

Development and Application of Urban Grid Fault Event Management System

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Keywords: energy management system; grid fault; intelligent modeling; expert system.

Abstract. The existed energy management system (EMS) grid model and fault information is relatively perfect, which realizes automatic synchronization of data in areas I and III. Urban grid fault event management system is designed and developed for this purpose. It locates at safe area III, using data of EMS to realize automatic analysis and diagnosis for grid fault event, and equips with functions such as whole-process business control, automatic release and statistics etc. This paper set forth overall architecture of system, main function and key algorithm.

Introduction

Grid fault is main factors that affecting grid safe and reliable supply of power. There are many facts that can cause tripping operation of grid equipment, consequently it is significant for grid to operate safely and steadily that related business department taking effective measures, reducing the probability on trapping operation, lessening workload on fault event processing and finding the regularity and tendency on its occurrence by using automatic judgment, flow processing and statistics and analysis on fault event.

In recent years, with rapid development of regional economy, regional grid size continuously expanding, grid fault frequency increasing, and fault causes showing to be diversified, grid fault event statistics and analysis workload increasing, labor intensity of production personnel at all levels are greatly increased. From current situation of grid fault event management, grid management department at all levels mainly rely on manpower to carry out decision, report and statistics and analysis on grid fault event. This mode mainly has the following problems:

(1) Grid model information of EMS and real time fault information haven't been fully used to automatically diagnose grid fault event. The intelligent degree is low.

(2) Because grid fault event is reported through manpower, misinformation, underreporting and late report etc. exist. That affects accuracy of statistics and analysis.

(3) Dispatching personnel need to inform support staff by means of telephone or text message when there is grid fault, which on the one hand affects fault processing efficiency of dispatching personnel, on the other hand, support staff can't understand grid fault condition at the first time. So power supply service level can't be improved.

(4) Because of secondary security of power dispatching, EMS system and daily business control system is isolated from each other for a long time, and grid real time analysis results can't be used to improve automatic degree of daily management work. That on the one hand increases workload of business control personnel, and on the other hand causes that data source of EMS can not be fully used.

Present on-line EMS system owns the newest and most complete grid model data and real time fault information data to realize the automatic synchronization of data of I area and III data, and its information conforms to IEC61970 standard specification. It can realize interface and sharing between EMS data and other systems' data. Through connecting III area grid model data of EMS and fault information into grid fault information management system, this paper realizes automatic diagnosis of grid fault event, uniformly standardizes grid fault events processing procedures, improves timeliness and accuracy of analysis, statistics and notice of fault events. That is significant to grid fault risks control.

Through developing, implementing and applying urban grid fault event management system, this paper set forth the overall architecture, key technology, functional composition and practical application of the system.

System architecture design

Urban grid fault event management system is deployed at safe area III, so we can both obtain grid model and real time fault information from area III WEB server of EMS by means of FTP, and publish analysis results to coordination work platform and text message platform by means of WEBSERVICE, thereby realizing effective integration of real time monitor and daily management business. Relation graph of urban fault event management system and other system is showed as Figure 1.

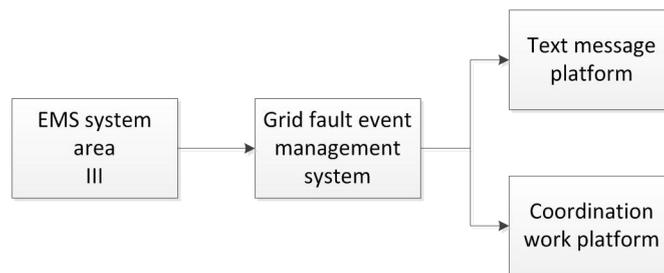


Fig. 1 Relation graph of urban fault event management system and other system

Based on software system architecture, urban grid fault event management system employs C/S and B/S hybrid architecture which contains five levels: interface layer, analysis layer, management layer, evaluation layer and publish layer. C/S architecture mainly realizes grid fault event analysis diagnosis, and B/S architecture mainly realizes grid fault event whole-process management, statistics and analysis and human-machine Interaction. This is showed as Figure 2.

1) Interface layer: interface layer follows CIM/XML and E language standard specification, obtaining grid model data and real time fault information from WEB system in area III of EMS.

2) Analysis layer: achieving analysis diagnosis for grid failure equipment according to grid model topology and grid real time fault information, automatically generating grid fault event report.

3) Management layer: having process permission definition function to realize whole-process management of grid fault event.

4) Evaluation layer: carrying out statistics, analysis and evaluation of grid fault event in a particular period, finding out occurrence regularity of grid fault event.

5) Publish layer: publishing grid fault event to coordination work platform and text message platform via WEBSERVICE.

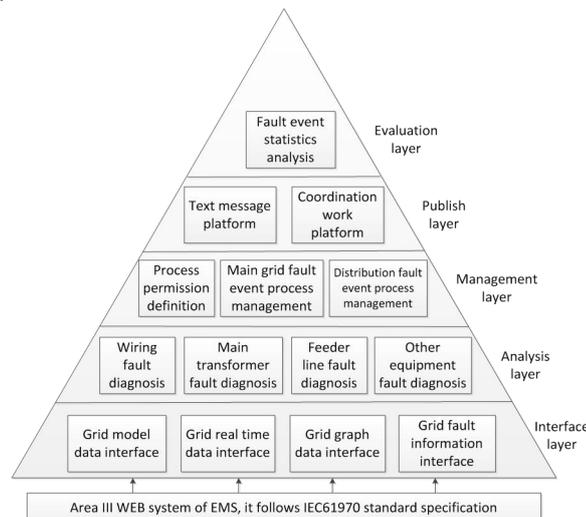


Figure 2 Grid fault event management system architecture

System function design

According to the need of grid fault event analysis diagnosis and management operation flow, this system can be divided into five main functional modules, which are showed as figure 3. Grid fault event diagnosis module includes two sub modules, which are fault event diagnosis knowledge base and transmission transformer and distribution equipment fault event diagnosis, and grid fault event process management module includes two sub modules, which are graphical process permission definition and grid fault event whole-process management. Interface that connected to the third party system includes interface that connected coordination work system and interface that connected text message platform. Specific functions of each module are introduced as bellow.

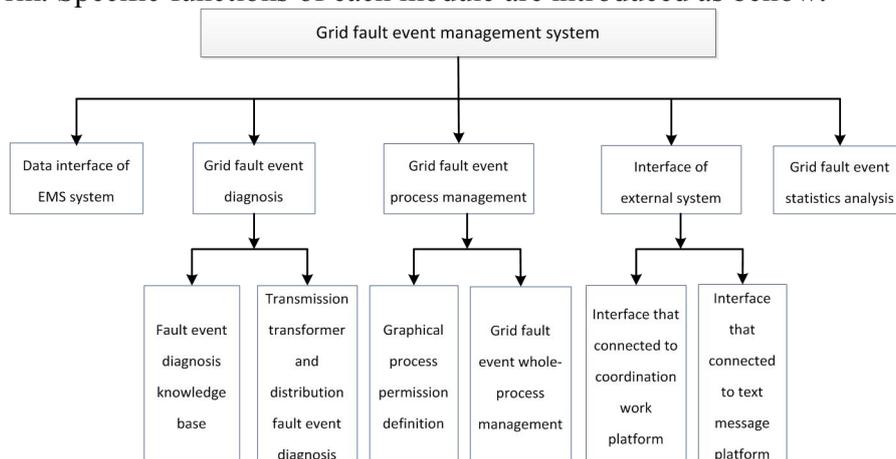


Figure 3 Grid fault event management system function composition

Data interface that connected to EMS system. Data interface that connected to EMS system follows IEC61970 international standard, employing CIM/XML and E language format, obtaining data such as regional grid model, real-time operation mode and grid fault information etc. via FTP. It obtains grid model data once a day, real time operation mode data once every five minutes, and grid fault information and position change of breakers information once every 10 seconds.

Grid fault event diagnosis module. Grid fault event mainly includes fault events of transformer equipment, transmission equipment and power distribution equipment etc. Based on grid model topology relationship and grid real time fault information, grid fault event diagnosis identifies grid power failure equipment, and then adopts forward reasoning algorithm according to grid fault diagnosis knowledge base, traversing rule tree, realizing grid failure equipment diagnosis, fault type analysis, lost load calculation etc., and automatically generating one record of grid fault event.

Grid fault event diagnosis module consists of two modules that are fault event diagnosis knowledge base and transmission, transformer and power distribution equipment fault event diagnosis. Fault event diagnosis knowledge base and transmission, transformer and power distribution equipment fault event diagnosis are respectively basis and core of grid fault event diagnosis.

(1) Fault event diagnosis knowledge base

Fault event diagnosis knowledge base defines logical order relationship of related protection and switch action when there are faults of different equipment by means of rule tree. Equipment in different voltage classes, equipment types and different connection mode are all able to define different fault diagnosis rule tree. Figure 4 defines feeder line fault rule tree. Nodes on rule tree include root node, sub-node and final node. Root node is the starting node of rule tree reasoning, if one rule tree can be reasoned to final node, that equipment is failure equipment. If it cannot be traversed to final node, that equipment is not failure equipment.

Each sub-node defines corresponding property information. Those mainly include the following properties:

1) Specific equipment which corresponds to node. That refers to primary equipment, protection, automatic equipment etc. which corresponds to the node.

2) Expanding mode. Whether expanding or not means that whether continuing reasoning after successful reasoning of that node. There are four expanding modes including default expanding, not expanding, correct action expanding and refusal action expanding.

3) Whether carry out reliability statistics. Whether carry out statistical reliability refers to whether add one reliability value after the successful reasoning. The higher the reliability is, the more the nodes that be successfully matched are.

4) Expected action value. Expected action value is value of circuit breaker and protection which corresponding to that node. If the circuit breaker should be cut off, the expected action value is 0; if it should be connected, the value is 1.

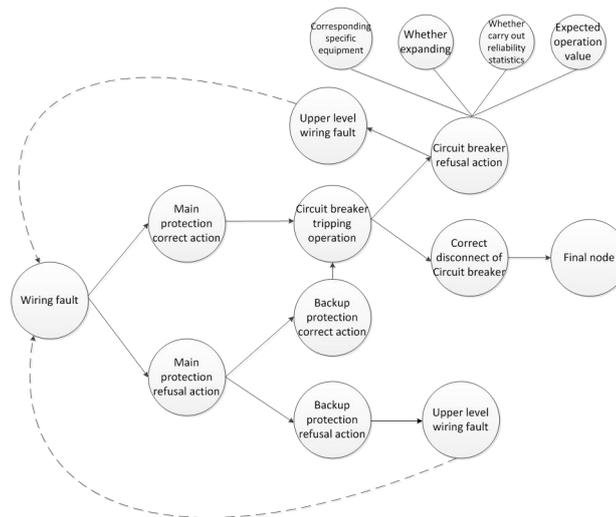


Figure 4 feeder line fault rule tree schematic diagram

(2) Transmission transformer and power distribution failure equipment diagnosis

Transmission transformer and power distribution equipment diagnosis module is core of grid fault event management system. Its main function is automatically diagnosing grid failure equipment according to grid fault information, generating grid fault event record. The specific flow is showed as Figure 5, including the following steps:

- 1) Obtaining grid fault information via data interface that connected to EMS system.
- 2) According to grid fault information and network topology analysis, obtaining possible power failure equipment.
- 3) Traversing all possible failure equipment, and matching corresponding rule tree according to equipment type, voltage class, connection mode etc.
- 4) From root node of rule tree, using forward reasoning recursive algorithm to match the rule tree.
- 5) Using grid fault information to match nodes of rule tree, if fault information of corresponding node occurs, that node matches successfully, then carrying out further reasoning according to defined expanding mode.
- 6) If it matched with final node, which means the equipment is failure equipment.

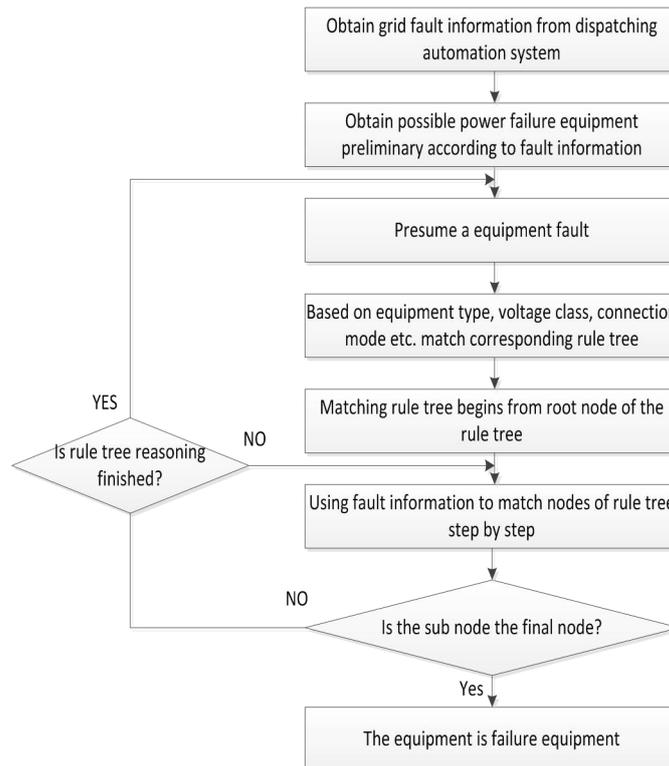


Figure 5 Transmission, transformer and power distribution equipment diagnosis flow

Grid fault event whole-process management module. Grid fault event whole-process management module includes process permission definition module and grid fault event business process management module. Different grid event business processes are different, and the departments that those processes involved are different. This system provides graph and process permission definition function, which is able to draw different flow charts based on different types of grid fault event, and defines process permissions for different roles.

Grid fault event process management module is based on B/S architecture, providing different types of grid fault event the whole-process management function by means of web. It has functions such as edit, submitting, rollback, and cancellation etc. of grid fault event.

Interface that connected to the third party. Grid fault event management system interfaces to the third party system by means of WEBSERVICE, automatically informing related business control department the grid fault event at the first time instead of making a phone call or sending text message by dispatchers, which reduces the dispatching work stress and improves grid event processing efficiency.

Interface that connecting grid fault event management system with the third party system includes coordination work system interface and text message platform interface. Interfaces that connected to coordination work platform can push grid fault event to coordination work system through WEBSERVICE, and related business personnel can timely understand grid fault within to-do list of coordination work system.

Interfaces that connected to text message automatically generate text message and send it to relevant personnel who is allocated in advance, instead of editing and sending the text message by dispatcher.

Grid fault event statistics analysis. Interfaces that connected to text message automatically generate text message and send it to relevant personnel who is allocated in advance instead of editing and sending text message by dispatcher.

Conclusion

Based on on-line EMS grid model and real time fault information to realize urban grid fault event management is an expanding with practical value for EMS function. This system follows ICE61970 international standards, having functions such as grid model and fault information automatic acceptance, grid fault event automatic analysis diagnosis, whole-press business control, automatic text message sending, automatic publishing of coordination platform etc. It's not necessary that dispatcher and management personnel analyze report and publish fault event, standardizing grid fault event processing flow, providing a powerful technology support platform for related department to handle grid event, for improving work efficient and for releasing workload. Practical application of this system indicates that it exerts the advantage of EMS system's real time data resource, contributing to build bridge between grid real time monitoring system and daily business control system, and realizing effective integration of safe area I and III.

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