Online Monitoring Method for Hazard Source of Power System Network Based on Mobile Internet

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Abstract. In the power system network, aiming at the low accuracy of traditional network hazard online monitoring method, an online monitoring method for hazard source of power system network based on mobile internet is proposed. Based on mobile internet, a power system network communication is constructed. The model uses this model to collect dangerous source data. After the hazard data is collected, the WAMS system is used to calculate the relative residuals of the hazard source data, and then the relative residuals are used to identify the hazard source parameters, and the branch with the hazard source parameters is present. The traveling wave positioning network is used to locate the dangerous source. After the hazard source is located, the hazard source is monitored online by the hazard source indicator. Under the condition that the experimental environment is the same, the method is compared with the online hazard source online monitoring method based on feature recognition technology and the online hazard source online monitoring method based on communication message parsing. The monitoring accuracy of these three methods is improved. The results are 41.1%, 68.8%, and 94.5%, respectively. The experimental results show that the monitoring accuracy of this method is higher than the traditional online hazard source online monitoring method, which proves the superiority of the method.

Keywords: Mobile internet · Power system · Network hazard source · On-line monitoring

1 Introduction

With the implementation of the national 1000 kV UHV networking strategy, a wide-area power system network with an installed capacity of more than 8 kW and spanning thousands of kilometers is being formed in China. Although the formation of a wide-area power system network will bring huge benefits to the national power system network, the security, stability and economy of the power system network will also face unprecedented challenges [1]. Through the research on the hazard source of power

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system network, people have a certain understanding of the cause of the hazard source: the traditional online monitoring method has slow information transmission speed, lacks wide-area synchronous measurement capability, and cannot monitor the dynamic process of the power system online in real time; The occurrence of potential chain accidents will lead to further expansion of the dangers. The main reason for the chain accidents is that the protection and stability control systems of traditional power systems can only rely on local information, and it is difficult to achieve global optimization and coordination control; The existing grid on-line monitoring method lacks robustness to changes in the operating state of the power system, especially in emergency situations such as cascading failures, which cannot provide accurate operational status information to dispatchers [2]. Therefore, an online monitoring method for hazard source of power system network based on mobile internet is proposed, which improves the monitoring accuracy of hazard source in power system network.

2 On-Line Monitoring of Hazard Source of Power System Network Based on Mobile Internet

2.1 Hazard Source Data Collection

A power system network communication model is constructed based on mobile internet, and the model is used to collect dangerous source data. The power system network communication model is mainly composed of five parts: local aggregator, building gateway, smart meter, user and trusted organization [3]. Local aggregators are affiliated with power grid companies; building gateways are generally affiliated with some outsourcing companies, such as mobile companies or China Unicom; trusted organizations are independent organizations, such as regional communication organizations or independent system operators. The communication architecture of the power system network communication model is shown in Fig. 1.

The power system network needs to know the user's power consumption information in real time, dynamically adjust the electricity price, and analyze and predict the power consumption in the next stage, which will generate a large amount of data transmission. In order to facilitate the acquisition of dangerous source data, the power system network communication architecture is divided into three hierarchical networks, namely regional regional networks, nearby regional networks and building regional networks. Among them, each building area network is composed of many users, and the information interaction interface between the user's smart meter and the smart grid is defined as the building gateway [4]. Each nearby area network consists of a number of building area networks, defining this layer of network nodes as local aggregators. The regional area network consists of a number of nearby regional networks, and the network nodes defining this layer are central aggregators. Information interaction between smart meters and building gateways can be transmitted via power line carriers, WiFi wireless broadband or Zigbee; information exchange between building gateways and local aggregators can be through broadband infrastructure such as WiMax Global Interoperability for Microwave Access or 3G/4G network, etc.; data communication and operational information control between the local aggregator and the central aggregator can be

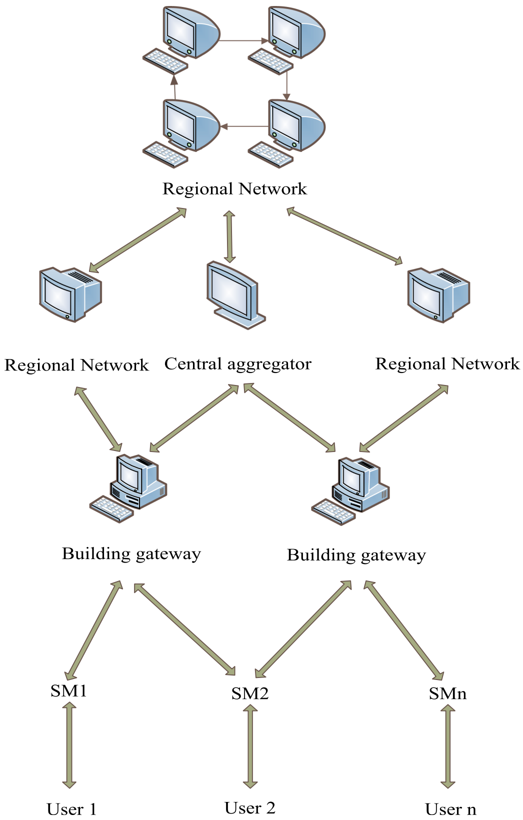

Fig. 1. Communication architecture of network communication model in power system

transmitted through optical fiber, and the security of communication can be guaranteed. Each user's home is equipped with a smart meter that can be used to periodically record the user's real-time power consumption data. And the smart meter periodically transmits the real-time power consumption data to the local aggregator through the building gateway. After receiving all the data, the local aggregator sends the data to the central aggregator in batches, and the central aggregator forwards the data to the control center. The control center adjusts the data transmission rate according to the power consumption information, so as to facilitate the collection of dangerous source data [5].

The trusted authority initializes according to the blind signature and generates initialization parameters, wherein the trusted authority is a pair of public and private keys issued by all entities such as smart meters, building gateways, and local aggregators [6]. Before accessing the power system network, the user presents the specific identity information to the local aggregator, and the local aggregator verifies whether it is a legitimate user [7]. After the verification is passed, the smart meter and the license book with the public and private keys and the unique secret number are embedded. To the user, finally, the local aggregator stores the data in its database, and then collects the dangerous source data [8]. The specific flow of hazard source data collection is shown in Fig. 2.

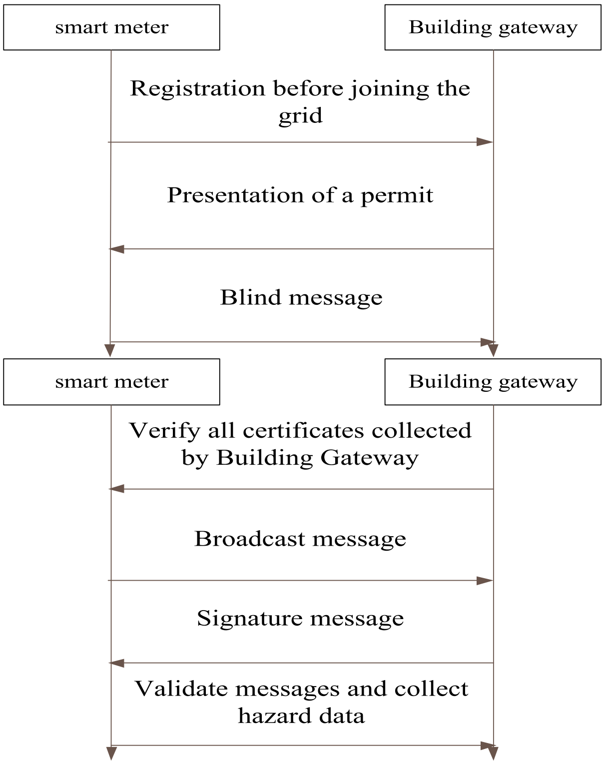

Fig. 2. Specific processes for data collection from risk sources

2.2 Hazard Source Parameter Identification

After the data collection of dangerous source is completed, the relative residual of dangerous source data is calculated by using WAMS system, and then the parameter identification of dangerous source is carried out by using the relative residual. Firstly, the WAMS system is used to estimate the linear state of the dangerous source data [9]. For a bus system with n busbars and m measurements, the linear measurement equation can be used to represent:

$$Z^{meas} = H \cdot X + e \tag{1}$$

Where Z^{meas} represents the m-dimensional PMU measurement; H is a $m \times (2n - 1)$ -dimensional measurement Jacobian matrix; X is a $2n - 1$-dimensional voltage state vector; e is a m-dimensional measurement noise vector. Then the linear state estimate with weighted least squares can be expressed as:

$$X^{est} = (H^T W^{-1} H)^{-1} (H^T W^{-1} Z^{meas}) \tag{2}$$

Where X^{est} is the voltage phasor matrix estimated by the linear state; W is the weight matrix. In order to measure the calculation error of the linear state estimation, the "measurement amount" calculated from the measured quantity and the voltage phasor obtained from the linear state estimation is compared here [10], and the difference between them is measured by using the relative residual, relative residual R^{mar} is calculated as:

$$R^{mar} = \frac{1}{n}\sum_{1}^{n}\left|\frac{Tn}{Z^{meas}}\right| \tag{3}$$

Where R^{mar} is the relative residual; T is the correlation coefficient between the measured quantity and the quantity to be determined; n is the number of measured quantities. Then use the relative residual R^{mar} to identify the source of the hazard and identify the branch with the hazard source parameter.

2.3 Hazard Source Location

For the branch with the dangerous source parameter, the traveling wave positioning network is used to locate the dangerous source. The traveling wave positioning network is mainly used to collect the initial traveling wave time information of the whole network, including the initial traveling wave arrival time and circuit breaker state information recorded by all traveling wave detecting devices in the power system network [11, 12]. First, determine the branch circuit with the dangerous source parameters, eliminate the invalid initial traveling wave arrival time, and then use all valid initial traveling wave arrival times to locate the dangerous source.

Analyze whether the initial traveling wave arrival time recorded by any substation in the power system network is valid, arrange all the initial traveling wave arrival times in a certain order, and then sequentially discriminate in order. The specific method is: the initial traveling wave arrival recorded for a substation. The time difference between the time, in turn, and the initial traveling wave arrival time calculation recorded by its neighboring substation. The dangerous source positioning master station arranges the effective arrival time of all effective initial traveling waves into two arrays on both sides of the dangerous source line, respectively, taking one line of arrival time from the two arrays, and calculating the dangerous source point according to the double-ended dangerous source traveling wave positioning algorithm. To the dangerous source distance of the substation, the traveling wave positioning steps of the hazard source of the power system network based on the above positioning principle are: determining the dangerous source line; simplifying the traveling wave positioning network; performing the elimination of the invalid initial traveling wave arrival time; calculating the dangerous source Distance; set weights for all hazard source distances; calculate hazard source distances and output hazard source location results.

2.4 Realizing On-Line Monitoring of Hazard Source

After the hazard source is located, the hazard source is monitored online by the hazard source indicator. The hazard source indicator is composed of a detection circuit, an analysis algorithm circuit, a trigger circuit, a wireless transmission circuit module, a power supply circuit, etc., and mainly uses a hazard source indicator to pass the detected dangerous sources such as power-on, power-off, grounding, and short-circuit signals. The distance radio frequency module is transmitted to the signal transmission terminal. The three hazard source indicators are a set of detection terminals, which are responsible for detecting the data of the line hazard sources. Each group is equipped with a data communication device, which can transmit the collected data information to the indoor main station receiving switch. The hazard source indicator is mounted on the line and can be directly loaded and unloaded by the operating lever without power failure. It is installed at the following location: at the exit of the substation, to determine whether the source of danger is inside or outside the station; The entrance is used to determine whether the hazard is on the main line or on the branch line; at the junction of the cable and the overhead line, it is used to determine whether the hazard is in the cable segment or on the overhead; in the plain or open area to reduce the hunt Work pressure.

The alarm display function of the hazard source indicator: when the line is positioned to the hazard source, all hazard source indicators of the hazard source line from the substation exit to the hazard source point are activated or flashed, and the hazard source indicator after the hazard source point Then it does not work. In this way, the lineman can quickly determine the section of the source of danger by means of the alarm display of the indicator and can find out where the source of the danger occurred. At the same time, the hazard source indicator can also detect the running status of the line and the point of occurrence of the hazard source in real time, such as short circuit, power outage, power transmission, grounding, overcurrent and other dangerous sources. When the running status of the line changes, the on-duty personnel and the operation management personnel can be quickly notified. They can quickly make a treatment plan, which can greatly improve the reliability of power supply, ensure the stability of power supply, and improve user satisfaction. Firstly, the hazard source monitoring of the distribution network is carried out. The hazard source monitoring of the distribution network refers to the data collected and transmitted to the host computer by the control center according to the hazard source indicator installed in the distribution network after the occurrence of the hazard source. The actual structure of the distribution network uses the distribution network information and hazard source information to automatically determine the location of the hazard source and reflect the source of the hazard in the network structure and topology map.

Then, based on the graph-based overheating search algorithm, the online monitoring of the hazard source of the power system network is carried out according to the hazard source model of the power system network. It regards the outlet switch of the substation and the switchyard, the segmentation switch of the distribution feeder and the tie switch as the apex, the feeder line segment is regarded as the arc, the load supplied by the feeder is regarded as the arc load, and the current flowing through the switch is regarded as The load at the apex, and the ratio of the load to the rated load, multiplied by 100 is the normalized load, then the hazard source segment is obviously those arcs whose normalized load is much greater than 100. Using the network topology formed by GIS, at the same time, the expert system can initially determine the possible dangerous source nodes based on the user's dangerous source telephone information record database and retrieval knowledge base. The inference engine performs dynamic search and backtracking reasoning based on the dangerous source nodes to form multiple dangerous source sequences, and then determines the dangerous source monitoring area according to the intersection of the key user information and the dangerous source sequence.

3 Experimental Research

In order to detect the on-line monitoring method of power system network hazard sources based on mobile Internet, a comparative experiment is designed.

The parameters of this experiment are shown in Table 1:

Table 1. Experimental parameters

Project	Data	Environmental science
Collecting data	Hazard source data	Software environment: data collection software, data processing software
Data base	On-line monitoring database of hazard sources in power system network	
Data sources	On-line monitoring and management system of hazard sources in power system network	
Operating platform	On-line monitoring and management platform for hazard sources in power system network	Hardware environment: mobile internet hardware system
Port	Bidirectional operating port	
Technical support	Mobile internet technology	
Contrast method	On-line monitoring method of network hazard sources based on feeder automation technology, on-line monitoring method of network hazard sources based on power load and on-line monitoring method of power system network hazard sources based on mobile Internet	Software environment + hardware environment
Evaluation criteria	Monitoring accuracy	
Data source path	Obtain actual parameters	
Experiment flow	On-line monitoring of network hazards in power system	
Operating system	Microsoft Windows XP	

Using the Microsoft Windows XP operating system, the online monitoring and management platform for the hazard source of the power system network is used to conduct online monitoring of the hazard source of the power system network, and the monitoring accuracy is compared. In order to ensure the validity of the experiment, the online hazard source online monitoring method based on feature recognition technology, the online hazard source online monitoring method based on communication message parsing and the online mobile hazard source online monitoring method based on mobile internet are proposed, observe the experimental results.

Using the on-line monitoring method of network hazard source based on feature recognition technology and the on-line monitoring method of network hazard source based on the analysis of communication message. The on-line monitoring method of network dangerous source of power system based on mobile Internet is used to monitor the network dangerous source of electric power system. The accuracy of monitoring is compared as shown in Fig. 3.

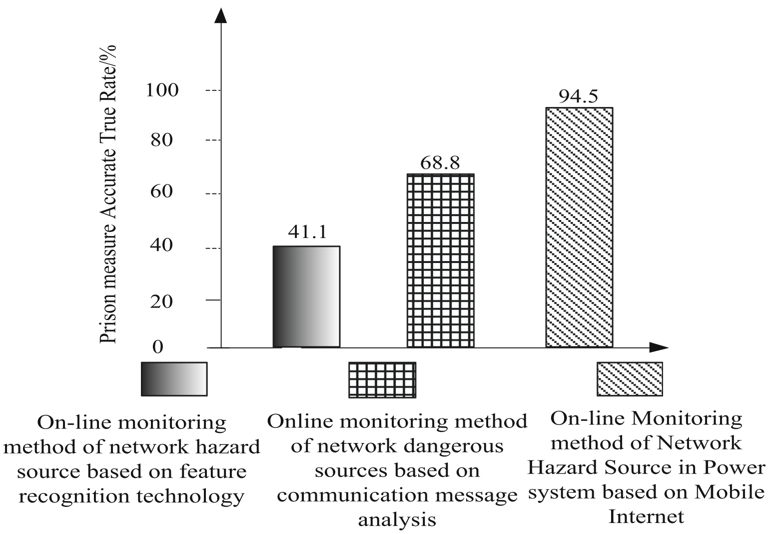

Fig. 3. Monitoring accuracy comparison

As can be seen from Fig. 3, the on-line monitoring accuracy of the on-line monitoring method based on feature recognition technology is 41.1%, that of on-line monitoring method based on communication message analysis is 68.8%, and that of on-line monitoring method based on the analysis of communication message is 68.8%. The accuracy of the on-line monitoring method based on mobile Internet is 94.5%. The comparison shows that the on-line monitoring method based on mobile Internet has the highest accuracy. The performance superiority of this method is proved.

4 Conclusion

The dangerous source of the power system network endangers the security of the power system. Its evolution or regeneration will lead to the large area interruption of the power supply network or the large area paralysis of the main business system. The on-line monitoring method of dangerous sources in power system network based on mobile Internet can realize the high-efficiency monitoring of dangerous sources, which has far-reaching significance for the smooth operation of power system networks. Due to space constraints, there is room for improvement in this study, especially in hazard monitoring, which will be my future research direction.

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References

1. Lin, J., Zhang, J., She, Z., et al.: On-line monitoring of dissolved gases in transformer oil based on BP network. Power Syst. Autom. **25**(28), 156–158 (2017)
2. Anonymous. Intelligent monitoring system for transmission line hazards based on in-depth learning. J. Nantong Univ. (Nat. Sci. Edn), **64**(71), 1418–1453 (2018)
3. Wang, X.: Software design scheme for on-line closure calculation of distribution network based on mobile Internet. Power Syst. Protect. Control **45**(54), 128–133 (2017)
4. Gu, K., Hu, W., Fu, C.: Design and implementation of handheld power data acquisition and analysis device based on mobile network. Power Syst. Protect. Control **46**(48), 110–116 (2018)
5. Zhu, Q., Dangjie, Chen, J., et al.: Power system transient stability assessment method based on deep confidence network. Chin. J. Electr. Eng. **38**(43), 123–123 (2018)
6. Huang, Y.: On-line monitoring method and implementation of EMS data quality based on multi-data source verification. Power Syst. Protect. Control **45**(57), 130–135 (2017)
7. Ma, J., River, W., Wang, X.: Current situation and improvement methods of network security of power monitoring system. Inf. Comput. (Theoret. Edn.) **21**(22), 187–188 (2017)
8. Hu, Z., Liu, J., Z, B., et al.: Environmental risk assessment of transmission line operation based on key risk characteristic quantities. Power Syst. Autom. **41**(48), 160–166 (2017)
9. Liu, S., Glowatz, M., Zappatore, M., Gao, H., Gao, B., Bucciero, A.: E-learning, e-education, and online training, pp. 1–374. Springer, USA
10. Fan, X., Yuan, Z., Guang, Z.: Research on the evaluation method of power communication transmission network operation state based on multi-strategy equilibrium. Power Inf. Commun. Technol. **10**(14), 109–113 (2017)
11. Zheng, P., Shuai, L., Arun, S., Khan, M.: Visual attention feature (VAF): a novel strategy for visual tracking based on cloud platform in intelligent surveillance systems. J. Parallel Distrib. Comput. **120**, 182–194 (2018). https://doi.org/10.1016/j.jpdc.2018.06.012
12. Liu, S., Li, Z., Zhang, Y., et al.: Introduction of key problems in long-distance learning and training. Mob. Netw. Appl. **24**(1), 1–4 (2019). https://doi.org/10.1007/s11036-018-1136-6