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CIM-based Data-sharing Scheme for Online Calculation of Theoretical Line Loss

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Abstract

This paper presents a new CIM-based data-sharing scheme for online calculation of theoretical line loss. The proposed method can read data from other applications which are being used in electric power company, such as electrical SCADA, Power Distribution Network GIS, DMIS, and so on. Moreover, the calculation model, which is used in theoretical calculation of line loss, is formed automatically. Users no longer need to manually input the structure data and operation data of grid. The operation data are updated from the DMIS and the SCADA continually, and the structure data are changing according to GIS and SCADA. Main electric wiring diagrams are also consistent with GIS and SCADA. Compared with conventional approaches, the proposed implementation can cut down the requirement of time and energy that line loss management must spend in maintaining the original data of calculation.

Keywords: CIM; Calculation of Theoretical Line Loss; Data-sharing; Online Calculation

1. Introduction

Line loss rate is an important technical and economic indicator in power industry. It not only reflects the rationality of the network structure and operating mode of power system, but also provides some reference information about reducing the line loss for planning department and operation department. Nowadays, computer has become very popular, and generally speaking, calculation of theoretical line loss has been accomplished by software. However, the line loss software was an isolated system on the whole in the long-term work of line loss calculation. Managers of line loss have to spend considerable time and energy in inputting original data. According to the statistics mentioned in [1] and [2], data collection and maintenance take up more than 80% of all workload of line loss management. Furthermore, because it is difficult to maintain the network structure model in time, conventional software can't calculate the line loss accurately and real-timely.

With the rapid development of information technology, power system automation has achieved

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constant improvement. Most of electric power companies have installed various management applications, such as the SCADA/EMS, the GIS, the DMIS, and so on. They have relatively perfect functionalities and could provide real-time data of power system. Therefore, it is attracting many researchers to study how to calculate line loss using those applications' resource. The reference [3] offers an approach to use the data of the GIS; the references [4~6] are successful in making use of the data of the SCADA and the DMIS. In general, these methods above provide useful help for this issue, though they neither have made full use of other applications nor form a complete data set that is required in calculation of theoretical line loss.

In this paper, a new CIM-based data-sharing scheme is presented. It fully uses SCADA, GIS and DMIS through Extensible Markup Language (XML) documents and Scalable Vector Graphics (SVG) files. Users don't need to input original data manually again, because the calculation model of line loss is formed automatically. It contributes to decreasing the workload of line loss management.

2. The CIM of Power System

2.1 About CIM

The CIM is the abbreviation for Common Information Model. It is one of the IEC 61970 series which define an application program interface (API) for an energy management system (EMS) and is based upon the work of the EPRI Control Center API (CCAPI) research project (RP-3654-1). The CIM is an abstract model that represents all the major objects in an electric utility enterprise typically needed to model the operational aspects of a utility. This model includes public classes and attributes for these objects, as well as the relationships between them[7].

Due to the size of the complete CIM, the object classes contained in the CIM are grouped into a number of logical Packages, each of which represents a certain part of the overall power system being modeled. The comprehensive CIM is partitioned into the following packages for convenience: Core, Domain, Generation, Generation Dynamics, LoadModel, Meas, Outage, Production, Protection, Topology and Wires.

Figure 1 shows these packages and their dependency relationships. The dashed line indicates a dependency relationship, with the arrowhead pointing from the dependent package to the package on which it has a dependency.

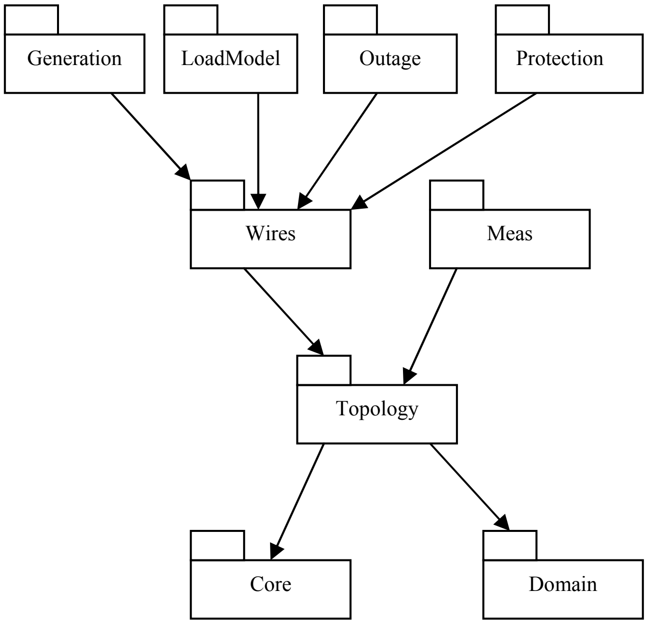

Figure 1 – CIM Part 301 Package Diagram

For most application software of power system, there are four packages usually used. They are Core, Wires, Meas and Topology. The Core package contains a lot of containers, which make it possible to manage power objects differently, although it does not define any equipment. This package does not depend on any other package, but most of the other packages have associations and generalizations that depend on it. The Topology package is an extension to the Core Package that in association with the Terminal class models Connectivity which is the physical definition of how equipment is connected together. In addition it models Topology that is the logical definition of how equipment is connected via closed switches. The Wires package is an extension to the Core and Topology package that models information on the electrical characteristics of Transmission and Distribution networks. This package is used by network applications such as State Estimation, Load Flow and Optimal Power Flow. The Meas package contains entities that describe dynamic measurement data exchanged between applications.

2.2 XML Document

XML is a kind of markup language for electronic document with structural information. It is the specified document type of CIM. In fact, the support to XML is also a part of the IEC 61970 series [8,9].

3. The design of data-sharing scheme

In order to form a reasonable scheme, we have made a survey of the software environment of Nanning Power Supply Bureau (NPSB). We find it has been equipped with the SCADA, the GIS and the DMIS. The structure data and most operation data of main network, whose voltage level is above 35kV, are stored in the SCADA. The GIS has the latest structure data of distribution network, while the DMIS has collected a little operation data of main network and all of distribution network. Therefore, we have designed the following scheme of data-sharing.

3.1 Acquisition of main network data

Because the SCADA is a system with extremely high security requirements, we must make sure at first that it is completely safe for the SCADA system to read data from it. The proposed method will not bring any threat, because line loss program downloads the latest main network data from Safety Third District, not Safety First District.

According to relevant provisions, calculation of main network should use the method of power flow. Therefore, besides the main electrical connection diagrams, it is necessary to fetch electrical equipment's parameter data, logical connection of equipment, switch state, transformer tap position and the operation data of each bay, such as the current, the voltage, the active power and the reactive power. We put these data into two types. The first one, named structure data, is relatively stable. They have little changes. There is no need to read such data again, unless some change has taken place. Equipment's electrical parameter data, logical connection of equipment and the main connection diagrams are all of this kind. The other one, named operation data, contains switch state, transformers' tap position, the current, the voltage, the active power and the reactive power. This kind of data changes frequently. They must be read in real time.

In practice, the SCADA could provide three formats of data files: SVG, XML and DT. The main electrical connection diagram is stored in SVG files, the structure data is stored in XML files, and the operation data is stored in DT file which follow the E language specification.

3.2 Acquisition of the structure data of distribution network

The GIS make us have access to the latest and most exhaustive information of distribution network except its operation data. So in this scheme, line loss software could only pick distribution network's structure data from the GIS, such as equipment's parameter data and their logical topology in XML format, one-line diagrams and electrical connection diagrams in SVG format. It is obvious that these data are relatively stable.

3.3 Acquisition of the operation data of distribution network

The DMIS is the important complementarities of the SCADA and the GIS. The DMIS contains all distribution network operation data and a little operation data of main network, such as main grid power supply, port capacity, power consumption of special transformer, power consumption of public transformer, user information, the operation data of special device, and so on. Unlike SCADA and GIS, DMIS opened a read-only user for line loss program. So line loss software could read directly these data from the database of DMIS.

Here, a CIM-based data platform for calculation of theoretical line loss could be formed. It is easy to save the data with a special structure to line loss database or documents in XML format. The data flow through the whole process can be shown as figure 2.

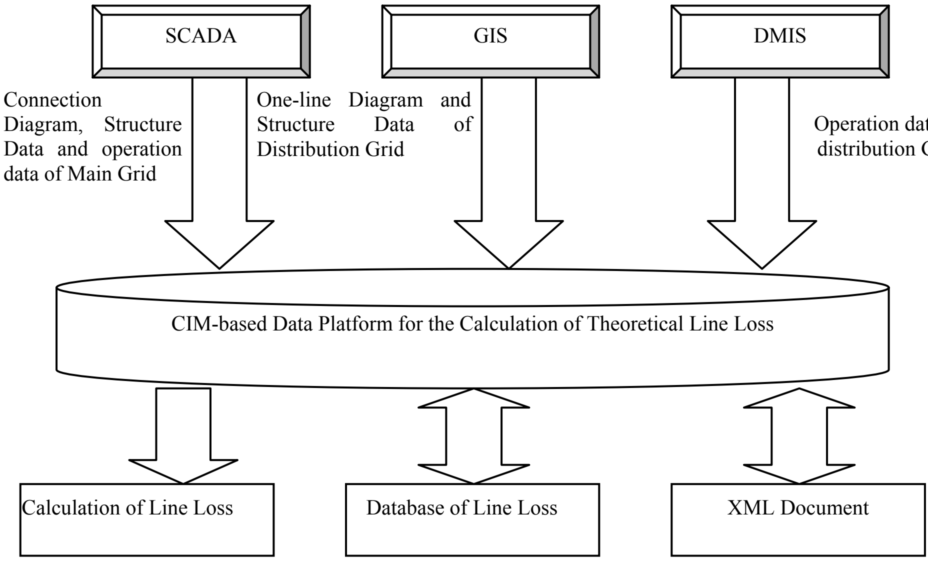

Figure 2 – Data flow diagram

4. Implementation

4.1 Development environment

In this project, we develop the Line Loss Software in the integrated development environment of Microsoft Visual Studio Team System 2008 Team Suite. We use the built-in language C#, which has a detailed XML programming interface. With the help of "xml" namespace, XML document is very easy to operate.

4.2 The whole process

The proposed process may be described as follows:

- Initialization. In this step, certain system parameters will be set. These settings tell the program where to read the SCADA, where to read the GIS, and where to read the DMIS. Besides, they also tell the program which database calculation result should be write to and where the output file in XML format should be placed.
- Read data from the SCADA, the GIS, and the DMIS. It is vital to read selectively from the SCADA, the GIS and the DMIS. At the same time, it would be better to make a check on those data that have just been picked up.
- Topology analysis. Further discussion will be given in part *C* of this section.
- Parameter conversion. The equipment parameter data and the operation data power system are original and they are usually not the value we except. For example, a record of AC line segment in the CIM may be its length and its parameters of unit length, but what we need is just the

resistance and the reactance of whole branch. The transformer parameters also need to convert. In addition, it is very popular to convert all original data into the per-unit system.

- Look for correct bus node for operation data. In respect that the operation data and the structure data are stored separately, it is indispensable to look for correct place to place operation data. When it comes to node branch model, this is of more importance.
- Form final data structures and fulfill them. Last but not least, defining special data structures and fulfilling them is essential so that calculation program could use directly.

4.3 Topology analysis

In the CIM, there are five classes related to the connection relation between electrical equipments. They are the Terminal, the ConnectivityNode class, the TopologicalNode class, the TopologicalIsland class and the ConductingEquipment class. The relationship between them can be briefly described as figure 3.

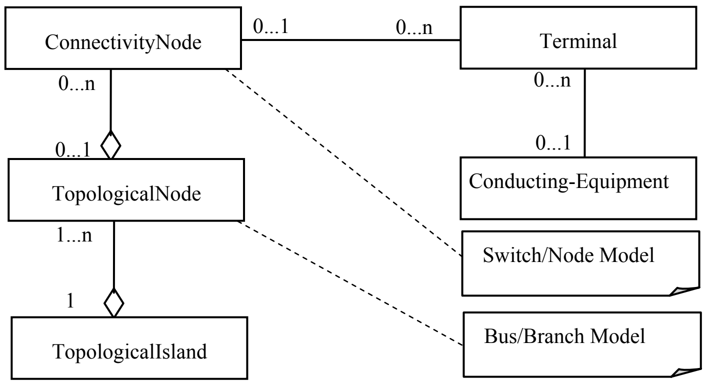

Figure 3 – The Simplified diagram of Topology classes

What we get from the SCADA and the GIS is just the physical definition of how equipment is connected together in switch/node model, not the logical connection in bus/node model which calculation program except. The target of topology analysis is just to translate the switch/node model into the bus/node model.

We have used the algorithm named Connection Node Merge Method (CNMM) to complete topological analysis. The basic idea of CNMM is to merge the two nodes of a switch whose state is closed until that all switches have been handled. The last remaining connection nodes are just the logical bus nodes. Afterwards, it continues to process specially T junctions of lines, transformers, compensators and power exchange lines. At last, a perfect bus/branch model will be founded formally. The flow chart of topology analysis could show as Figure 4.

4.4 Notices

When it comes to application, there are at least three problems which we should pay attention to.

a) In most cases, the SCADA, the GIS and the DMIS are supplied by different companies. Each company has its own understanding of the CIM. Thus, normally, there are discrepancies between various

XML files. This fact reminds us to offer a robust algorithm for all cases.

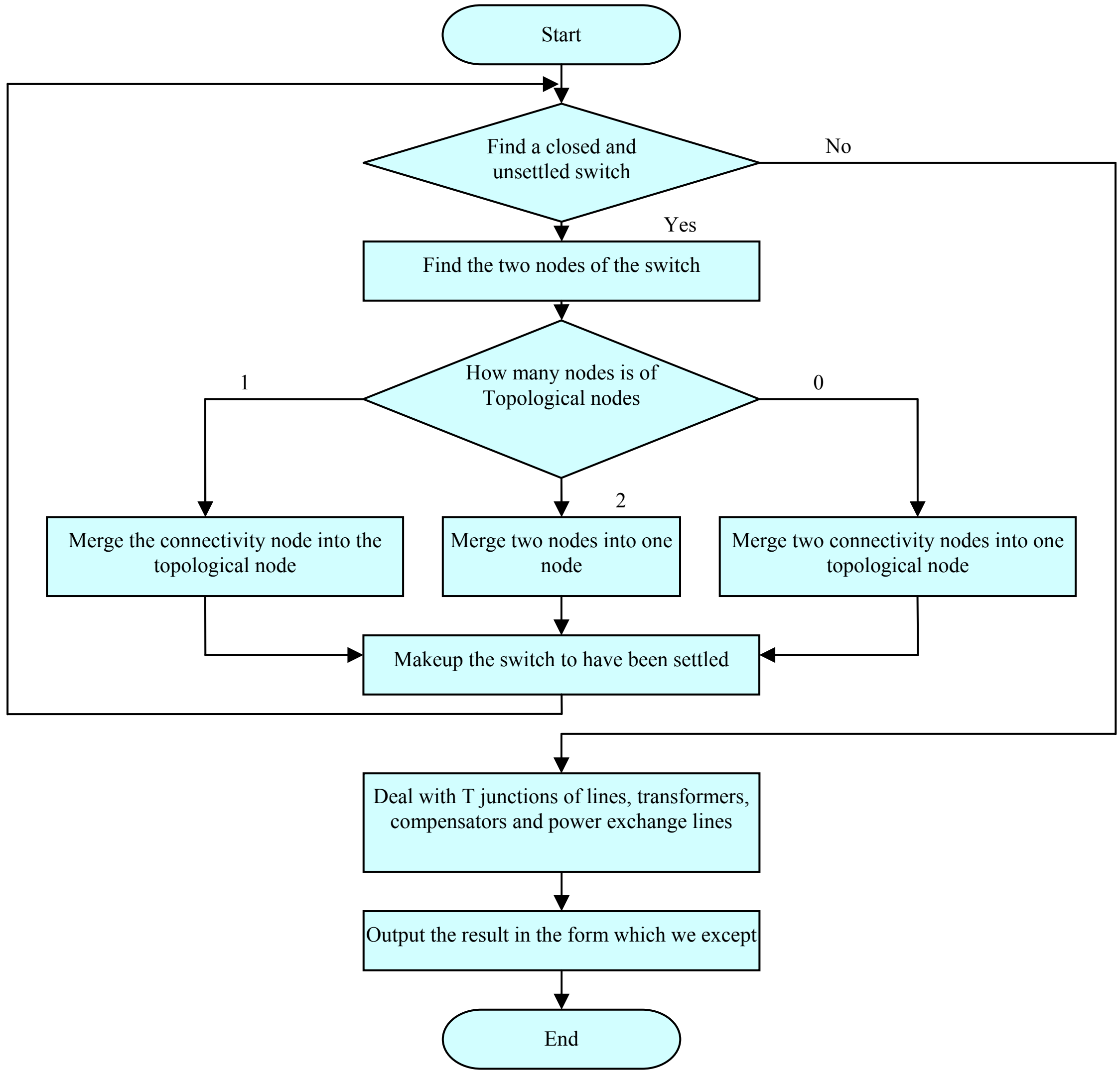

Figure 4 – Topology analysis flow chart

b) It is not easy to find the correspondence among these data from different systems. Careful studies on each system should be made.

c) The telesignal data, which is used to indicate the states of switch, may be incorrect for all kinds of reasons. So does the telemetering data. Therefore, all data are in the need of preprocessing before topology analysis and other calculation.

5. Engineering Application

Scheme proposed in this paper was applied in Online Calculation of Theoretical Line Loss Project of

NPSB. In the old line loss calculation software of NPSB, users need draw the electric wiring diagram, input grid structure data and operation data manually. In spite of the using of the integration technology of Graph, Model and Database, which made it relatively easy to query and maintain the gird's parameters, the old software was an isolated system and could not make use of the data from other applications. Besides, it was difficult to keep its data concordant with the real power system. Strictly speaking, it could not satisfy the requirement of online calculation.

As soon as the new software system put into practice, managers of line loss do not need to face the fussy work of drawing electric wring diagrams. They have the capacity to avoid inputting large amount of data of power grid. What they had to do is to run the program and set a series of environment parameters. The data sharing from other systems makes sure that the data is synchronous and concordant with real system. What is more, the workload is largely cut down. Thus, users can spend much more time and energy in formulating solutions to save energy, to optimize grid structure, and to improve power quality and the power supply reliability.

In conclusion, CIM-based data sharing scheme is of very good value in engineering. It provides data support for the implementation of online calculation of theoretical line loss.

Acknowledgment

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References

[1] Xiutai Yang, "Theoretical calculation and analysis of power line loss," China WaterPower Press, Beijing, May 1985(In Chinese).

[2] Xueqi Liao, "Calculation and analysis of rural line loss and its reduction measures," China WaterPower Press, Beijing, August 2003(In Chinese).

[3] Min Wen, Xuejun Xu, Fang Chen, "GIS-based implementation solutions of line loss in transmission and distribution grid," Computer Engineering, vol. 29, No. 8, pp. 161–163, May 2003(In Chinese).

[4] Xiaosong Li, "SCADA-based implementation method of online calculation of theoretical grid line loss," Yunnan Electric Power, vol. 36, No. 3, pp. 5–6, June 2008(In Chinese).

[5] Jun Wang, Zheng Guo, Jianping Yu, "Practical Calculation Method of Theoretical Line Loss in 10kV Power Distribution Network Based on Dscada" Electricity Distribution, 2008. CICED 2008. China International Conference on , pp. 1–6, August 2009.

[6] Decheng Wang, Yan Chen, "A study on GIS-based Model of theoretical calculation of line loss," China Water Transport, vol. 8, No. 8, pp. 122–123, August 2008(In Chinese).

[7] DL/T 890.301-2004/IEC 61970-301:2003, Energy management system application program interface (EMS-API) Part 301: Common Information Model (CIM) Base, National Development and Reform Commission (In Chinese).

[8] Yong Jin, Qiaoyan Xu, Zhongxiao You, "Constructing Common Information Exchange Model with CIM and XML for EMS," Electric Power Automation Equipment, vol. 22, No. 4, pp. 45–47, April 2002(In Chinese).

[9] Chongru Liu, Hongbin Sun, Boming Zhang,Yue Dong, Yaozhong Xin, "An Investigation on Common Information Model for Energy Management System," Automation of Electric Power Systems, vol. 27, No. 14, pp. 45–48, July 2003(In Chinese).