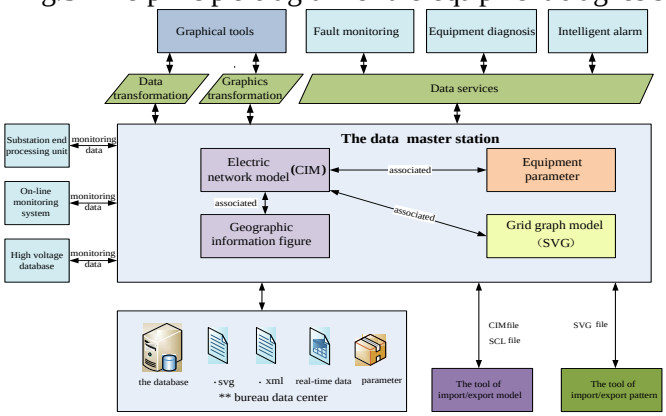


Fig.3 The principle diagram of the equipment diagnosis



The analysis platform is established to extract condition monitoring characteristics, and implement the preliminary diagnosis analysis of equipments; it is the core of the whole system, and includes two parts such as fault diagnosis and expert analysis.

The algorithms of fault diagnosis module mainly are three ratio method, neural network algorithm, the fuzzy analysis, decision tree method and comprehensive diagnosis and so on. It compares and deduces measurement data and past experience through all kinds of intelligent algorithm, and gets correct diagnosis conclusion, its diagnosis principle is shown in figure 3.

Expert analysis module mainly includes the monitoring analysis of transformer, insulator, circuit breaker, GIS device, lightning arrester, capacitive equipment and mutual inductor and so on. It makes a horizontal contrast analysis and longitudinal trend analysis of the historical data of the same equipment and the similar data of different equipments, and generates change trend chart automatically.

Quality monitoring platform

Quality monitoring platform is responsible for collecting the data integrity analysis, providing data quality checking rules, distinguishing data validity, and giving out an alarm of abnormal data source. It includes data quality detector, quality evaluation module and data quality panoramic view, etc., and interfaces to interact through a standard procedure

It is designed in modularization of SOA architecture, the extracted and analyzed data of the system is put into the data platform if it conforms to the rules of formal data, and while, the defected data will put into the list of dirty data for unified analysis and cause investigation. At the same time, the data and indicators of monitoring system, monitoring data code standard definition are put into quality monitoring platform, all data standards and index definitions are released and implemented by quality monitoring platform in order to realize the standardization and normalization of the data management.

Other platform module

Unified data management platform, is mainly responsible for data display, show the overall operation situation of substation in various ways through the GIS geographic information interface, SVG wiring diagram and configuration figure, and focus on the alarm display.

Running monitoring platform is responsible for monitoring the operation situation of each subsystem and data interface, giving out an alarm system anomalies if necessary.

Intelligent alarm engine module is mainly composed of unified warning center and auxiliary decision-making and alert processing of three modules.

Unified warning center generated alert after receiving the alarm information which was sent by the monitoring device, for the average, more severe, the most serious alert, supplemented by monitoring interface icon flash, sound and light alarm, Mobile phone short message alarm to those responsible respectively.

Auxiliary decision module, responsible for delivering the related information to the customer, assist users determine early-warning and make decision. And alert processing mainly includes the early warning and positioning, the confirmation and recovery, early warning history library, etc.

Conclusion

Aiming at the shortcomings of the existing monitoring system, a practical substation equipment condition monitoring integrated operation system is introduced in this paper, and its design principles， function requirements, system architecture, communication protocol, overall frame and main functions are expounded. The system has been used in some bureau, its construction and use promote the intelligent level of power grid.

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