Research and Application of Power Information Risk Early Warning System Based on Big Data

Zhenying Tang¹, Yeteng An¹, Ziqian Li¹, Liyang Xu¹, Fan Li², *, He Wang²

¹State Grid Customer Service Center
²Nanjing Data Foundation Technology Co., Ltd.

*Corresponding author email: 782742370@qq.com

Abstract. With the increase of power equipment and business systems and the increasing complexity of IT system architecture and operation scale, the existing manual operation and maintenance mode can no longer meet the needs of business. This paper proposes an electric power information risk early warning system based on big data, which analyzes operation and maintenance data from five angles of transaction analysis, trend analysis, comparative analysis, composition analysis and comprehensive analysis. The system consists of three parts: data collection, data management, data analysis and risk early warning. By improving the operation and maintenance automation level, the system security level and operation efficiency are greatly improved.

1. Introduction

With the rapid development of electric power informatization, the objects and boundaries of electric power information system operation and maintenance are constantly expanding, the operation and maintenance management is becoming increasingly complex, the two operations are growing rapidly, and the operation and maintenance requirements are continuously improving. The end between the existing manual operation and maintenance mode and the operation and maintenance development requirements is becoming more and more prominent. The network topology relation is difficult to maintain manually due to its complex architecture, the low efficiency of manual patrol inspection is difficult to find the network availability state, and the failure is difficult to locate due to incomplete state information. With the increase of business volume, the increase of the quantity and quality of operation and maintenance personnel leads to the continuous increase of cost consumption. There are a large number of table maintenance status quo for basic account data of machine room, such as equipment data and cabinet data, which is difficult to maintain, share information and process. Therefore, in order to improve the operation and maintenance management level of the national grid power system, we must pay attention to the research and introduction of intelligent information technology for operation and maintenance, so as to meet the needs of new environment, new situation and new tasks, and ensure the safe, stable and efficient operation of the information system.

At present, large data platforms and statistical methods have been used to construct the power grid information operation and maintenance early warning system at home and abroad. Literature [1] uses a variety of statistical methods and classification models based on deep neural networks, which can not only give advance warning to the state of substation equipment, but also accurately judge the possible fault types of substation equipment, thus greatly improving the health level of substation equipment.
Literature [2] based on big data, using six methods to efficiently analyze the operation and maintenance data such as infrastructure data, established a power grid information operation and maintenance early warning method system. Literature [3] used the Hadoop platform to analyze and collect data from sensors and video surveillance, and judged the running status of high-voltage cables, which greatly improved the operation and maintenance efficiency. Documents [4] [5] proposed an information and communication risk early warning system based on big data, realizing real-time warning and accurate trend prediction of the operation and maintenance system, and improving the efficiency of operation and maintenance.

Power grid information early warning technology based on machine learning is also widely used. The method is also used in the literature [6] by using logistic regression, deep learning and other machine learning methods to achieve online monitoring of the status of substation equipment, real-time fault detection and early warning, and successfully applied to 101 substations. Literature [7] proposed a trend-based intelligent analysis and adaptive data collection method, which improved the stability of power communication networks. Reference [8] combined "micro operation and maintenance" tools with traditional monitoring platforms to improve operation and maintenance efficiency. Literature [9] combined association rules and analytic hierarchy process and proposed the Apriori-AHP risk assessment method, which improved the accuracy and effectiveness of the risk assessment of the power communication business. Reference [10] calculates the possibility index of failure through the BP neural network, which can effectively evaluate the short-term operation risk of the power grid and adjust it in time to reduce the threat of galloping to the power grid. Literature [11] developed a set of network security algorithms based on log analysis using the improved FP-Growth algorithm, which can detect and communicate security threats to information and communication systems. Literature [12] used K-means, Apriori algorithm and D-S evidence theory to establish the health index and importance index of power equipment, which significantly reduced the risk of power equipment operation and maintenance decisions.

2. Risk Early Warning System Architecture
The risk early warning framework of power information risk early warning system mainly consists of data collection, data association, data analysis, risk identification and trend analysis.

![Risk early warning framework of power information](image)

Figure 1. Risk early warning framework of power information
2.1. Data collection
On the basis of comprehensive monitoring, the aggregation of core business operation and maintenance data is realized through data aggregation management.

2.2. Data association
Through analyzing the relationship between the core business system, the call platform, the online customer service system, the intelligent knowledge base and the robot's business operation, the relationship between the system monitoring data and the mobile ring of the machine room, and the relationship between the robots. Through the effective configuration, encapsulation and integration of each link system, the core system-centered associated network topology is formed to organize and analyze the risk identification and trend of the core system and the associated impacts.

2.3. Data analysis and risk early warning
By monitoring hardware devices such as switches, firewalls, servers, and application nodes such as core business systems, call platforms, intelligent knowledge bases, and robot systems, the extended analysis capability centering on these devices and/or nodes is built. When the monitoring node is abnormal, the system can quickly track the node, not only from a single dimension to in-depth analysis, but also from multiple dimensions to systematically analyze, comprehensively display its operation status, associated nodes and other operation information, thus realizing the control of the system operation status.

Building a standardized analysis process of business scenario correlation analysis, on the basis of data collection, correlation and analysis, through in-depth customization of business scenarios, the risk identification and trend analysis capability of the monitoring system is finally realized.

3. Data analysis and risk early warning method
By monitoring hardware devices such as switches, firewalls, servers, and application nodes such as core business systems, intelligent knowledge bases, and robot systems, the extended analysis capability centering on these devices and/or nodes is built. When the monitoring node is abnormal, the system can quickly track the node, not only from a single dimension of in-depth analysis, but also from multiple dimensions of system analysis, comprehensive display of its operation status, associated nodes and other operation information, so as to achieve the control of the system operation status.

3.1. Transaction analysis alert
By comparing the current index data with the historical/forecast/baseline index data, the abnormal data is found as the starting point for further analysis.

![Figure 2. Business changes](image)

As shown in Figure 2, the historical mean curve is obtained through the calculation of historical values, which are generally daily or monthly averages. When examining whether the operation is normal, you can compare the current value $Y$ with the historical average at a certain moment, and find that the
The current value relative to the historical average is ($\Delta / \bar{Y}$) %. If the change amplitude exceeds the normal range, it is regarded as the analysis object abnormality, and the influencing factors can be analyzed according to the change period.

### 3.2. Trend analysis warning

Through the trend analysis of the historical data of the index in a specific cycle, the change trend of the operation quality is reflected.

![Figure 3. Trend analysis](image)

As shown in fig. 3, a trend line is formed by the one-month value of the failure processing ratio of processing link 1, which reflects the trend of the index. The trend line is generally composed of multiple peaks and troughs. If the peaks and troughs are correspondingly higher than the previous peaks and troughs, then it is called an upward trend. On the contrary, if the wave crest and wave trough are lower than the previous wave crest and wave trough, then it is called downward trend. For indicators whose ideal trend is an upward trend, such as top-up transaction volume, if a downward trend is found on the trend line, it needs to attract the attention of business operation and maintenance personnel. On the contrary, for indicators whose ideal trend is a downward trend, such as the backlog of startup work orders, if an upward trend is found on the trend line, there may be problems in the business system, requiring business operation and maintenance personnel to find out the reasons in time. Trend analysis is generally applicable to analysis of single index value.

### 3.3. Comparative analysis and early warning

The comparative analysis method usually compares two interrelated index data, or compares the data of different dimensions and different links of the same index, and quantitatively shows and explains the size of quantity, the level of efficiency, and whether various relationships are coordinated. As shown in Figure 4, the blue red curve represents the comparison curve of business volume indicators in different links, and the indicators shown in this figure are normal indicators.
3.4. Composition analysis early warning

In data analysis, some indicators have composition relations (for example, the total average duration in the whole system operation process is composed of the average duration of the three business processing links), and basically consistent composition ratios can be found according to experience. If the composition ratio curve is abnormal, analysis should be carried out in time.

As shown in fig. 5, the total average duration of business processing consists of three parts: the average duration of business link 1, the average duration of business link 2, and the average duration of business link 3. By analyzing the proportion of processing time in these three links, we can find out the proportion rule of the three links. If the proportion of one link exceeds the ideal situation, it needs to be analyzed in a timely manner. Composition analysis is applicable to the proportion analysis of related indicators, related businesses or links.

3.5. Comprehensive analysis and early warning

Two analytical methods are provided, either a single analytical method or a combination of multiple analytical methods. Comprehensive analysis method is generally suitable for comprehensive analysis of single index and multi-index and multi-dimension.

4. Practical Application of the System

The system has been applied in the national network customer service center. By improving the automation and intelligence level of operation and maintenance, the system safety level and operation efficiency are greatly improved, the labor and maintenance costs are reduced, resources are intensively
used, independent innovation is relied on, and the role of informatization in improving quality, increasing efficiency and leading innovation is played.

5. Summary

According to the State Grid Information Operation and maintenance status, this paper constructs a power information risk early warning system based on big data. From the five angles of transaction analysis, trend analysis, comparative analysis, composition analysis and comprehensive analysis, the operation status and operation information such as associated nodes are comprehensively displayed. Not only can the fault be located efficiently, but also the fault existing in the power information operation and maintenance system can be analyzed from multi-index and multi-dimension, thus comprehensively improving the operation and maintenance level.

References

[1] Fan Liping, Zhang Xiaohui, Su Wei. Research and application of fault early warning for transformer equipment based on big data mining [J]. Electric Power Big Data, 2019, 22 (01): 1 - 7.
[2] Chen Long, Wan Ming, Li Shifeng. Active monitoring and early warning system for power network information operation and maintenance based on big data [J]. Electrical Application, 2015, 34 (S2): 522 - 525.
[3] Zhai Guo, Li Huan, He Haohui, Luo Xinhong. Research on the application of high-voltage cable operation and maintenance management based on big data [J]. Enterprise Technology Development, 2019, 38 (07): 77 - 80 + 89.
[4] Wang Jianqing, Jin Dan, Yu Jun, Wu Qianjun. Research on early warning technology of electric power information communication based on big data [J]. Electric Power Information and Communication Technology, 2017, 15 (09): 64 - 69.
[5] Chen Long, Hao Hanyong, Chao Yujian, Li Peng, Luo Ling, Ma Yuandong, Hu Yang. Research and Application of Intelligent Risk Early Warning Strategy for Electric Power Information Network Based on Big Data [J]. Electric Power Information and Communication Technology, 2019, 17 (01): 18 - 24.
[6] Fan Liping, Zhang Xiaohui, Su Wei. Design and application of a new type of substation intelligent operation and maintenance platform [J]. Electrical Switch, 2018, 56 (05): 100 - 102.
[7] Lu Shunli, Wu Desheng, Zhu Pengyu. Research and Application of Key Technologies of Adaptive Data Acquisition Based on Intelligent Analysis [J]. Electric Power Information and Communication Technology, 2018, 16 (06): 73 - 78.
[8] Wang Dongbao, Du Wenyong, Deng Zhidong, Li Huiqin, Lu Jingxian, Gan Kun. Introduce "micro operation and maintenance" to build an integrated information monitoring and management platform [J]. Electric Power Information and Communication Technology, 2018, 16 (01): 106 - 110.
[9] Lu Shunli, Yang Jihai, Deng Wei, Shi Jian, Lu Tao. Research and Application of Apriori-AHP Algorithm in Risk Evaluation of Electric Power Communication Network Business [J]. Computer and Digital Engineering, 2018, 46 (04): 667- 671 + 681.
[10] Chu Shuangwei, Xiong Xiaofu, Liu Shanfeng, Liao Jun, Wang Jian. Short-term risk assessment of power grids taking into account galloping of transmission lines [J]. Power System Protection and Control, 2018, 46 (09): 86 - 93.
[11] Li Gang, Chen Yixiao, Huang Peishuo, Li Yang, Yan Li, Xue Honglin. Research on early warning of information communication network security based on log analysis [J]. Electric Power Information and Communication Technology, 2018, 16 (12): 1 - 8.
[12] Cai Zexiang, Ma Guolong, Sun Yuyan, Huang Yuhan. Data mining operation and maintenance and decision analysis methods for power equipment [J]. Journal of South China University of Technology (Natural Science Edition), 2019, 47 (06): 57 - 64 + 71.