A New System Of Operation Ticket For Generation and Misoperation Prevention in Smart Distribution Network

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***Abstract*—A solution of switch operation ticket system is proposed to improve its versatility and maintainability. The object - oriented expression mode is used in the single - line chart modeling to realize its automatic initialization. The manual operation ticket generation is implemented by equipment selection and operation selection. According to the operating rules of distribution network, the reasonable verification against misoperation is carried out. Like the way of experts' thinking, the syster separates the primary equipment operation from the secondary equipment operation and realizes the automatic operation ticket generation. The layered operating rule templates are adopted, the operating rules are classified according to equipment type and saved in database, and the excellent man-machine interface is provided for modification. The system is convenient for ticket generation, easy to be maintained, and works accurately, which has been successfully applied to a municipal distribution network.**

Key words—distribution network； operation ticket； dynamic rules； object-oriented； man-machine interface

Ⅰ. INTRODUCTION

The operation ticket of distribution network is an effective measure of guaranteeing operation and management of the electrical power system safe. The problems of the maintainability and the versatility of the distribution network had still not been solved very well. At present, promoted work of the electrical network operation ticket expert system has been slow, and its primary cause is that the existing operation ticket system has not achieved good maintainability and versatility. The common shortcoming of the paper[4-7] is that the operating instruction is solidified in the procedure, and the user is not easy to maintain the operating instruction. The common shortcoming of the paper[8-10] is that it's quite complex to establish the relations of the equipment with the frame theory.

The merit of this system lies in the object-oriented turn of expression, which abstracts the first equipment into class and simultaneously takes the second equipment as data member of the class to seal in the kind. Moreover, it uses the dynamic template rule and it's easy for user revision. At the same time, this system has realized sharing real-time data with the SCADA system, writing a ticket automatically or manually, the good justice against miscarriage and the simulation demonstration function. Now the system has already been applied successfully in the Jiujiang distribution network.

Ⅱ. SWITCH OPERATION TICKET GENERATION AND MISOPERATION PREVENTION SYSTEM FOR DISTRIBUTION NETWORK

This operation ticket system contains operation ticket production module which contains functions of writing the ticket automatically and manually, line diagram cartography module, graph simulation demonstration, flow process verification and so on. The Structure of the system is shown in Figure 1.

Ⅲ. THE PRODUCTION OF THE OPERATION TICKET

The production of the operation ticket is a quite complex process. The production process of the operation ticket contains synthesis utilization of the network analysis situs, the traversal way, the operating instruction and so on. There are two ways about the generation of the operation ticket: Automatic production and manual production. This system simultaneously has the function of the automatic order and the manual order. The production process of the operation ticket of this system will be introduced from four aspects in the following.

A The analysis situs models of the line diagram

The equipment of the distribution network includes the switch, the knife switch, the box that is controlled, the ring net cabinet, the distribution transformer and so on. These equipments on the line diagram are primitive. The equipments of the distribution network include the serial name, voltage class, nominal current, whether to be separated and so on attributes. How to express the primitive is a question which we must consider.

The rule of production pattern is one kind of very natural knowledge expression form, has the accurate nimble

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characteristic, but the expressed object is simple and the rule is unable to describe the complex object effectively; The semantic network is the diagrammatic representation of the knowledge excelling in expressing static relations between the thing; The frame is one kind of multiple structure semantic network, and can describe the complex thing effectively. But the object-oriented knowledge expression is one kind of ideal knowledge expression form, which takes the abstract data type as the foundation, can describe the static characteristic, the dynamic behavior and the interaction of the complex object, conveniently and has the merit of the above general knowledge method of portrayal[11].

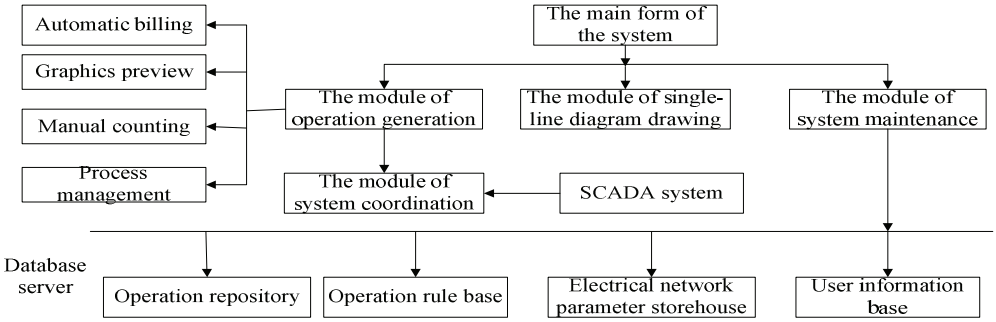

Figure.1 The integrated function diagram of the operation scheduling system of distribution network

Considering numerous merits of the object-oriented expression method, the system uses the object-oriented expression method, abstract the primitive of the line diagram to the kind and take the serial number, the name, whether to be separated and so on attributes as the attribute of the kind[12-13]. Thus, when the condition of the equipment is to be changed such as the switch is to be transferred from the closed state to the disconnected state, we just only need change the attribute of a switch. It's very convenient to express so.

Here a question must be considered that whether it's necessary to abstract all primitives of the line diagram to the class. We discovers that the operation sequence in the ticket only involve 4 kinds of equipment :the switch, the knife switch, the box which is controlled, a ring net cabinet, as well as the attached knife switch, the knife switch attached to earth and so on second equipment[14-15] , but the box which is controlled and the ring net cabinet may also decompose finally into the operation of the knife switch and switch, namely each kind of operation can be completed only to carry on the operation to the related switch, the knife switch and second equipment. Therefore, it's not necessary to abstract the bus bar and the transformer and so on first equipment into the kind alone, but only to abstract the switch to one kind, and abstract the knife switch as another one kind. As the operation of each kind of second equipment, like "separating the knife switch that is attached to some switch" and so on, is the supplement or the coordination of the switch and the knife switch, to carry on the highly effective inference, therefore seal all second equipment as the data member in a corresponding equipment class, but abstract the kind not alone.

The connection relation of the equipment in the line diagram, namely the analysis situs model of the line diagram is an important question which must be considered. The analysis situs model is related with the speed and the fit and unfit quality of the algorithm when traversal. As the survey of the equipment and so on geography information has been stored in the database, this system draws the equipment of the distribution network automatically through the coordinate of the equipment, and carries on the analysis situs initialization. If the analysis situs initialization is correct after the judge of the procedure, the result of the analysis situs initialization will be reads into the database. The information such as serial number, the direction of the electric current is saved in the database.

B Generating operation order from operation phrase

The generation of the ticket manually in this system is completed by the operation of the point and chart. The equipment operations of this system are divided into the simple operations .which include separating the switch, closing the switch, hanging up the caution sign and so on., and the complex operations, which include transferring the movement, transferring spare, transferring the overhaul and so on. The complex operation will be decomposed into certain simple operations after procedure analysis. When the user has chosen equipment and single-clicks the right key menu, the procedure will carry on the judge to the type and condition and so on attributes of the equipment, and thus demonstrate the corresponding menu. If the user has chosen a closed switch and single-clicks the right key menu, the procedure will demonstrate "separating the switch, transferring spare, transferring the overhaul" and so on menus in the right key menu after certain judgment. Here the menu had mainly demonstrated the operation movement and has not demonstrated other information of the equipment primitive. When some operation menu has been clicked, the system will obtain the name of the equipment according to the serial number of the selective device, will then obtain the link or the ring which the equipment is in, and will thus generate operational order. The operational order is composed by four items: the operation verb, the line name, the equipment name, and the device type.

Moreover, as a result of certain reason, certain operation is hard to be produced by the operation of the

point and the chart, thus the operation can be produced through inserting operation order in the sequence of operation form. The method of inserting the operation order is: When the user clicks the menu "insert operation order", a window will spring. The run order can be generated by choosing the link which the equipment is in, the equipment name, the initial state, the final state in the window.

C The justice against miscarriage of each step order

As the computer replaces the human to write the operation ticket, it's not only necessary to enhance the efficiency of writing the ticket, but also necessary to enhance the accuracy of writing the ticket. Therefore, in the operation ticket system, whether the operation ticket is correct or not is one of important conditions that whether the system is successful. Therefore, it is essential to carry on the justice against miscarriage to the operation ticket. The justice against miscarriage of the operation ticket must defer to the operating instruction of the distribution network. For example, the knife switch cannot pull gathers when having the load, the switch and the attached knife switch must be operated according to certain operation sequence when separated and closed. The flow of the justice against miscarriage that this system carries on to each step of the step order is shown in Figure 3.

D Generate operation ticket automatically

The generation of the operation ticket by the system automatically is a comprehensive job. The analysis situs, inference way, and so on factors must be considered in the generating process of the operation ticket. Here, imitate the way of the expert pondering the question. The operation sequence of the first equipment is considered first, then, the operation of the second equipment is added. Such system succinct of knowledge arrangement is clear and sprightly. The flow that the system generates operation ticket automatically is shown in Figure 2.

After obtaining the operation ticket, the user may carry on the simulation demonstration in this system. In the simulation demonstration, if he finds the problem, the user then carries on the correction and will print the operation ticket after confirming the operation ticket is right.

IV. THE REALIZATION OF THE OPERATING INSTRUCTION TEMPLATE

An operation ticket is an operation set of instructions that change running status of the related equipment according to the specific equipment, the specific operation duty, the working instruction of distribution network, and standard operation terminology. Therefore, we may think the operation ticket is composed by the operation object, the operation duty, the operating instruction and the operation terminology[16]. The operation objects include all the first equipment and second equipment that may be operated in the distribution network; the operation duty include all the operations which are carried on to the lines and the equipment in the distribution network; the operating instructions refer to certain operations that should be followed when carrying out some operations. The operation terminology refers to the expression of these operations. And the operating instructions play an important role in the operation ticket. The operating instruction is the basic strategy that guarantees the safe operation in the electrical network. The formulation of the instruction operation sequence, needs to make unifies with movement condition of the real-time electrical equipment, the wiring way of the electrical network and the protection.

As the structure of distribution network is complex, the formulation and consummates of operating instruction unceasingly become an important question of distribution network. Therefore, this system proposes one kind of operating instruction template of lamination, corresponding with the different kind of equipment operating instruction. At the same time, this operating instruction template may be maintained by the user.

The operating instruction template is divided into five kinds of the line, the switch, the knife switch, the controlled branch Box, the ring net cabinet according to the device type. And each kind can be divided according to the operation duty, the related equipment, the initial state and the final state. Take the line as an example to explain the design of layered templates as shown in Fig 4.

After having designed the operating instruction template, the user may have the custom-made regular template according to the characteristic of distribution network, and may form rule storehouse to be supplied for the quotation of the concrete equipment. The system has provided the function of choosing the device on the wiring diagram and developing the operation duty. The procedure may carry on the topology analysis according to the operation duty, seek for the related wiring and equipment, and carry on the inference through the operating instruction, and finally produce the operation ticket that conforms to the request. Regardless the simple operation duty or the complex operation duty, it can use the regular template to product corresponding regular storehouse dynamically, moreover the template technology of the dynamic operation rule is easy for the user to realize the rule revision and the consummation. This way enhances the versatility of the system.

V. APPLICATION EXAMPLE

This system has obtained the application in the Jiujiang distribution network. After the movement test, it indicates that the production time of the operation ticket through the normal automated reasoning is less than one second. The production time for the operation ticket that has many steps and complex content is less than three second. The user may complete the graph examination and the analogue function of the operation ticket. The system may increase the serial number automatically for the operation ticket, carry on the storage and management, and preserve the related ticket information such as the person of writing the operation ticket, the time of writing the operation ticket, the serial number of the operation ticket, the content of the operation ticket and so on. And it may inquire according to the people

that write the ticket, the time of writing the ticket or the serial number of the operation ticket; simultaneously the module of printing can be customized fully consistent with the operation of the site ticket form according to the needs of users.

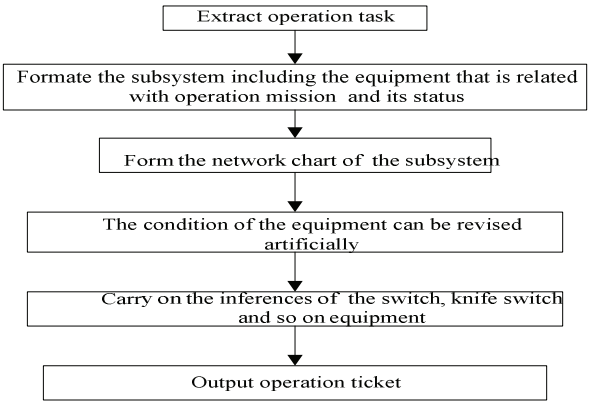

Figure.2 The flow chart of the system automatically generating operation scheduling

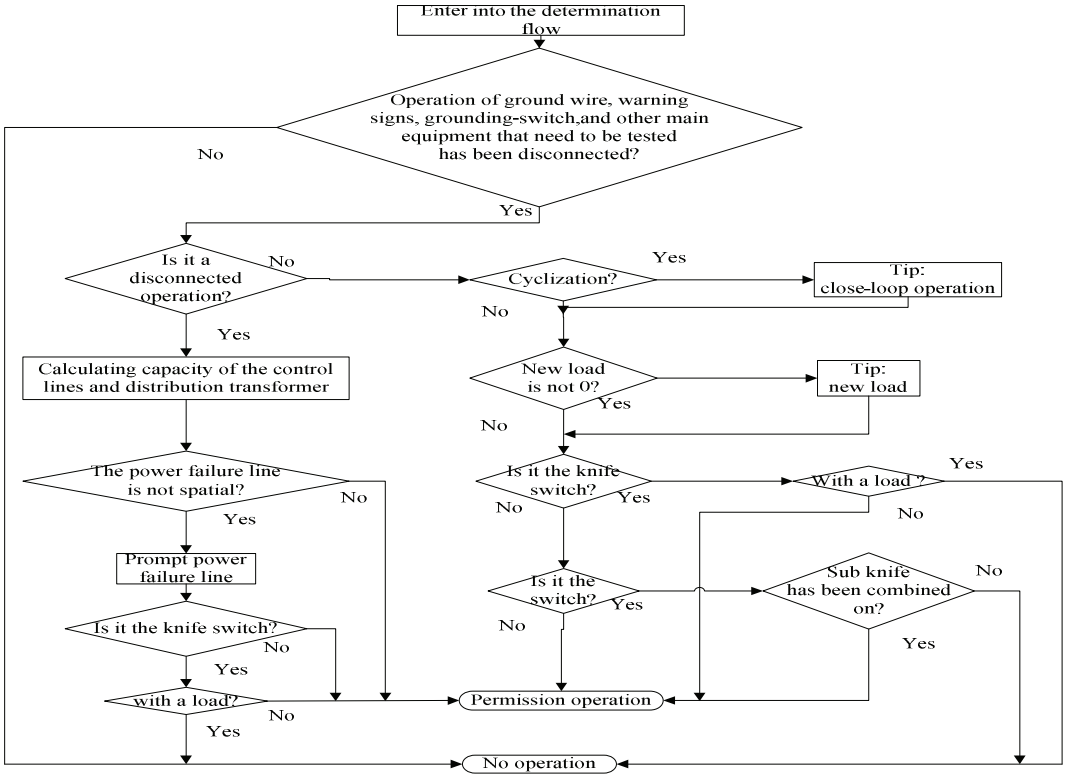

Figure.3 The flow chart of determination against misuse of the operation scheduling system of distribution networ

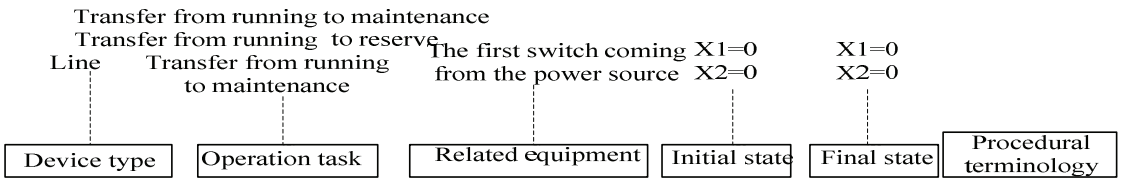

Figure. 4 The template structure of lamination operating rule of the line

VI. Conclusion

The main features of this system are: object-oriented expression may facilitate the expression of the characteristics of distribution network objects; it's easy to operate when automatically generating the operation ticket is combined with manually generating the operation ticket. It has greatly enhanced the accuracy of billing that the judge against disoperation is appropriate for the situation. The stratified dynamic template rules are easy for the user to maintenance.

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