Research on Terminal Management Technology Based on Distribution Management System

Song Yinghua\textsuperscript{1,2*}, Wang Gang\textsuperscript{3}, Li Zhongwei\textsuperscript{1,2}

\textsuperscript{1}NARI Group Corporation (State Grid Electric Power Research Institute), Nanjing, 211106, China
\textsuperscript{2}NARI Technology Co., Ltd, Nanjing, 211106, China
\textsuperscript{3}State Grid Liaoning Electric Power Supply Co., Ltd, Shenyang, 110004, China
\textsuperscript{*}Corresponding author’s e-mail: ssyyhh786@163.com

Abstract. With the continuous development of distribution automation technology and the rapid growth of the number of distribution equipment, this paper analyzes how to carry out the operation management of distribution network equipment and the key technology of application based on the existing distribution management system. The key technologies include the unified management, automatic control and online monitoring of equipment. Through the research of related technologies, the rapid and effective management and control of mass distribution equipment is realized, the management efficiency of equipment is improved, and the technical support means for the rapid construction of distribution network are provided.

1. Overview
In recent years, with the rapid development of distribution network construction, the research of distribution automation technology continues to deepen, and the operation and management of distribution network equipment is gradually valued by power companies. Since 2012, large and medium-sized cities in China have successively built distribution automation main station and distribution network emergency repair system, which plays a positive role in improving the operation monitoring level of distribution network, fault emergency repair efficiency and power supply reliability, but there has been a lack of effective technical means in equipment operation management. How to use the existing research results of distribution automation to carry out the research of distribution network equipment operation management technology and realize the efficient management of distribution equipment is an urgent problem to be solved in the construction of distribution management system [1-3].

Based on the development of dispatching automation, distribution automation and rush repair dispatching in most areas, this paper proposes an intelligent distribution network equipment operation management system, and studies the key technologies, focusing on promoting the construction and practicality of distribution equipment management function.

2. Key technology composition
The operation management technology of distribution network equipment is divided into two parts: operation and failure, and the key technology composition is as follows. In the equipment operation stage, it includes terminal management, operation risk assessment, reliability analysis and other
technologies; in the equipment failure stage, it includes equipment defect management, equipment change management and equipment self-healing strategy management. We elaborate on several important technologies.

![Device Management](image)

Figure 1. Device management function diagram

3. Key technologies

3.1. Terminal Management Technology

As the coverage of power distribution automation increases year by year, the number of power distribution collection terminals is increasing, and the workload during the access terminal debugging and subsequent operation and maintenance of power distribution terminals is increasingly heavy and inefficient. Excellent terminal management software can not only greatly reduce the debugging time of distribution management systems and field terminals, reduce the workload required for data access, but also enhance the terminal maintenance and management capabilities of the distribution management system. The operation and maintenance cost of the power distribution terminal improves the operation efficiency of the entire power distribution management system [4-5].

Based on the requirements of distribution terminal management and the analysis of distribution management system architecture, we recommend that the distribution terminal management software has the following functions:

- **Battery monitoring**
  The storage battery of the power distribution terminal equipment provides power for the normal operation of the power distribution terminal and the operation of the switch, especially in the process of fault isolation and recovery after a power failure. Therefore, the reliability of battery performance is of great significance to the reliability of the entire system. On the one hand, after the power distribution terminal is put into operation, it is basically no longer maintenance, and it is not realistic to check the battery one by one. On the other hand, the performance of the battery is difficult to judge from the appearance. Impact, with increasing operating time, battery aging is inevitable.

- **Terminal status monitoring**
  There are many types of terminals in the power distribution system, and there are various communication methods. Terminal operating conditions frequently occur, and there are many reasons for the abnormal status of the power distribution terminal, such as the quality of the terminal itself, the quality of the communication line, or the configuration of the automation system. If comprehensive analysis can be made by combining the state of the terminal with the state of the communication network, it will be beneficial for the system maintenance personnel to carry out the terminal management work, and it will also be convenient for access debugging and handling of problems with abnormal terminal status.

- **Wireless traffic monitoring**
  Wireless communication, as an important method of terminal communication, is becoming more and more widely used in the field of power distribution automation. At present, mobile companies
calculate the cost of wireless communication according to the traffic method. In most areas of China, mobile offers small monthly data packages, which can basically meet actual needs. However, during the operation of the terminal, wireless traffic often gets out of control and exceeds the expected cost. Therefore, it is necessary to count the communication traffic of the wireless power distribution terminal and analyze whether there is abnormal traffic in the APN leased line as a reference basis for the wireless access quality and tariff management of the power distribution terminal.

- Online rate statistics

  The terminal online rate is an important indicator for evaluating the distribution management system, and it reflects the data access situation of the entire system. In actual engineering applications, the terminal online rate can also be subdivided, such as the terminal online rate of different manufacturers, the terminal online rate of different types, the terminal online rate of different communication methods, and the terminal online rate of different regions. By refining the classification, the lean management capabilities of the terminal can be improved.

- Remote modification of protection setting

  Protection setting is the basis for correct operation of relay protection. Correctness and adaptability of setting value play an important role in correct operation of relay protection and safe operation of power network. Because the operation mode of the distribution network changes frequently, in order to ensure the safe, stable and reliable operation of the distribution network, the relay protection device value should be adjusted accordingly with the change of the operation mode. Relying on the traditional manual modification of the fixed value on the spot will inevitably increase the workload of operation and maintenance personnel, so terminal management needs the ability to modify and check the fixed value remotely.

3.2. Equipment Risk Warning Technology

Distribution network is an important part of power system, its security and reliability will directly affect the development of national economy and the living standard of residents. According to incomplete statistics, 80% of power outage faults in China are caused by distribution network faults. Therefore, how to improve the power supply reliability level of distribution network has very important practical significance[6-7].

Real-time monitoring of distribution network operation mode and equipment risk warning, timely detection of hidden dangers in the operation of distribution network, and early warning can significantly improve the power supply reliability of distribution network.

Equipment risk warning is divided into two parts: operation mode prediction and electricity risk.

- Risk Assessment of Distribution Network Operation Mode and Operation Status

  Through dynamic analysis of distribution network operation mode, weaknesses and risk points in the distribution network can be found in real time. Visual display methods such as coloring, flickering, graphic positioning, index comparison, key indication can help dispatchers focus on monitoring and pay attention to the development of distribution network risk points.

  There are several types of potential power supply risk in distribution network:

| Serial No. | Types                        | Result                                                      |
|-----------|------------------------------|-------------------------------------------------------------|
| 1         | Line maintenance             | Load of opposite side communication line lost                |
| 2         | Area load                    | The local load density is too high, and it is difficult to transfer the connection line. |
| 3         | Peak power segment           | Line overload and overload                                   |
| 4         | Changes in operation         | Distribution radius is too long                              |
| 5         | Power supply for important loads | Multiple power sources cannot be reliably guaranteed        |
Distribution network operation mode and operation state risk assessment will make dynamic analysis of the above operation states, and give the evaluation results and optimize the auxiliary decision-making, providing a convenient and fast means of operation for dispatchers.

Electricity risk warning

Distribution network operation dispatch is concerned from the point of view of user power consumption. The distribution management system is combined with the regional power dispatch automation system, and further analysis is based on the static security evaluation results of the superior dispatch system. Combined with the information exchange among distribution automation information systems, such as the operation information of medium voltage distribution network equipment obtained from the analysis of distribution management system, the low voltage user information is obtained from the marketing system, the data of power automation system running through the high, medium and low voltage levels are analyzed, and the analysis results are displayed in the distribution management system.

3.3. Plug and Play Technology

An important feature of distribution network is the wide range of terminal equipment points, which leads to the high cost of construction and maintenance of distribution network automation. The communication protocol currently used only solves the problem of data transmission, but there are still some problems such as unclear data meaning, weak data association, and lack of self-description capability of terminal devices. How to achieve fast and efficient access of distribution terminals has been a major problem that plagues the development of distribution network automation[8-9].

IEC 61850 provides a unified standard for substation automation and provides a basis for interoperability between different terminal devices. This paper applies substation automation technology and methods to distribution network automation, and combines with IEC 60870-5-104 standard, which is widely used at present, solves the problem of interactive communication between distribution terminals and the main station of distribution management system, finally realizes the plug and play of distribution terminals, and reduces the workload of construction and maintenance. The specific research content includes the following two aspects:

1) Automatic discovery and identification of distribution terminals for plug and play of distribution terminals

2) Fixed-value management of distribution terminals, historical data access.

Implementation Principle

Distribution management system communicates with distribution terminals through two separate channels. The real-time data channel is the original data channel. Three remote real-time data is transmitted by IEC-104 or IEC-101, and a new WebService communication mode is added to transmit model information and historical data. The detailed communication mode is shown in the following figure.

![Plug and Play schematic diagram](image_url)
Automatic Discovery

After the distribution terminal is connected to the distribution automation communication network, the distribution management system scans the fixed network IP, discovers the new distribution terminal, and remotely modifies the actual IP of the terminal. The principle is as follows:

1) Distribution management systems create registration service ports, open monitoring services, configure the IP address of the primary station's front server when the distribution terminals are installed, initiate connections actively, and establish communication links.

2) Distribution terminals send terminal information, such as terminal number (public address) or name, etc. Distribution management system will identify specific terminal devices after receiving the information.

3) Distribution management system chooses the actual operating channel of the terminal to communicate with the distribution terminal and transmits data remotely in the original way.

Automatic Interaction

Distribution terminals transmit information such as device self-description information and service capabilities to distribution management systems. Automation systems can select services they need to subscribe to within service items supported by terminals. Based on the distribution model information of automation systems, system configuration files of terminals are generated and distributed to distribution terminals. Distribution terminals generate their own configuration information based on the received system configuration files.

To achieve automatic interaction of distribution terminal equipment information, the specific process is shown in the following figure. The combination of automatic interaction of distribution terminals and standardized terminal construction can simplify the interaction process of distribution terminals, further reduce maintenance workload, reduce the probability of error, and be more conducive to the promotion and application in engineering projects.
Remote Debugging

1) On-site debugging of distribution terminals
Distribution terminals provide in-place debugging tools to test the connection between distribution terminals and primary equipment on the site, as well as the functionality of remote sensing, remote signal collection and remote control.

2) Debugging of distribution terminals and distribution management systems
For distribution terminals with wireless communication, before installation in the project site, the warehouse and distribution management system can be jointly debugged to ensure that the three remote interactions between the background system and the terminal are normal.

4. Summary
How to improve the operation and management efficiency of distribution network equipment based on the existing distribution management system and related technologies is of great significance for the lean management of equipment. In this paper, we start from several links of equipment operation, and intercept several important functions to elaborate.

Of course, in the management of power distribution network equipment, we still need to carry out a lot of research and development work, such as the intelligent transformation of terminal management modules. At the same time, we also need to combine the latest science and technology to apply new technologies such as big data, artificial intelligence, and the Internet of Things to the operation and management of distribution network equipment in order to continuously improve the level of distribution automation.

References
[1] GUO Jiancheng, QIAN Jing, CHEN Guang, et al. Technical scheme of smart distribution grid dispatching and control systems[J]. Automation of Electric Power Systems, 2015, 39(1): 226-231.
[2] ZHANG Tao, TIAN Bin, ZONG Zhigang, YU Yuan, et al. Planning and Typical Engineering Application of Distribution Automation. Electric Power. 2017, 50(9):44-51.
[3] WANG Liang. Discussion on application practice of distribution automation. Power system protection and control. 2016, 44(20):12-16.
[4] WANG Haoming, TANG Chong, et al. Dynamic Reliability Assessment of Distribution Network Based on Equipment State Evaluation Model[J]. Proceedings of the CSU-EPSA, 2017, 27(7):68-74.
[5] Lü Yan, DENG Chunjian, ZOU Kun. Design of Portable Antenna Device Control Equipment[J]. Laboratory Research and Exploration. 2017, 36(4):119-122.
[6] LIU Hong, ZHU Zhenhuan, MA Kang. Distribution Network Operation Risk Forewarning Based on Scenario Analysis. Proceedings of the CSU-EPSA. 2015, 27(5):39-44.
[7] LI Min, YU Shi. Research of risk early warning technology on operating state of power grid information system. Electrical Measurement & Instrumentation. 2018, 55(15), 71-74.
[8] LIANG Wumin, ZHOU Shuibin, PAN Jing, WANG Weijie, ZHENG Hao, MAO Lina. A plug and play sensor design method of high voltage equipment. Electrical Measurement & Instrumentation. 2018, 55(6):133-135.
[9] LIU Junhong, DENG Zhaoyun, LI Zeke, LI Huanming. Automatic information verification technology of smart substation based plug and play. Power system protection and control, 2018, 46(2):137-143.