Research on power system scheduling method based on cross-platform sharing

FengKai Lin\textsuperscript{1a*}, YanRong Li\textsuperscript{1b}, YaWei Liu\textsuperscript{1c}, LingXiao Chen\textsuperscript{1d}

\textsuperscript{1}School of Electrical and Power Engineering, China University of Mining and Technology, Xuzhou, Jiangsu, 221116, China
\textsuperscript{a*}17184981@cumt.edu.cn, \textsuperscript{b}lyr199904@163.com, \textsuperscript{c}17184973@cumt.edu.cn, \textsuperscript{d}17184928@cumt.edu.cn.

Abstract—As a large, complex system with wide distribution and high real-time, the safe, stable and reliable operation of the power system is inseparable from the power automation system. In this paper, an in-depth study is conducted on the key issues of this solution in the process of software cross-platform integration around the EPRI graphic center method, combined with the power data interface standard. The dispatch center graphics system and the dispatch center power graphics application method are discussed in detail in the paper. In addition, the paper also explains the online calibration system for relay protection ratings with smart grid dispatching technology support system. The methods and sample systems in this paper have been practically applied in large scale power grid dispatching centers, providing a reliable guarantee for the safe and stable operation of the power grid.

1. Introduction
With the development of information technology, automation system is changing the production and life style of human society. In recent years, in response to the call of the State Grid Corporation to build a strong smart grid, the automation system application software at all levels of the dispatch center is gradually integrated into the domestic security operating system platform, and the process of replacing the old and new systems inevitably requires data exchange operations between heterogeneous systems. Graphic information, as an important part of heterogeneous information sources, often has higher complexity in extraction, matching, reorganization and use than conventional text and digital information [1]. In recent years, in order to build a strong smart grid, the State Grid Corporation has gradually integrated the grid dispatch center software system to a domestic security operating system platform and adopted a national standard unified graphics and model description specification. Numerous application software need to be upgraded in order to adapt to the new system platform and new data specifications [2]. Therefore, it is very important to propose a cross-platform sharing and application method for grid dispatching center graphic information, focusing on the complexity and special features of graphic information in the cross-platform integration of application software.

2. Construction and Geometrical Dimensions of Specimens
In order to solve the problem of incompatible graphic systems for various independent applications in the field of power system, the IEC61970 series of standards are adopted for the power grid dispatching center, and the public information model CIM is developed into the power system data model description language CIME and the power system graphic description language CIM/G in practical applications. The graphic system of the dispatching center graphic system exists in the form of text files, containing
graphics, graph elements, data, charts, interval templates and other types, distributed in directories at all levels of the operating system graphics folder. When users use the smart grid dispatching support system, according to the front-end operation, the system calls and parses the corresponding files in real time, and forms a display interface on the front-end for grid dispatchers to view and use.

2.1. Graphical Data Structures
Dispatch Center graphic files follow uniform naming rules to distinguish different graphics, commonly used naming forms such as: (name) + (. attribution) + (. type) + (.g) + (suffix). The naming rules use a segmented description format to characterize the role of graphics files in the overall graphics system through different information segments.

Graphics files are mainly distinguished by the type of folder in which they are located, and a specific folder contains a collection of graphics files of the corresponding type, which are further classified internally according to hierarchy (e.g. sys, In, fac) or device (e.g. transformer, generator). The standard graphics file *.g is usually found in pairs with four files *.g.h, *.g.data, *g.png. The three files with suffixes complement the information in the *.g file when it is called from the Dispatch Center platform.

2.2. Model data structure
The dispatch center data model file is stored in a different form than the graphical file, it exists as a single text file based on CIM/E language blind description, which internally follows XML rules and divides each sub-table by tags to correspond to the model description of different types of data.

Although there are some differences in the table names and the list of object attributes in the tables of model information of different dispatch centers, the specifications used by each dispatch center have a good consistency in the commonly used model tables. Usually there are a dozen to several dozen tables in a model, and the model information they contain can be divided into three categories: topology tables, which express the main topological relationships between different control area city plants and stations connected by AC line segments; equipment tables, which describe the basic attributes of equipment and some equipment data; and data tables, which describe the detailed power data, and this part of the tables has the largest amount of information and the most complex types. This part of the table has the largest amount of information and the most complex types, and occupies more than half of the model file, with tables of global variable types and specific data returned by various types of collection devices.

Generally, the size of the model file varies from a few MB to several hundred MB, with certain differences depending on the level of the dispatch center and the composition of the information tables.

3. Dispatch Center Power Graphics Application Method

3.1. Scheduling Center Graphics Application Principles
The resolution and application method of scheduling center graphics proposed in this paper will be built around the core of EPRI's graphics center sharing scheme. The graph centric method, in which the model object, the graph object and the description rules of the graph are first exported from the source system when the graphs are exchanged, and then the graph object references the model object to associate with the target system data, and the description rules are referenced so that the graphical information can be correctly expressed in the target system. the "graph centric" around which the sharing scheme described in the EPRI graph centric method is built The "graphics center" around which the sharing scheme described in the EPRI graphics center method revolves is the generic SVG format graphics information exported from the source system's dedicated graphics information through conversion. However, even if the exported graphics are generic, they still require targeted processing when integrated into a standalone application software graphics system. Therefore, this paper simplifies the process of exporting from the source system by eliminating the conversion process and focusing on filtering useful information and improving transfer efficiency.
Fig. 1 Scheduling Center Graphics Application Principles

The process of dispatch center graphics application is divided into two steps: the parsing of power graphics and the attachment of application data.

The core research of power graphics parsing is the conversion of CIM/G graphics information dedicated within the dispatch center into generic SVG information, where CIM/G elements, graphics and models are separated and only generated in real time by the software platform at the time of display. Referenced graphics, such as elements and interval templates, need to be parsed into predefined objects in SVG format and stored in the form of files or objects first; when parsing the topology graphics, the predefined types of referenced graphics are placed according to the corresponding coordinates and reference marks to complete the graphic representation.

The topological graph with grid alone is not enough to show the complete independent application information, and needs additional application data [4]. The application data are used to find the corresponding graphical elements through the model and then to express the data. Since there is inevitable variability in the description of the same power element by different software, the data of the independent application needs to be matched with the CIM/E model for the name of the heterogeneous system first. After determining the correct data of each component, the corresponding graphic elements are linked according to the mRID in CIM/E and Keyid in CIM/G, finally forming a complete graphic system representation for the front-end display of the stand-alone application software.

3.2. Integrated construction of power graphics
This section describes the integrated construction of power graphics for graphic systems. The SVG file format, as an open graphic format standard based on XML language, is compatible with JavaScript, CSS and other web technologies, and is capable of presenting complex content and achieving the requirements of flexible interaction. To use it for power system graphics, it is also necessary to design the functional structure of the generated SVG file by combining the expression characteristics of power graphics.

(1) Basic display of graphics
Canvas definition: The content at the beginning of the file up to the <svg> tag line is the canvas definition for the SVG. This section explains to the browser that this is an SVG graphic, and describes the namespace and canvas size, display mode, and other basic properties that the graphic contains.

Template definition: The content of the <defs> tag is the template definition part of the graphic display, each <symbol> tag represents a display template. The content of <symbol> tags is not directly reflected in the SVG graphics, but only by post-reference will the graphics described by its content be displayed in the specified location. Templates described above can only be referenced below, so the <symbol> tag of the basic power graphic element comes before the <defs> tag in accordance with the
reference dependency. The `<symbol>` definition of the interval template is started only after the definition of all basic power graphs is completed.

Topology drawing: The content in the middle of the template definition end tag `</defs>` to the SVG file end tag `</svg>` is the comprehensive drawing area of the SVG file, and each tag in this area corresponds to the graphical related display and function. The representation of power topology graphics is realized in this section.

(2) High-level features of graphics

File link: The high-level topology graph needs to be interlinked with the low-level topology graph, for example, click the corresponding drawing element in the high-level topology graph to jump to the low-level topology graph, and click the outgoing line of the low-level topology graph to jump to the high-level topology graph. The file link is based on the `<a>` tag, and uses the extended action feature of SVG to identify the linked file by the xlink:href attribute, so that mouse click events can trigger the jump between graphs.

Application data appending: Application data appending finds the corresponding power components on which complex information processing can be performed. Processing can include changing the display properties of existing graphics, adding new text, new templates or new drawing information, and even creating advanced effects using tags such as `<animation>`, giving full play to the extensibility of information in the SVG format.

Feature extensions: SVG also supports JavaScript and CSS features. External JavaScript scripts can be used to extend the interactive properties of SVG, such as infinite zooming with the mouse wheel, free dragging and dropping of graphics with the mouse, etc., to allow users to better navigate power graphics. Through the embedded CSS style rules description, it can replace the complex style attribute and use the unified class attribute to standardize the style information of the corresponding voltage level of the text or line to enrich the content of the graphic display.

(3) Graph construction process

![Fig.2 Power graphics integrated construction process](image)

The first to be resolved is the drawing element class file. The `<symbol>` template information is generated by the basic graphical element for reference by other graphical files: the interval template references the basic graphical element and adds new drawing information to generate the `<symbol>` composite template information [5]. The topology graphics are generated sequentially from the lower level to the higher level, referencing the meta template information, attaching application data, linking related graphics, adding advanced features, and finally forming a collection of SVG files with power graphics information, which together form a new graphics system.

4. Cross-platform Integration of Relay Protection Calibration System

4.1. Online calibration system for relay protection calibration

Based on the real-time data of the power system, the online relay protection calibration system can solve the accuracy problem of offline calibration calculation under the situation that the scale of the power grid is increasing and the operation mode is changing frequently. After acquiring the topology of the power grid, real-time operation mode cross-section and other information, the system monitors and
calibrates the field value information of the relay protection devices in the power grid online, and makes online calibration calculations to give advice on the modification of the value, and realizes online warning of the relay protection value.

Online operation mode acquisition and pre-processing module provides online operation mode for calibration calculation. This module obtains the operation mode data from the dispatching center in real time, and matches the data with the calibration calculation system to determine the current operation mode of each power component in operation or out of operation, forming the mode information for calibration calculation.

The module is responsible for obtaining the name of the plant and station, the name of primary equipment, the name of protection devices and fixed value items, and the calculated fixed value, and determining the name correspondence between the calibration and calculation system and the online calibration system through automatic identification by software or manual intervention to form the fixed value information for calibration and calculation.

4.2. Smart grid dispatching support system

Previously, China's power automation system was completely dependent on foreign operating systems, which could potentially threaten the security of important information systems in China. In order to
ensure the security of power grid operation, the smart grid dispatching technology support system adopts the operating system Galaxy Kylin (KylinLinux), which is completely developed by China. Since the Linux operating system is fundamentally different from the Windows operating system, the runtime library and platform environment of application software have also been changed. With the adoption of a domestic operating system, the independent software supporting various types of power automation applications needs to be integrated cross-platform to ensure continued operation. As an advanced standardized platform, the smart grid dispatching technology support system adopts a standardized real-time data model, and considering the development trend of power automation system integration, the graphics system of each independent application software tends to combine with the graphics information of the dispatching center in the cross-platform integration process.

In the future, the intelligent dispatching system should adopt the general idea of horizontal integration of various applications, and safely integrate the traditional energy management system, wide area vector measurement system, dynamic warning system, dispatching plan system, electric energy measurement system, water condition and water transfer automation system, protection management and fault information system, lighting positioning monitoring system, dispatching management system and other ten sets of independent application systems in the dispatching center into an integrated platform [6]. The platform mainly consists of four categories of applications, such as real-time monitoring and early warning, dispatching plan, safety verification and dispatching management, realizing application integration within the dispatching center and supporting panoramic monitoring and analysis of various operation information such as steady state, dynamic and transient state of the power grid.

5. Conclusion

It is of great theoretical and practical significance to study the cross-platform sharing and application methods of graphic information in power grid dispatching center to ensure the availability and efficiency of power graphic information in the process of software system upgrading. In order to meet the needs of various types of power business in different periods, proprietary power system application software needs to be developed and used continuously, and integrated integration and interoperability of multiple systems is the development goal of integrated power system automation. Although this paper has proposed the sharing and application methods for the graphic information of the dispatching center, more in-depth work is needed for the practical implementation of the application integration of the dispatching center, and the contents worth studying include:

1. Information standards among dispatching centers need to be further unified.
2. Open interfaces for independent software and provide interface use cases will facilitate more complete application of graphic information in dispatch centers.

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