Research on Intelligent Supervision Technology of Power Operation Security Risk Based on Internet of Things

Yuanlin Li¹, Fan Deng²*, Weiliang Li¹, Yajie Chen¹

¹ Hubei Central China Technology Development of Electric Power C., Ltd. Wuhan, China
² School of Geosciences, Yangtze University, Wuhan, China

*Corresponding author e-mail: dengfan@yangtzeu.edu.cn

Abstract. According to the situation of power production safety and existing problems, this paper proposed a security intelligent monitoring solution for power grid based on Internet of things. The solution integrates the perception, communication and analysis technologies with the characteristics of the Internet of things. In the field, intelligent mobile terminals, intelligent security tools and other multi-source sensing equipment are used for on-site safety monitoring information collection, and data communication is realized by integrated application of 4G and narrowband Internet of things (NB-IoT). On this basis, cloud computing and edge computing are used to jointly analyse and evaluate security risk big data.

1. Introduction
The operation environment of power grid is becoming more and more complex, and the safety risk supervision of people, equipment and power grid operation in power production process is facing higher challenges.

The safety supervision department of electric power has summarized a set of effective methods and management experience in many years of safety work, but there are still many problems in the severe safety situation, such as the shortage of safety inspectors, resulting in the limited coverage of inspection. The reporting of on-site information often leads to the lack of timely and authentic process control information and the timely elimination of on-site hazards after work. Insufficient accumulation of security data and inadequate analysis model building lead to inadequate ability to predict security; Cross-disciplinary business collaboration and data fusion are not strong enough to make good use of existing resources and capabilities.

The effective integration of smart grid and Internet of things has become the development strategy and development goal of developed countries. With the support of governments of the United States and European Union, the development model of smart grid and Internet of Things integrating and promoting each other has become one of the important measures for developed countries to occupy the global market [1]. In June 2013, America's first large-scale smart grid went into operation. This smart power grid uses millions of smart instruments and meters, and its main feature is to use the Internet of things technology to connect all intelligent instruments and meters to the network for unified management, which fully meets the user's demand for power while improving the power grid's ability of flexible power supply and intelligent dispatch.

In China, the research scope of IoT technology and smart grid technology is very extensive, including almost the entire transmission link of power system. According to the technical platform and
functional characteristics of the smart grid in each link, the researchers proposed the layered IoT system architecture for the four links of smart grid power transmission, power transformation, power distribution and power consumption [2].

Therefore, this research starting from the necessity and urgency of electricity safety regulation, focusing on the shortage of the existing security management and information systems to introduce large data, cloud computing, mobile computing, etc. New technology, with the Internet of things as the top carrier system framework, build intelligent electric power safety risk supervision system, by means of informatization and innovation to improve the efficiency and effect of safety regulation.

2. The IoT model for the safety supervision system

The model architecture of electric power safety monitoring Internet of things is shown in figure 1. The classic IoT model structure is the layer of perception - network – application [3]. On this basis, this research model is enriched and expanded according to the actual needs of power safety supervision.

2.1. Perception layer

Make a comprehensive application of perception to the elements involved in safety regulation -- personal, power grid, environment. In terms of the perception of personal safety, the sense and recognition of the identity of personnel are realized through the sensing equipment such as camera and RIFD, and the identity consistency test is conducted. Through mobile video equipment and intelligent safety tools, the construction behavior compliance of personnel is perceived and examined. On the perception level of grid security, the security situation of the grid operating state is perceived through the state sensors such as current and voltage, which are attached to the power facilities. In terms of the perception of environmental security, it senses and forecasts the weather and other external environmental factors through external sensor information.

2.2. Communication layer

Through the communication transmission of various wireless and wired networks, external power networks and internal power networks, the transmission and convergence of perception-layer data can be realized. After analysis and judgment, information such as warning will be transmitted in reverse to realize necessary connection between the site and the main station, people and things, and things and things.

2.3. Service layer

The service layer is responsible for the aggregation of sensor information, analysis and calculation, as well as the integration with regulatory business and processes, and is the "central brain" of the whole system. Its service capacity not only relies on the cloud computing foundation and capacity of the external network and the Internet, but also on the ability of horizontal business data penetration of the internal network.

2.4. Application layer

The large-screen visualization application terminal is located in the command hall of more than 100 safety supervision centers in provinces, cities and counties. The PC terminal is also located in the third-level security supervision center, which is used for daily supervision duty. Mobile terminal for different user roles have different function, working controller role for the data input of safety control, including text, images, video, positioning information; The role of the field inspector is used to obtain evidence for the safety of the field operation.
3. Key technologies in the IoT model for the safety supervision system

3.1. Narrowband Internet of things (NB-IoT) communications technology
At present, using wireless sensor network technology to build power communication network is a new trend. Among the numerous wireless sensor network technologies, NB-IoT technology is the one with the most application advantages at present. It has the features of wide coverage, large connection (the connection amount of the same base station), low power consumption, low cost and low speed, and is an effective two-way interconnection wireless communication technology.

3.2. Internet of Things connection management platform
In the face of a large number of IoT connected devices, how to effectively and orderly informatization management of them using SIM cards is an important issue. Based on this requirement, an IoT connected management platform is established to form a complete management system. The system structure diagram is shown in figure 2.

3.3. Internet of Things positioning technology
With the improvement of the third-generation technical system, beidou system is superior to GPS in terms of signal system. Beidou RTK precision can reach cm-level on the plane, with higher reliability and better anti-interference ability. Since 2010, state grid has vigorously promoted the application of beidou in the power industry. In the field of power grid control, dispatch automation system time
synchronization, power communication network frequency synchronization, accurate positioning of people and vehicles, and the use of beidou short message in remote and unmanned areas of data collection and return have formed a variety of application solutions.

3.4. Cloud-edge collaborative security big data computing and processing technology

As an application of video intelligent monitoring in power industry, power safety management can introduce edge computing theory to improve the real-time intelligent analysis level of video monitoring data and environmental state perception data in operation site \cite{4,5}. On this basis, the study on intelligent scheduling of electricity safety supervision mobile video coordinated by cloud edge is carried out to improve the efficiency of safety supervision and reduce the labor cost.

The edge computing framework of video for power safety management adopts cloud edge coordination \cite{6}. The edge computing node realizes the real-time monitoring and intelligent analysis of the operating environment by using the on-site environmental perception data, and analyzes and identifies the illegal operations of operators on the scene video screen, and extracts the illegal events. According to the types of violations, different video diversion strategies (local storage, video synchronization and abstract upload, etc.) and queuing strategies (split scheduling, hierarchical scheduling and video description framework priority) were selected. Through a series of intelligent analysis and scheduling strategies mentioned above, real-time extraction and return of safety tube video can be guaranteed. The safety level and event type of the operation points received by the power safety management cloud shall be subject to video monitoring and scheduling. The edge calculation framework of electric power safety management video is shown in figure 2.

![Figure 2. Electric power security management video edge computing framework](image)

4. Conclusion

This paper proposes an information-based solution to the security risk control of power operations based on the Internet of things architecture. The scheme integrates multi-source perception, Internet of Things communication and big data analysis technology. Multi-source sensing equipment such as mobile terminals and intelligent security tools are used to collect safety monitoring data at the job site, and information communication is realized by integrating 4G and narrowband Internet of Things (NB-IoT). On this basis, cloud computing and edge computing combined to analyze and evaluate security risk big data can significantly improve the level of security risk management and control of power operations.

References

\[1\] XIN Pei-zhe, CAI Sheng-xia, ZOU Guo-hui, YUAN Shuang-chen, WANG Shou-xiang. Development strategy research of smart grid adapting to new era economic and social development[J]. Distributed Energy, 2018, 3(1): 21-27.

\[2\] SONG Xuan-kun, HAN Liu, JU Huang-pet, CHEN Wei, PENG Zhu-yi, HUANG Fei. A review on development practice of smart grid technology in China[J]. Electric Power Construction, 2016, 37(7): 1-11.

\[3\] Gubbi J, Buyya R, Marusic S, et al. Internet of Things (IoT): A vision, architectural elements, and future directions[J]. Future Generation Computer Systems, 2013, 29(7):1645-1660.
[4] SHI Wei-song, SUN Hui, CAO Jie, ZHANG Quan, LIU Wei. Edge-computing—an emerging computing model for the Internet of everything era[J]. Journal of Computer Research and Development, 2017, 54(5): 907-924.

[5] SHI Wei-song, CAO Jie, ZHANG Quan, et al. Edge Computing: Vision and Challenges[J]. IEEE Internet of Things Journal, 2016, 3(5):637-646.

[6] WANG Jing-fu, YANG Xin. Research on MEC and its application in video service[J], Telecommunications Network Technology, 2017, (12): 52-56.