Maintenance technology of substation source end based on IEC61850

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***Abstract*—The source maintenance of data is the basis of the integrated construction and standardized operation of power automation system, and it is an important way to avoid repeated data transmission and improve the integration of automation system. In view of the current situation that the information demand of dispatching section and substation end is not equal, this paper decomposes the SCD file of substation, removes the irrelevant data of dispatching end, reconstructs the SCD file of main station and substation, and constructs the multi service unified data model of the whole station at the plant and station end. In order to improve the operability of source end maintenance, this paper adopts the file transmission and dynamic number based on IEC61850 The data set function realizes the key file transfer, subscription and publishing process, greatly reduces the intermediate mapping and maintenance process, and improves the source side maintenance stability and efficiency. The technology shown in this paper has been put into engineering operation in Guangdong power grid company, and the effect is good in the trial operation stage, so as to improve the efficiency of joint commissioning of infrastructure stations.**

Keywords—Source maintenance; substation; IEC61850; communication

I. INTRODUCTION

At present, the old IEC61850 standard is used to model the new intelligent substation, but because the dispatching center model is based on iec61750 standard, there are differences between the models, which makes it difficult to achieve interoperability. So how to ensure the unification of data models at both ends has become an urgent problem for the development of smart grid.

The intelligent substation adopts IEC61850 standard to realize the unified data modeling of the whole station, which makes the data source maintenance possible. To realize the source side maintenance, it is necessary to unify the data model in the configuration and maintenance of the substation side. The dispatching side only needs to import and use the data model directly, and finally realize the unification of the model. However, the SCD file contains the complete data of each voltage level, while the data content concerned by the dispatching center of different levels is different. Sending the SCD file completely not only wastes the network resources, but also the dispatcher chooses the data he needs, which wastes more time. Therefore, if the information content has been extracted on demand before the SCD file is submitted, the efficiency will be greatly improved. This paper focuses on this problem, and realizes the selection and extraction of SCD files according to voltage level, which provides some reference for the development of source maintenance.

II. COMPARISON OF SUBSTATION AND DISPATCHING TERMINAL MODELS

At present, most of the station models are based on the common information model CIM based on IEC61750 standard at the dispatching system end,. The model of dispatching terminal pays more attention to the detailed information of all primary equipment and the relationship between primary and secondary equipment; the description of relay protection, wave recording, online monitoring and other models of secondary equipment is deficient.

For the dispatching terminal, the data volume of IEC61850 substation model is too large. If the telecontrol device uploads all the substation data to the dispatching center through IEC 61850 standard, it not only occupies the bandwidth, but also contains too much redundant data, which increases the workload of the dispatching terminal.

Therefore, it is a necessary process of source maintenance to compare the information of dispatching terminal and substation side and eliminate unnecessary information of dispatching. See Table 1 for the comparison between substation model and dispatching terminal model.

TABLE I. COMPARISON BETWEEN SUBSTATION MODEL AND DISPATCHING TERMINAL MODEL

Model type	*substation*	*dispatch*
Primary equipment model	contain	contain
Secondary equipment model	contain	lack
Acquisition model	contain	contain
Control model	contain	contain
Communication model	lack	contain

According to table 1, secondary equipment model is not important but complicated.We can analyze the SCD

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file, eliminate the secondary device information, and then upload the schedule in a unified format, so as to ensure the feasibility of source side maintenance.

III. PARSING AND FILTERING OF SCD FILES

A. Analytical method

There are mainly DOM (document object model) parsing methods and SAX (simple API model of XML) parsing methods for XML file parsing. Sax is based on the analysis of event flow, moving through each node from the beginning of the document to locate a specific node. DOM is based on the parsing of XML document tree structure, which establishes the type description for the document nodes loaded into memory. In the end, these descriptions present a laterally mobile, potentially huge, tree like structure. According to the actual needs of SCD file parsing, the characteristics of SCD file are not very big, and the advantages of DOM parsing method, this paper selects DOM interface based on Java language to parse SCD file, and completes the extraction process.

B. Filtering process

The analysis and filtering process of SCD file is to complete the tree expansion of the file, the comparative analysis of the file and the filtering output of the final new SCD file.

The tree structure expansion of the file makes use of the DOM parsing method in Java language. This method reads the SCD document and creates a DOM tree. The DOM tree is implemented by firstchild nextsibling tree. There are many methods defined in the Java language, which are used to get the parent node, child node and sibling node, insert, replace or delete nodes, or get node characteristics. The root node of DOM tree is a document instance; the list of child nodes includes 1 DocumentType (representing DOCTYPE declaration), 1 element (representing root element of document), Processing Instruction node and comment.

The comparative analysis of files is to reconstruct the read SCD files and generate a new structure tree that meets the requirements. In the process of reconstruction, the structure node is reconstructed through the map Association container in Java. For the data model (such as redundant communication model) which is not needed by the dispatcher, we can traverse the communication model of SCD file, find out the unnecessary child nodes according to the keywords, and delete the node elements. For elements that do not need to be changed, copy them directly into the new structure tree to complete the modification of SCD files.

Based on the modified DOM tree, the filtered output file splits the DOM tree of SCD file again according to different voltage levels. The SCD file of a substation should contain different voltage levels. In the process of filtering, first query the attribute value of voltagelevel1 element, then filter and extract the file according to the different attribute values, and generate a new SCD file with the same voltage level, named :* * substation * * kv.scd.

C. Software implementation

Before using java to parse SCD files, we should clarify the functions of specific code. First, read the SCD file and generate a DOM tree before parsing the SCD file. In the Java language, the root node of the DOM tree is a document instance. The Java language's javax. XML. Parsers. Documentbuilder interface provides the parse () method, which can parse a given file into an XML file and return a new domdocument object. Read the SCD file through the parse () method to generate a DOM tree.

In the process of parsing files, the data structure of the tree needs to be defined in advance to generate a new structure tree. The SCD file structure has been analyzed above, and the root element in the DOM tree generated by it is SCL. The root element also contains header, substation, IED, com, datetypetemplates and other elements. Each element contains the attribute attr, its related child elements and text elements. Through traversing SCD documents, the data structure information of substation model is obtained, and a basic model tree is generated in memory according to the structure. By querying the model tree, we can know which equipment (such as TCTR,XSWI, etc.), which voltage level (such as the attribute value "220kV" of voltage level), and the connection mode between equipment, etc. are used in the substation.

Finally, we need to complete the screening of SCD files and generate new SCD files with the same voltage level. The specific steps are as follows:

1) Enter the header node from the root node SCL, obtain the version information, and copy it to the predefined SCD structure tree;

2) Get the substation node element, get the name attribute and desc attribute value of its child node Voltagelevel element, and compare with the preset value. If the attribute value is the same, copy all contents under the Voltagelevel element to the new structure tree, and get the interval device name attribute under the voltage level;

3) Read the communication node element, because the communication model generally does not contain voltage level devices, so the node element is directly copied to the structure tree;

4) Read IED node elements. Each substation generally contains multiple ied node elements. For different ied devices, it is necessary to read the interval devices accessed by its communication access node. If the interval does not belong to the voltage level, its child nodes shall be deleted. Through this operation, the IED nodes are filtered, and the filtered node elements are copied to the structure tree;

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5) Finally, read the datatypetemplates node element to get the attribute ID of its child node lnodetype. If the child element contains the definition of the deleted part, delete it, and then copy it to the structure tree.

The overall process of traversal filtering is shown in Figure 1, and the UML diagram of the program is shown in Figure 2.

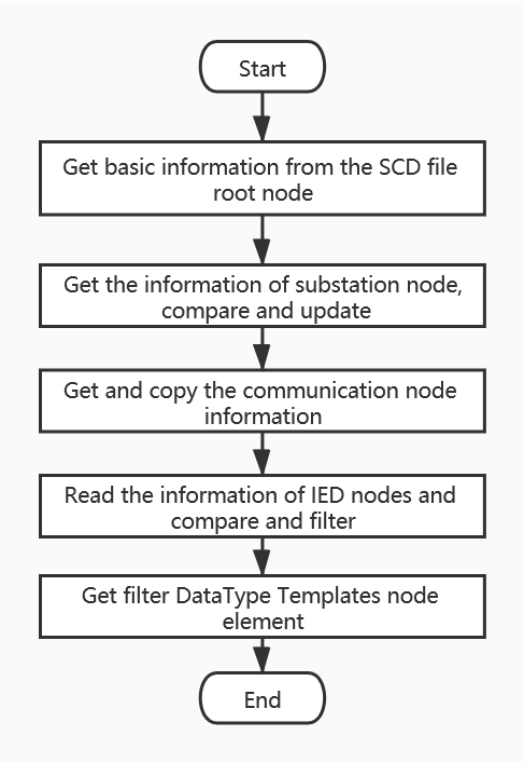

Fig. 1. General flow chart of traversal filtering.

Through the above five steps, the SCD file for the voltage level file is basically filtered. Finally, the copied DOM structure tree is output to generate a new SCD file named "* * station.xxkV.scd". Figure 2 shows the structure of the program.

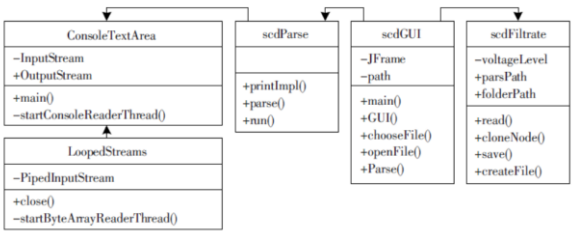

Fig. 2. UML diagram of Java program

IV. MPLEMENTATION SCHEME OF DATA SOURCE MAINTENANCE BASED ON IEC 61850

In the III chapter, through the SCD file selection, the consistency of substation and dispatching information is achieved, which lays the foundation for the source end maintenance. This chapter mainly introduces the implementation scheme of source maintenance.

A. Implementation of data source maintenance

After the master station obtains the drawing and model files generated by the station, it completes the model splicing and drawing import, and automatically generates the substation equipment table, measurement signal table and other relevant parameters. IEC61850 is taken as the outbound station of source data The protocol, making full use of IEC61850 dynamic data set technology, can simply and conveniently apply these data models and graphs formed by the substation in the dispatching end, complete subscription and release and realize data maintenance free.

According to the standard configuration file, the dispatching (control) center automatically parses and imports it into its own system database to realize the shared modeling of the plant station and the master station. The main technologies involved are: IEC61850 and IEC61970 model conversion technology, master station model splicing technology, graphic layering and automatic mapping technology based on SVG Standard format, data exchange point table customization and link automatic reconstruction technology, and model version management technology. Maintain the corresponding relationship between the substation model and figure, telecontrol communication protocol data point table, master station model and figure at the substation end, and simplify the engineering configuration and debugging.

After the communication protocol is changed from IEC60870-5-104 to IEC61850, SCD and ref files are added to the original SVG and CIM files. In order to maintain downward compatibility, try to reuse the files shared by the original implementation and the original process, and keep the format unchanged. IEC61850 communication can be established by the sub station in the station level ied when modeling, and then through the change of this point, trigger the master station to issue the command to call the corresponding file, so as to realize the source side maintenance file delivery at any time.

B. Difficulties and solutions of source maintenance

The III chapter unifies the information model through the SCD file screening, but considering that the data model involves multiple business systems, how to achieve the distributed source end maintenance, unified use, unified management, complete the top-down and bottom-up combination of policy maintenance and use of data model is the difficulty of source end maintenance and how to maintain the uniqueness of each system data model is more important .

In the metadata of the global model, it is associated with organization and professional system according to object type and attribute. The following methods are adopted to ensure the unique source and accuracy of maintenance information:

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a) Only one business system is responsible for creating objects and data, which are referenced by other business systems;

b) The creation of the object shall ensure that the source is unique. For example, the transformer object shall be subject to automation, the protection device shall be subject to the maintenance of the protection department, and the registration center shall assign a unique ID;

c) The model parameters shall be guaranteed to have unique sources, for example, the static parameters shall be maintained by automation, and the transient parameters shall be maintained by mode

The business model needs to be verified in the business system to ensure that the data in the professional scope is correct, and then submitted to the working version of the panoramic model for consolidation and global verification.

C. Implementation flow of data source maintenance

The implementation of the source side maintenance method based on IEC61850 can be summarized into five parts: file transfer, model/graph verification, model/graph import, data filtering / subscription publishing and start data transfer.

1) File transfer

The information exchange flow of source maintenance based on IEC61850 is shown in Figure 3.

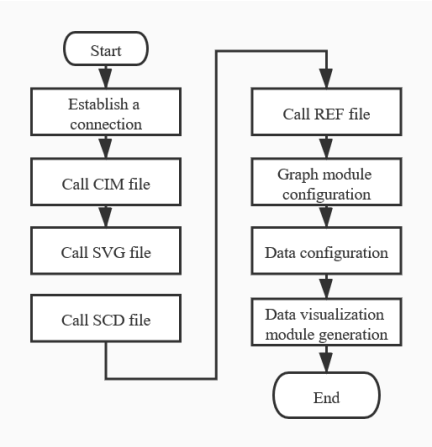

Fig. 3. Source maintenance flow based on IEC61850 wide area communication

2) Model/Graph verification

The master station needs to verify the validity and rationality of the received CIM and SVG files. CIM model verification tool and SVG file verification tool shall detect the model and graphic files provided by the substation end, which shall meet the requirements of IEC61970. The master station shall check whether the SVG graphics meet the SVG Standard. After the verification is passed, the CIM file and SVG file shall be converted into the master station graphics and model parameters.

When the model files are exported and imported, the topological connection and state estimation calculation shall be verified in combination with the measurement information. After the validation test, the model and its corresponding database, image, index table, etc. can be put into online operation.

3) Model/Graph import

The graphics system provides the function of import and export. Based on the standard entity file provided by the master station, including the primary entity such as circuit breaker, disconnector and transformer, the standard entity is imported into the local graphics system by using the SVG import function, saved into the local file format, and the display of the standard entity of the local system is completed.

If there is error information in the process of parsing SVG graphics file or in the process of conversion, clear prompt should be given.

4) Data filtering / Subscription publishing

The master station can realize the flexible configuration and dynamic management of substation model and data through subscription and publishing service. After the verification and import of the diagram module, the dispatching end often does not need to subscribe to the complete data of the substation, but hopes that the substation can provide dispatching related data. In order to reduce the traffic and avoid unnecessary information transmission, it is necessary to filter the information sent on the sub station, and inform the front server of the filtering results to complete the configuration of relevant parameters.

Subscription publishing is a dynamic subscription to the data concerned by the dispatcher based on the source maintenance. The main implementation method of source maintenance is to provide the data relation file of the substation. The dispatcher can obtain the complete IEC61850 standard data model of the whole substation and the corresponding relationship between IEC61850 standard and CIM based on this file, but the relation file can not be modified dynamically. This can be achieved through the dynamic data set of IEC61850 standard. The dispatching end selects the concerned data based on the complete model to form the data set of IEC61850 standard. The data set is distributed through the dynamic data set service of IEC61850 standard. The telecontrol device updates the data sent to the dispatching center based on the new data set , complete the subscription publishing function.

In order to complete the data set customization, the IEC61850 client of the dispatching center provides the createdataset and deletedataset services. The dispatching center uses this service to complete the reorganization of the required data. The reorganization of the data set needs to be completed in the subscription publishing logical device. The subscription publishing logical device model needs to provide enough report control blocks to meet all client requirements. The data set corresponding to the

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report control block is generated and specified online by the client.

5) Start data transfer

After the master station publishes the filtered data, the IEC61850 server can re establish the association between the report control block and the dynamic data set through the interface call, so that the selected report control block can start the normal data transmission.

V. CONCLUSIONS

Based on IEC61850, the substation source end maintenance technology has been deployed in Guangdong power grid company. Through commissioning and acceptance, it is found that the source end maintenance technology can maintain and dispatch the master station system from the substation end and reduce the joint commissioning pressure. The results of batch experiments show that the method has good stability and can avoid the wrong modification of the main station by means of artificial confirmation. During the operation period, the effect is good and the process of configuration and commissioning of infrastructure project is simplified.

ACKNOWLEDGMENT

Thank for the endorsement of the project:Science and technology project of Guangdong Power Grid Co., Ltd （No.032000KK52180063）.

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