The Research of Internet of Things in Operation and Maintenance for Distribution Grid

Hengbo Xu, Wenbo Wang & Qian Sun
Henan Electric Power Research Institute, Zhengzhou, Henan, China

Longjun Deng*
Xiamen Great Power GEO Information Technology Co., Ltd, Xiamen, Fujian, China

ABSTRACT: This paper takes state monitoring, operation and maintenance as business application scenarios, and then introduces the application of the Internet of things technology in equipment condition monitoring, equipment assets management, operation and maintenance of distribution network. The system realizes the accurate acquisition of running status and environmental information of the distribution network equipment through the installation of RFID, the bar code / QR Code and a variety of sensor devices. The practice shows that the application of the Internet of things technology in the distribution network operation and maintenance can effectively solve the problems of insufficient condition-based maintenance method and equipment on-line monitoring and other issues, and enhance the distribution network equipment management and utilization efficiency significantly. Meanwhile, it further enriches the internet of things’ application scenarios in the grid, and effectively supports the construction of smart grid.

Keywords: Internet of Things, distribution, smart grid, status monitoring, run maintenance

1 INTRODUCTION

At present, China’s investment in the field of distribution network is gradually increasing. The related infrastructure is being gradually improved, and also a variety of information gathering and communication network construction are carried out gradually in distribution grid. With the rapid development of information and communication technologies, condition monitoring information for a variety of operational and environmental information of distribution grid’s equipment is also being gradually improved and better. However, because the pre-distribution grid’s construction is lagging behind, the current distribution grid is still in the weakest link. In fact, it still has shortcomings in many aspects, such as monitoring information collection, comprehensive application of information and distribution network monitoring means, etc.

In recent years, the Internet of Things technology has played an important role in the electric power industry. For example, Qiu et al [1] designed a unified deployment and multi-station application of substation intelligent aided system based on the Internet of things technology, which provides a new way for the development of intelligent substation system. Wang et al [2] introduced in detail the application of Internet of things technology in power transmission and transformation equipment state monitoring and full life cycle management; Li et al [3] described how the distribution equipment monitoring can be represented as an event-based system in combination with the Internet of Things technology. Gao et al [4] proposed the application of information perception and communication network model based on the Internet of things technology in electric vehicle charging and switching operation network, which provides a new power for the development of electric vehicles. Ou et al. [5] proposed a distribution network state monitoring and early warning system based on the Internet of things technology, and realized the equipment condition monitoring, environmental monitoring, security monitoring, comprehensive analysis and query function. Yang et al. [6] introduced the application of the Inter-
net of things technology in the power company communication room monitoring and asset management. Through the use of the Internet of things technology, the communication resources are reasonable and effective and it can provide effective support for the operation and maintenance of electric power communication room.

With the development of the Internet of things monitoring technology and based on the original temperature, humidity, water immersion, current and other basic sensor types, more monitoring devices or sensors have been developed, such as the backbone node for integrated monitoring of power distribution and substation, the zero sequence current sensor and so on. The wide application of these monitoring devices can not only provide more kinds of monitoring data collection, but also can provide the data basis for comprehensive analysis, making the distribution network monitoring more effective and accurate.

In this paper, the Internet of things technology is introduced into the operation and maintenance of distribution grid. To achieve an accurate acquisition of all kinds of operating environment information of distribution grid’s equipment, RFID, the code / two dimensional code and a variety of sensor devices are deployed and installed. This paper tries to strengthen the state management idea and regulate state maintenance process of distribution grid by using the information management method based on the Internet of things technology and the continuous improvement of the management mode. The ultimate goal is to realize the closed-loop management of the information collection, equipment testing, status evaluation, risk assessment, maintenance decision-making, the implementation of maintenance, evaluation after maintenance, etc.

2 PROBLEMS FACED BY DISTRIBUTION GRID’S OPERATION AND MAINTENANCE

(1) The method of on-line monitoring of distribution network equipment is insufficient. The existing monitoring system has no real time performance of the monitoring data of the distribution network equipment. Too few data types lead to systematic analysis of the basis too one-sided, and the system is lack of effective comprehensive analysis method.

(2) Traditional state evaluation method is difficult to meet the needs of condition-based maintenance of the distribution network. As the scale of the distribution network is increasing, the number of distribution network equipment is increasing, the ratio of the maintenance personnel and equipment is unbalanced, and the maintenance workload is becoming more and bigger. Due to lack of the necessary technical means to support with condition-based maintenance work, it is difficult to finish the work in time when the personnel are limited, and this reduces the operation reliability and service level of the distribution network.

So how to transform the traditional maintenance mode to the intelligent maintenance mode is a practical problem.

(3) The assets of distribution network over a broad area, the life cycle management of equipment is difficult. In the daily inspection and assets inventory aspects, the current inventory ledger is still mainly rely on manual check of equipment nameplate, This often makes the distribution ledger, equipment asset nameplate, field device could not be mapped, resulting in a lot of manpower and material resources waste and great difficulties for field operation. And the inspection personnel cannot obtain operation status of the equipment accurately and fill in the form of field work.

3 CONSTRUCTION SCHEME OF DISTRIBUTION NETWORK OPERATION AND MAINTENANCE SYSTEM BASED ON INTERNET OF THINGS

3.1 Overall architecture

The overall architecture of the system is to follow the overall architecture of the power system, including the perception layer, network layer and application layer (See Figure 1).

The perception layer is mainly used to achieve information acquisition, recognition and collection by various sensing devices. Its focus is to achieve a unified information model, specifically including the unified identity, unified semantics, unified data format, and so on.

The network layer is responsible for the transmission and load of the information from the perception layer, which aims to enrich the communication mode through the introduction of a variety of converged communications technology. Problems of information collection, coverage and flexibility are resolved by the interconnection between the sensor and the sink node, which use the micro power wireless communication technology and so on. And the problem of remote transmission and reliability between the sink node and the access gateway is resolved by the interconnection through the optical network, PLC, wireless broadband and other technologies.

The application layer is to build a unified data model of the electric power network based on the SG-ERP architecture, and its main function is to achieve the release of a unified data service and package system. It can provide all kinds of service for the existing business system, and also provide a higher level of service function for other business systems.

3.2 Construction of perception layer

The construction of the perception layer mainly includes the equipment identification, the installation of
on-line monitoring equipment (see Figure 2), and the security of the monitoring data. Realization of the data model of perception layer is referenced by the unified information model of the electric power network. The perception layer mainly includes the following devices: (1) RFID: RFID logo for the cabinet, server, power supply, cable, fiber optic cable and other equipment. (2) RFID read head: you can use it to read or write RFID. (3) Bar code & QR Code: It can be used for the identification of a single cable or optical fiber. (4) Terminal equipment: It can be a dedicated mobile terminal or mobile phone, which can support RFID and bar code scanning, WIFI access, site information query, field work instruction and record. (5) Sensor: including environmental and energy consuming monitoring sensors. The environment sensors includes temperature, humidity, access control, water immersion, smoke sensing intelligent wireless sensor, energy consumption for different 10A, 50A, 100A wireless sensor. (6) Backbone node: It can collect the data of all the sensors in a certain range, and gather data to the convergence controller based on the unified model.
3.3 **Convergence controller**

The convergence controller is a bridge between the perception layer and the network layer. It is responsible for uploading the perception layer data to the gateway in accordance with the unified information model and the unified communication protocol. Figure 3 describes the functional architecture of the convergence controller.

3.4 **Construction of network layer**

Power optical fiber is used in this system for data transmission and communication. After the data of the perception layer is collected by the convergence controller, it uses the unified communication protocol and is uploaded to the master station through the fiber channel. The devices involved in the network layer include the convergence controller, WIFI router, communication adapter and unified access gateway, etc.

3.5 **Application Architecture**

The application architecture of the system is shown in the following diagram (see Figure 4).

3.5.1 **Basic support application**

The basic support application is to realize the configuration and management of all kinds of system data, such as the power grid monitoring, the authority and so on, and to realize information maintenance of the terminal equipment so as to form basic data of various models and monitoring related data for running the system. It provides a pluggable service component for the upper layer by providing components’ life cycle management, security management, and service management.

3.5.2 **Unified application (data) service**

In order to meet the needs of information service and multi service integration under the enterprise information architecture, multi-source data is stored and managed in a unified by the unified data and application services, and data processing is based on this. Each business application can call the system’s external release service through the ESB (Enterprise Service Bus). The services provided by the system include basic services, monitoring services, query and analysis services, security services, interactive services and comprehensive management services.

4 **FUNCTION IMPLEMENTATION**

Based on the Internet of things monitoring technology, the system obtains the operating and environment information of the distribution network equipment by installing a variety of monitoring sensors. Then, these monitoring data is uploaded to the monitoring control station accurately and quickly through the construction of effective transmission network. The background program of master station will provide effective analysis results through the comprehensive utilization of these monitoring data. The interaction between the system and the equipment monitoring data is achieved by the two-dimensional GIS interface, so as to realize the accurate positioning and fault analysis of the equipment. The main function modules of the system are as follows: (1) On-line monitoring module for distribution network equipment. (2) Whole life cycle management module of distribution network equipment. (3) Condition-based maintenance module for distribution network equipment.

4.1 **Online monitoring of distribution network equipment**

According to requirements of distribution network production, this paper selected column transformer, box type transformer, switch on column, line, power distribution room, cable branch box, towers and other distribution equipment as the research object. The system collected operating environment and state data of distribution equipment through installation of these
sensors, such as temperature sensor, humidity sensor, flooding sensor, manic sensor, fault current sensor, tower inclination sensor, noise sensor, harmonic sensor, and Leakage current sensor, etc. It provides support for the distribution network equipment’s on-line analysis, operation management, fault warning and fault location base on the monitoring of the operation condition and environment (see Figure 5).

4.2 Full life cycle management of distribution network equipment

In accordance with the relevant material encoding logo specifications of State Grid, the equipment identification has been established in system by installing RFID tags on the distribution network equipment. Operation and maintenance personnel can acquire equipment ledger information, monitoring and operation information by the field operation terminal, so as to realize the communication with the field equipment of distribution network.

In this paper, a one-to-one correspondence between the encoding of the equipment assets and RFID information is built by establishing and improving the accounting information of distribution network equipment. The demonstration project has set up the electronic assistant management system of the equipment assets and operation state, which covers the construction, maintenance, overhaul, transformation, retirement, transfer, scrap and other production processes (see Figure 6). And it realizes the full life cycle management of the distribution network equipment in
the demonstration project area.

4.3 The condition-based maintenance for distribution network equipment

Through the use of wireless handheld terminal based on automatic identification technology, we can quickly identify and locate the device properties, view online ledger information, running information, fault records, maintenance records of distribution network equipment (see Figure 7), and also can carry out on-site evaluation to support and services the condition-based maintenance for distribution network equipment.

5 CONCLUSION

Aiming at the problem that the monitoring method is insufficient and the equipment management is difficult in the operation and maintenance of distribution network equipment. The Internet of things technology is introduced into the distribution network operation and maintenance in this paper. Through the application of the Internet of things technology in the distribution network, the level of equipment management and utilization efficiency has been improved, and the state maintenance and the full life cycle management has been promoted; and the health level of the equipment and service life has also been effectively improved. Internet of things technology can all-round improve the depth and breadth of the smart grid information on all aspects of perception and provide basic data support for the realization of intelligent power system and information flow, business flow, the power flow of highly integrated. Next, it will play a huge role in the power grid construction, safety production management, operation and maintenance, information collection, security monitoring, measurement application, user interaction, etc.

REFERENCES


