Analysis and Design of Intelligent Management and Control System for Relay Protection Based on Information Fusion Technology

Yang Liu[1], Wenqiang Zhu[2], Lisheng Li[1] and Jiang Guo[2,*]

[1]State Grid Shandong Electric Power Research Institute, Jinan, China
[2]School of Power and Mechanical Engineering, Wuhan University, Wuhan, China

*Corresponding author email: guo.river@163.com

Abstract. Combined with the current problems of the large number of professional systems for relay protection and the inability to collaboratively share data. This paper analyzes the current application of relay protection information systems. Through analysis of four key relay protection systems including OCS (Operation Control System), Protection and Information System, Wave Recording System, and Traveling Wave System, the core technical parameters are sorted out, and the XML-based (Extensible Markup Language) data specification and model fusion method, introduced the overall architecture of the information fusion relay protection intelligent management and control system, and designed the application function of the intelligent management and control system to realize the information fusion and intercommunication of multi-source heterogeneous systems to improve Power grid coordinated control and emergency response capabilities.
Keywords: Information fusion; Relay protection; Intelligent management; XML; Troubleshooting.

1. Introduction

As the first line of defense in the power system, relay protection is an important part of ensuring its safe and stable operation. When an electrical component fails, the relay protection system can quickly remove the faulty component from the power system to ensure that the power system resumes normal operation as soon as possible [1].

The operation management of the relay protection is supported by a large amount of real-time operation data. However, the data collected by the existing relay protection system and the application system information cannot be effectively shared, and it is difficult to achieve unified processing and analysis of the information [2-3]. By deploying high-speed data buses and general service buses in the grid operation control system (OCS) and operation management system (OMS) respectively, the interaction between OCS and OMS can be achieved [4]. At the same time, information fusion technology has many applications in relay protection setting calculation, status maintenance decision, distribution network fault location [5-8]. Some new algorithms for wide area relay protection based on multi-information fusion can establish state expectation function and fitness function [11]. Therefore, a set of dispatching automation system is constructed to ensure reliable operation of dispatching automation system and dispatch management information system (DMS) [12]. In recent years, XML has been used as the intermediate process for storing data, based on XML, E file interface, Web Service, FtpFS and other technologies and implemented a new method for real-time synchronization of large-scale data across security zones and systems,

improving large-scale power grids Real-time and stability of running data synchronization [15-16]. Combining with the current status of the relay protection profession and the requirements of electric power companies to promote the integration of the entire network regulation and control, this paper starts from the actual needs of the relay protection profession, in the existing relay protection data collection system, based on information fusion technology, based on XML data normalization conversion and model fusion method realizes real-time data interaction and information fusion between multiple systems, and supports intelligent management and control of the entire process of relay protection fault diagnosis services and information.

2. Existing Problem Analysis

At present, China's relay protection automation technology has developed rapidly, but most application systems for protection are mostly designed separately for different business requirements. The following problems are common:

(1) Decentralized modeling and independent maintenance of each application system, no unified power grid model.

(2) The system involves multiple manufacturers, resulting in poor system coordination and interoperability, difficult information sharing, heavy maintenance tasks, and inability to meet the needs of the continuous development of the power grid.

(3) Each application system lacks a unified platform support, there is no unified specification for graphics and databases, the horizontal integration and vertical penetration of the system are difficult, and the interface with external systems is complex.

(4) The isolated information between the systems makes it impossible to make full use of the data for detailed fault analysis, alarm event handling, etc. The comprehensive application analysis is lacking.

(5) There are fault diagnosis or integration of multi-source fault diagnosis results based on steady-state data, transient data, and dynamic data in China, but no detailed fault analysis has been made using the guarantee data; the lack of data collected or reflected by the OCS / guarantee system alarm analysis and research of event information after clustering.

The above-mentioned problems in the application of the relay protection professional system have restricted the promotion and development of relay protection to a certain extent, and its decentralized operation mode cannot realize the integration, informatization, and intelligence of relay protection management.

3. Basic Data

The intelligent management and control system for relay protection based on information fusion acquires the information of the professional power grid operation control system (OCS), the credit guarantee system, the wave recording system, and the travelling wave system, and integrates the key parameters and indicators of each system to support comprehensive analysis.

(1) OCS system: Currently, it mainly stores historical real-time data such as data acquisition and monitoring and control systems, power grid wide area monitoring systems, water regulation, relay protection fault information, and stability. The telemetry and tele-signal in the OCS are integrated in protection management and control system.

(2) Credit Guarantee System: The key data of the system is integrated in protection management and control system: protection settings, switching values, analog values, alarm information, action events and waveform data.

(3) Recording system: The system realizes the dynamic recording of changes of electrical parameters of power system faults, including data acquisition, calculation, analysis, triggering, storage, analog and switch. The key data of the recording system is integrated in protection management and control system, the total station recorded waveform data.

(4) Traveling wave system: This system can be divided into two types: single-ended traveling wave ranging and single-ended traveling wave ranging. The specific parameters are shown in Table 1.

Table 1. The parameters of traveling wave fault location system.

Types of	parameter
Double-ended traveling wave ranging	Ranging result, the end of the first. 1 wave the first time, the first peer. 1 wave the first time, the fault current, the fault voltage, the length of the line, the line name, the name of the substation, the substation name of the peer, the wave velocity
Single-ended traveling wave ranging	Ranging result, the end of the first. 1 wave the first time, the fault current, the fault voltage, the length of the line, the line name, the name of the substation, the wave velocity

4. Information Fusion

4.1. Based on XML Data Normalization

Information fusion as a multi-source information processing technology is multi-level. There are three basic types of fusion of hierarchical information, as shown in Figure 1.

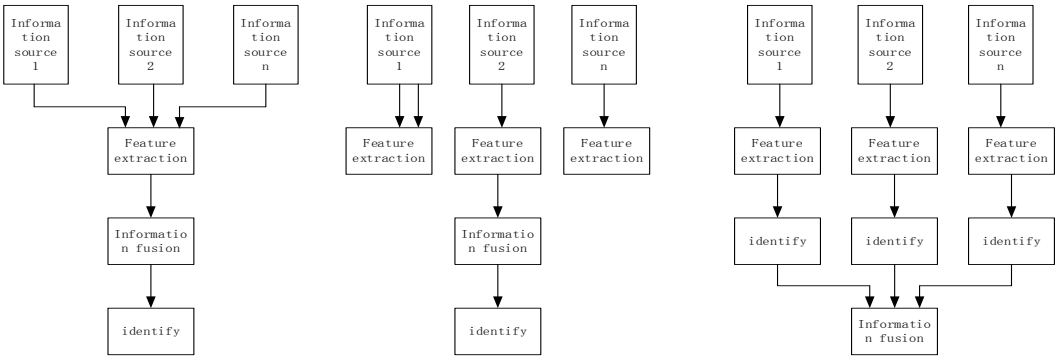

Figure 1. Information fusion process.

Data layer fusion is the fusion of the most basic data at the bottom, that is, the fusion of basic data collected by the sensing layer device or sensor.

The feature layer fusion is the middle layer of information fusion, that is, the data of various types of perception layers are obtained through feature extraction and analysis to obtain information with a certain amount of features, and the features of various types of extracted analysis are integrated for unified information fusion and analysis.

Information fusion at the decision-making level is advanced information fusion in the information fusion. The equipment collected at the perception level provides feature support for the analysis and judgment of the results according to certain rules after performing feature extraction and information processing according to certain features.

Through the analysis of the basic data of the relay protection intelligent management and control system, the data that can be seen includes structured data such as switching values and telemetry. Such data is data layer data information; there are also textual and unstructured data such as alarm information and fault waveform diagrams. This kind of data is mostly feature layer or decision layer data. To achieve the fusion of information scattered in various systems, this paper builds the XML-based data structure standardized processing model to achieve the conversion of different data forms [12].

Taking the action event in the guarantee system as an example, a guarantee action event based on XML technology is proposed. As shown in Table 2, the action event page information of the guarantee system is shown.

Table 2. The Action Events of protection information management and fault analysis system.

2019-01-23 11:22:00.492	protections	CPU1	Current differential protection	Current differential protection: action, relative time:0, fault number:0, fault location:0
2019-01-23 11:22:00.524	protections	CPU1	Jump A	Jump A: action, relative time:0, fault number:0, fault location:0

The analysis of action event information is as follows:
Data structure name: Action Event (T_ActionEvent)
Data structure description: It is used to model the action events of the guarantee system, including action time, action type, equipment, object., and a default data unit is specified.
Data structure description:

Table 3. The structure of data.

Attributes	Description
ActionTime	Meaning: action time, the format is yyyy-mm-ddTHH: mm: ss.SSS
ActionType	Meaning: Action type, described using enumerated types
Device	Meaning: Action equipment
Target	Meaning: Object, described using an enumerated type
Content	Meaning: Action content, subdivided into ActionPattern (enumeration), Relative Time (data unit), FaultSequenceNumber (data unit), FaultLocator (data unit)

Through the XML-based data normalization form, it is possible to effectively transform data such as scattered systems and provide data support for the relay protection management and control system.

4.2. Model Fusion

This paper proposes a standardized model conversion algorithm based on the model mapping and fusion between the IEC61968 / 61970 standards to meet the data sharing between different application systems and realize the fusion of various models through the data fusion of each independent system.
Model fusion mainly includes:
(1) According to the IEC61968 / 61970 standard, a unified information model for power distribution is constructed to realize the expression, sharing and reproduction of business data meanings.
(2) Through the extraction of multi-source heterogeneous data, the use of differential analysis and model comparison technology to achieve the conversion and association mapping between the terminal IEC61850 model and the IEC 61968/61970 model to form a unified model instance.
(3) Follow the standardized information exchange interface to unify the interaction modes between business application systems, and realize message transmission in the " publish / subscribe " and " request / response " scenarios.

5. Design of Relay Protection Intelligent Management and Control System

5.1. Overall Architecture

The architecture of the relay protection management and control system constructed in this paper is divided into three parts: data acquisition, data fusion, and advanced applications. The overall system architecture is shown in Figure 2.

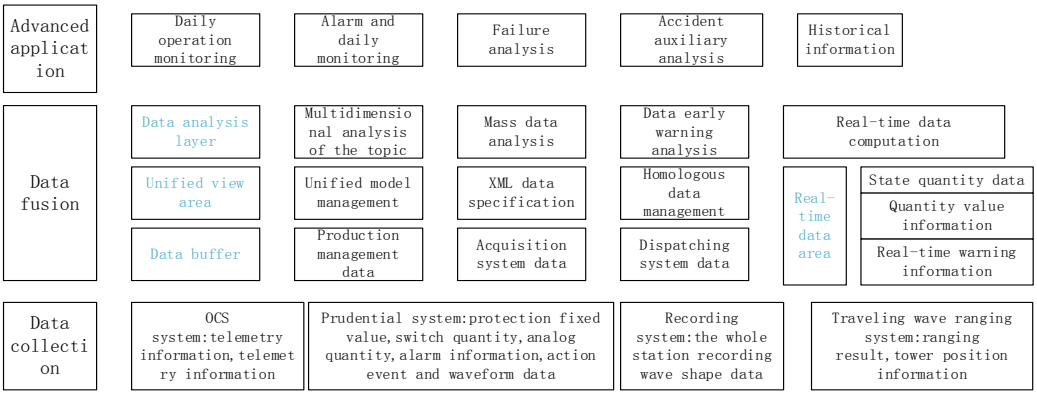

Figure 2. The diagram of system frame.

Data acquisition layer: Obtain models and data from the guarantee system, recorder system, travelling wave system, and OCS system of the relay protection profession , and fully integrate and utilize the telemetry and remote signal information in the OCS system, extracting the supporting relay protection management and control system Basic core data.

Data concentration layer: pre-processes the data and files of various professional subsystems; includes real-time data area, data buffer, unified view, data analysis layer; implements multi-source data sharing based on data fusion technology; Data, for unified integration and storage, to determine the unique keyword index; regularly and dynamically update data from information sources.

Advanced application layer: Through the integration of multi-source data and in-depth mining analysis technology, the daily operation monitoring, alarm and abnormal monitoring of protection professional equipment, intelligent auxiliary analysis and processing of power grid accidents, historical fault information filing and historical data of power grid fault equipment Full-process management and control platform for post-analysis applications.

Through collaborative operation analysis of data acquisition layer, data concentration layer, and advanced application layer, a complete set of processes for data collection, intelligent fusion, and advanced analysis of the relay protection system is realized.

5.2. System Functions

(1) Daily operation monitoring: By obtaining information of different systems, real-time display of the operating status of the equipment and the role of monitoring line protection, monitoring of protection devices, switch protection, and whether the settings are abnormal. People with different authority and different departments pay different attention to information and realize personalized display of people with different roles.

(2) Protection action check: It implements the function of mutual correction of two sets of protection action behaviors of dual configuration, records the difference in behaviors, analyzes the protection abnormal behaviors by recording waveform analysis of inconsistent behaviors. Based on the fault record waveform analysis, the integrity of the main protection action is judged, and suspicious action elements and missing elements are prompted.

(3) Alarm information: Alarm information is obtained by OCS and assurance system scattered alarm event information. Through the comprehensive analysis of identifying cluster grouping association, combining with the linkage verification of real-time section data and model information, the comprehensive display of warning information is realized.

(4) Fault diagnosis: The fault diagnosis data includes the plant name, line, device address, management serial number, operational serial number, absolute starting time, serial number, phase of the operation, relative time of the operation, the component of the fault, the result of the fault ranging, and the fault phase. , Fault phase current value, fault zero-sequence current, fault differential current, input status at start, post-start displacement report, fault waveform and other data.

a) Failure analysis: Fault diagnosis data, including fault protection action after the factory name of serial number line device address management action sequence number starting absolute time serial

number action phase action relative time action component fault location results don't fault phase fault phase current value fault zero sequence current differential current starting open intake status when starting shift report after fault waveform data, etc.
b) Fault location using waveforms: According to the obtained COMTRADE waveform analysis, the fault location, fault type, fault phase, fault current (including phase current, zero sequence negative sequence current), fault voltage and other information are given. At the same time, the traveling wave ranging data is used to accurately locate the fault.
(5) Intelligent auxiliary analysis of accidents: The instantaneous information of the accident can be predicted through the fault diagnosis function. Data information such as the fault record file and the setting values required for waveform analysis are stored in the accident intelligent assistant analysis module due to the time-consuming summoning. The fault diagnosis result is verified by fusing the data of the fault record system.
(6) Historical information: Through the accumulation of information on relay protection raw data collection, analysis, fault diagnosis and auxiliary comprehensive analysis, faults and alarms are used as top-level events, and statistical query of historical fault information file and alarm information of faulty equipment is realized.

6. Conclusion

In this paper, through the analysis of the status of relay protection and the data structure of smart grid, an XML-based data structure normalization method and a unified relay protection system model are proposed, and a grid operation protection system, a protection and information system, a recording system and a traveling wave system are constructed. The intelligent fusion architecture of the wave system. The relay protection management and control system effectively breaks the current data bottleneck of relay protection, on the one hand, it improves the integration and deep mining of relay protection data, on the other hand, it realizes the full process management and intelligent analysis of data, and fully supports the integration of regulation.

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