Power Network Fault Diagnosis Based on Multi-source Network Message Data

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Abstract. In the event of a grid failure, the network message data (SMV, GOOSE) contains all the information about the primary and secondary devices. The amount of information data is large, and it is difficult for the personnel to make a quick and accurate judgment about the fault type from the massive data, affecting fault handling and safe grid operation. In this paper, modeling is unified based on network message data about the primary equipment. The comprehensive data analysis between multiple substations can be achieved by acquiring alarm information, network message information and wave recording information through network message analysis devices; meanwhile, the longitudinal differential principle is applied to fault diagnosis, which can realize accurate fault diagnosis of power grid, and provide data basis for accident treatment.

Keywords: Network message; Massive data; Unified modelling; Longitudinal Differential; Fault diagnosis.

1. Introduction
With the continuous development of smart grid, intelligent substation already has the secondary circuit digital, information transmission network, secondary equipment modeled and some new features, based on digital substation network analysis device has been widely used in substations. In the event of a grid failure, the network message device can obtain the multisource fault information for all the intervals associated with the faulty device for the first time. Meanwhile, with the continuous improvement of the smart grid communication network, the importance of the network packet analysis system composed of multiple network message devices is also gradually highlighted. The network packet analysis system analyzes the SMV and GOOSE packets of the process layer through the mass record analysis, and effectively selects the filtering of the network packets, online records, network traffic statistics, abnormal online analysis of the packets, and real-time monitoring of the communication network. Through these functions, we can find out the weak links and fault equipment of the power system communication network in advance to prevent the occurrence of electric power system accidents, and avoid the economic losses caused by the power system accidents caused by the failure of the communication network or the failure of the primary equipment and secondary equipment.

The network packet record analysis device described in paper [1] can only realize the real-time warning and online or off-line analysis of a voltage level process layer network or station control layer network, and can not realize the analysis and evaluation of the network condition in the whole station, and can not To achieve a comprehensive analysis of data between multiple stations. In paper [2], a fault diagnosis method based on fault recorder is proposed. The analysis is limited to the analysis in the station and does not apply to the fault diagnosis of the whole network. Meanwhile, paper [2] proposed a
fault diagnosis and analysis of the whole network based on fault recorder network system, but its analysis method is based on the traditional analog fault analysis, which helps the protection action in the station and the diagnosis result Emphasis on the protection of equipment to determine the specific type of failure. In the paper [3], a faulty fault diagnosis system based on wide-area fault recorder is proposed. The data is derived from the fault recorder, which is affected by the device. The fault diagnosis is mainly based on the simulation, but did not carry out an in-depth analysis of the protection of the action.

In this paper, based on the network message data to a unified model of equipment modeling, direct use of the process layer of message information to solve the traditional use of fault recorder data analysis difficult problem due to device differences, sampling rate, time scale is not uniform and other factors. At the same time, by taking the longitudinal differential principle method based on the protective equipment, the fault of the inter-substation line, the station bus and the transformer is analyzed accurately and the reliability is high. In addition, it can realize the evaluation of the correctness of the protection action by sorting and collating the relevant equipment alarm information. Especially when the line fault is faulted, it can accurately analyze the reason of the refurbishment and malfunction of the line longitudinal protection according to the protection signal output, achieved effective and reliable diagnosis of related primary and secondary equipment.

2. Massive Network Message Data Filtering
In the digital substation, the status of the equipment in the process layer is sent by the merging unit in the substation (SV and GOOSE packets). The network packet analysis device passes the specified sampling frequency (currently 4000HZ, the sampling rate is generally a unified standard), and the digital station has a GPS pair, therefore, by the network packet analysis device to collect SV and GOOSE have a unified sampling rate and time scale[5,6,7].

![Figure1. Massive process layer network message data structure](image)

The data source of the fault diagnosis method proposed in this paper is based on the massive data of network packets. As shown in Fig1, through the record function of the network packet analysis device, the message information of each primary device in the whole station process layer is obtained when the power grid fails. Since the network packet analysis device in the substation is recorded according to the voltage level classification, the network analysis system composed of the plurality of network analysis devices contains all the data of the plurality of stations. Due to data redundancy, it needs necessary screening for network packets of massive data.

1): Mass data classification: SV and GOOSE sorting.

2): Primary devices sorting, divided into transformers, bus, lines. Where the transformer and bus only need the same substation network message data and the line needs the relevant two stations between the substation network message data.

3): Based on primary devices, established relationship between the device and all associated network message data.
3. Massive Network Message and Primary Device Association Model

The corresponding model of massive data association is established by using the primary device as a unit, and the corresponding data model is formed corresponding to the network message data. Model can be classified: station (bus, transformer), Inter-station (line).

Substation related relationship:

Through the analysis of the station SCD file, access to substation network configuration, IED model, virtual terminal connection and other information, and as a basis, to obtain primary device related information, such as: Transformers and bus: three side (or two side) Analog, protection of the switch, alarm information. As shown in Fig 2.

(1) Transformer: The high and low sides of the transformer (or two sides) are located in three (or two) different network analysis devices.

(2) Bus: bus on both sides of the inlet and outlet are located in the same voltage level, generally located in the same network analysis device.

![Figure 2. The Structure of the Station based on Network Packet Branching Device](image)
Figure 3. Interstation Structure Based on Network Packeting Branching Device

Inter-station relationship:
Mainly through the line between the different stations SCD file, access to the line-related information, such as: Voltage and current at both ends of the line, switch, and alarm information. As shown in Fig3, the voltage and current at both ends of the line are located at different stations of the network packet analysis device.

4. Fault Diagnosis Method Based on Pilot Differential Principle
With the power communication function is increasingly perfect; the power grid in the event of failure, each end of the network message data can be quickly and accurately through the network to a side. Therefore, according to the network information obtained by the network analysis device, the primary device of the power grid is used as the calculation unit to calculate the differential flow, and the difference value and the difference flow setting value are compared to realize the fault type judgment and the protection action Situation to be analyzed.

Based on the analysis of the differential fault analysis, bus, transformer, line differential flow calculation method is as follows [8]:

Definitions: 1) The TA polarity of each device is the same, the current direction flows out from the bus is the positive direction, and the incoming bus is negative direction. 2) Differential flow limit setting value to the maximum operating mode of the grid operation, due to load imbalance, current transformer measurement error and other factors led to the maximum differential value, the actual operation $\Delta I_{\text{max}}$ can be set to set the floating threshold. 3) In addition practice, the value of the differential flow is:

$$\Delta I_{\text{max}} = n \ast I_{\text{rated}} \ast n = 0.1$$

(1)

I take primary rating, the actual ratio is not uniform, and the secondary rating is 1 A or 5 A. For the sake of convenience, took a unified use of primary rating to set the calculation. Transformer, bus calculation method is as follows:

$$\Delta I = |I_{\text{in}} + I_{\text{out}}|$$

(2)
Based on the protection of the principle of differential fault diagnosis process as shown in Figure 4:

$$\Delta I = \left| IM_{(i,o)} + IN_{(i,o)} \right|$$

(3)

5. Protection Verification Based on Fault Diagnosis

Actual in the grid, due to the correct protection of the action, the associated primary device voltage and current will show a corresponding change, for example: the line in the event of failure, the protection will go through the following changes as shown in Fig5:

Figure 4. Fault diagnosis process

Figure 5. Protection action process

Therefore, by comparing the logic action in the protection of the fault and the action flow of the switch, it is possible to judge the correctness of the protection action and test the reliability of the protection. To set up the information statistics table for the alarm information of the equipments in the station based on primary equipments. Statistics and classification of equipments alarm information for each time period, and the analysis result of the fault diagnosis and the information of the alarm information are integrated to form a secondary equipment fault information summary table [9,10], as shown in Fig6. For the maintenance personnel or dispatchers in theory to analyze the different fault protection actions and processes.
According to the data of the primary equipment, the information of the switching quantity is inconsistent with the analysis result of analog quantity in the network message, and analyzes the possible reasons for the protection of the misoperation, and even the possibility of refused operation. Such as, through the transmission and reception of signals can be a rough way to determine the cause of the misoperation of longitudinal differential protection.

6. Conclusions
In this paper, a fault diagnosis and analysis method based on network message data is established. The network packet analysis device is connected with the primary equipments by using the unified modeling method between multiple substations. By sorting the network packet data of the process layer and introducing the principle of longitudinal protection analysis into the fault judgment, which greatly improves the accuracy of fault judgment. Meanwhile, the fault diagnosis result is used to verify the accuracy of the protection action, which can overcome the problem that the line protection actual process can not complete the main protection because of the optical fiber failure. It obtained the reasons of abnormal protection really and effective protection of action behavior was evaluated.

The method obtains the message data from the process layer, and the data source is reliable and can effectively avoid the problem caused by the device. The quantitative analysis methods and rules of network message data are established with the equipment and voltage level network as the object. It realizes the comprehensive analysis of the whole substation and the province's network message data, which provides effective support for the accident analysis of the substation and the accident analysis between the substations; moreover, it can quickly find the cause of the accident. As stated above, it has a good application prospect.

7. References
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