Design and Implementation of Big Data Cloud Platform Supporting Fault Diagnosis and PHM System for Switch Equipment

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Abstract: Switch equipment plays an important role in railway signal system with the high failure rate. Ensuring the good work condition of railway switch equipment is of great significance for the safety and efficiency of railway transportation. Based on technologies such as information sensing, Internet of Things, cloud computing, expert system, artificial intelligence and fault prediction and health management (PHM), a structure design of the fault diagnosis and PHM system for switch equipment is put forward. A big data cloud platform, gathering and managing massive data reflecting the working state of switch equipment, is designed and implemented. It will be a powerful support for the system to reduce failure rate and improve operation and maintenance capability of switch equipment.

1 INTRODUCTION

As an important railway signal equipment, railway switch equipment is an indispensable part of ensuring the safe operation of trains. At present, the monitoring method of switch equipment relies on the data of switch action current and voltage in the centralized monitoring system of manual browsing, which has the shortcomings of poor intelligence and high leakage rate (Su K.Y., et al, 2007). The major railway bureaus in China generally adopt the mode of periodic maintenance and post-fault maintenance to maintain the switch equipment (Li N. and Dong H.Y, 2013). The health status of the switch equipment can not be obtained in time. The maintainers who are not rich in experience can not accurately judge the causes of the switch equipment faults. It is difficult to form an effective maintenance plan (Zhang X., Du X.S. and Liu C.Y, 2009).

In order to adapt to the new situation of railway development, a system for the real-time monitoring and fault diagnosis of the railway switch equipment with modern technology needs to be established (Gao C., Zhou W.X. and Zhang Y.B, 2016). It is a general trend to improve the interconnection, data sharing and intelligence level, eliminate data islands, combine information sensing, artificial intelligence, big data, cloud computing, Internet of Things and other technologies. Build an intelligent switch equipment fault diagnosis and PHM system to solve the existing problems and meet the growing demand is an important foundation for railway integrated operation and maintenance platform.

2 STUCTURE DESIGN OF THE FAULT DIAGNOSIS AND PHM SYSTEM

2.1 System Description

The fault diagnosis and PHM system of switch equipment is based on information sensing, wireless communication for data transmission, building big data cloud platform and configuring station customer service terminal, combing fault diagnosis and prediction algorithms, expert knowledge database, artificial intelligence, etc.

Big data cloud platform provides data source and serves as the basis for switch fault diagnosis and PHM. Big data and cloud computing complement each other. Data mining of big data relies on distributed processing, distributed database, cloud storage and virtualization technology of cloud computing. Cloud platform is not limited by time

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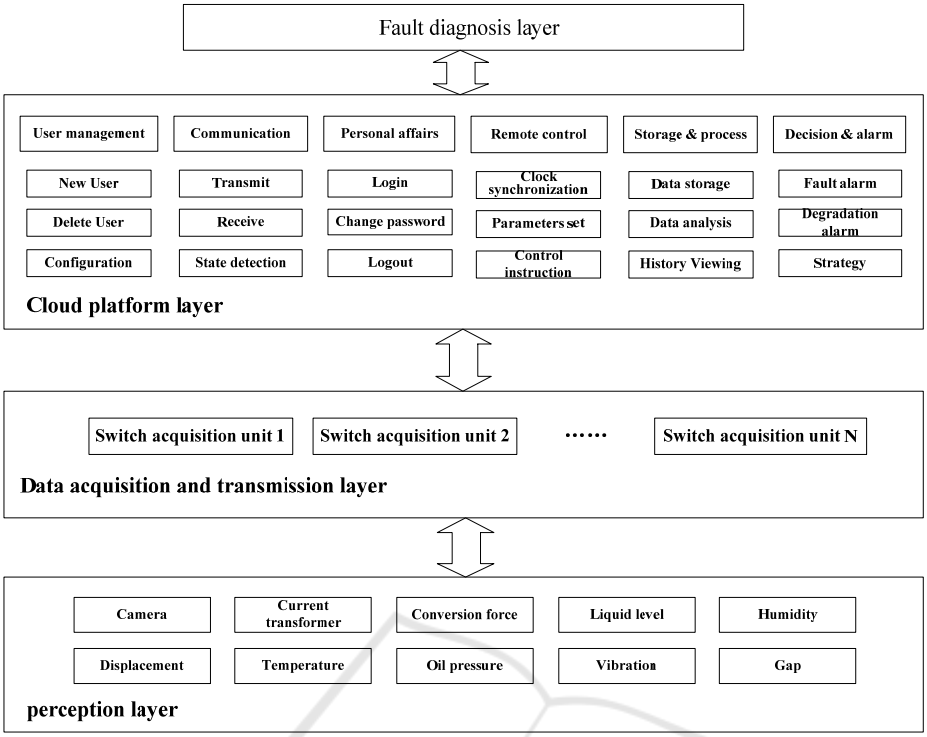

Figure 1. Structure of the fault diagnosis and PHM system for switch equipment.

and space, switch acquisition units transmit all kinds of monitoring data to cloud platform through wireless communication anytime. Large-scale data management and calculation problems of switch equipment are processed and solved.

PHM is a comprehensive subject related to the study of systemic health management. It uses the collected information to predict the system failure effectively before it occurs through various intelligent and self-learning algorithms and models to assess the health status of the system. PHM is a further expansion of built-in test and state monitoring capabilities for complex systems traditionally used. With the ability to predict future faults of the system, it transforms traditional condition monitoring into systematic health condition management, the occurrence of faults can be identified and managed. Then a reasonable maintenance plan is planned to reduce the cost. The maintainability, safety and reliability of the system are improved, the condition-based maintenance and self-support of the system are realized (Zeng S.K., Michael G.P. and Wu J,2005).

The application of PHM technology in switch system and even the whole railway signal system can describe the state of equipment through real-time monitoring data. When the equipment is in a healthy state, the system monitors continuously to analyze the degradation types, define health level, predict the possible future failure and formulate a reasonable maintenance plan. When the equipment is in failure state, the system sends alarm to identify and position the failure, shortens fault diagnosis time and improves diagnostic efficiency.

2.2 System Structure

The fault diagnosis and PHM system for switch equipment collects various state parameters of switch machine, external locking device, installation device and switch environment online, monitors and predicts the typical faults of switch equipment for a long time, and forms a reliable fault diagnosis model, which provides basis and decision-making reference for routine maintenance. The system includes sensing layer, data acquisition and transmission layer, cloud platform layer and fault diagnosis layer. The structure is shown in Figure 1.

Sensing layer consists of various sensors for running and environment status information collection of switch equipment, including camera, displacement sensor, current transformer, temperature sensor, conversion force sensor, oil pressure sensor, liquid level sensor, vibration sensor, humidity sensor and switch gap sensor.

Data acquisition and transmission layer is formed by switch acquisition units with wireless communication. An acquisition unit communicates with sensors in the sensing layer to acquire switch equipment data, and communicates with cloud platform through wireless communication, such as 4G, Lora, NB-IoT, etc.

Cloud platform layer is responsible for real-time data transmission, data display, storage, statistical analysis, remote communication, condition monitoring, fault handling, management and other functions.

Fault diagnosis layer reflects the actual situation of the switch equipment with the functions of alarm, early warning, fault diagnosis, fault prediction, operation log, maintenance suggestion, etc.

3 DESIGN AND IMPLEMENT OF THE BIG DATA CLOUD PLATFORM

3.1 Function Description

Real-time data transmission with switch acquisition unit.

Data display, storage, management and analysis.

Remote control of all switch acquision units.

Communication status monitoring.

Fault handling and alarm.

Event processing and decision making.

Safety protection.

3.2 Software Structure

Cloud platform software consists of three parts: C/S, B/S and database. As shown in Figure 2.

C/S of cloud platform is mainly used for communication with switch acquisition unit. On the one hand, the received data is stored in the database for reading by B/S at the appropriate time; on the other hand, C/S sends user commands (operation commands, switch acquisition unit parameter configuration commands, etc.) to the switch acquisition unit.

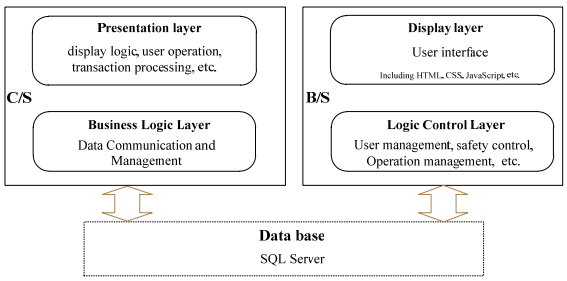

Figure 2. Software structure of the cloud platform.

B/S of cloud platform processes user operations and presenting system data and status to users.

The database is used to store data, including the data received by C/S from the switch acquisition unit, as well as the user's control instructions and operation records. At the same time, the database also plays the role of communication between B/S and C/S. The control instructions of the user for the switch acquisition unit are written to the database by B/S, and then read and sent to the switch acquisition unit by C/S.

3.3 C/S Design

Data source of C/S is used to interact with system database. Database write and query services are provided. The module encapsulates all the details of accessing the database and provides transparent data operation services for the upper layer.

Data source module of C/S is based on ADO.net data access module. Strong data sets are used as data manipulation intermediaries. The functions of the data source module in the whole C/S section are shown in Figure 3.

3.4 B/S Design

B/S of the cloud platform provides human-machine interface for users to view the system status and data. It is also responsible for interpreting the user's operations, then the related operations are transferred into commands and stored in the database for C/S to read.

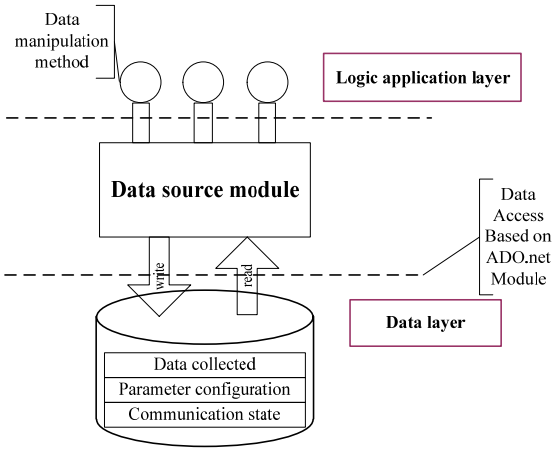

Figure 3. Data source module of C/S.

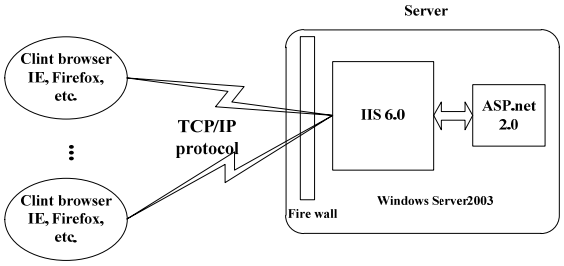

Figure 4. B/S network diagram.

The network part adopts the Web platform provided by Microsoft IIS and uses ASP. NET as the Web implementation method, as shown in Figure 4. The server side runs Windows Server operating system, which integrates IIS 6.0. The client side uses IE and Firefox browsers, and the communicaiton protocol between client and server is TCP/IP. clients interact with the server by requesting ASPX web pages. IIS receives the page request information from client browser, locates the ASPX pages, and sends the request information to ASP. NET module for processing. ASP.NET module analyses ASPX files, executes the server-side command code, generates pure HTML documents, and returns them to IIS. Finally, IIS returns HTML to the client browser.

3.5 Safety Measures

Wireless VPN private network communication is established, data is encrypted, and virtual servers are replaced by physical independent cloud servers to achieve physical isolation of data.

Clear the responsibility for security management, check and strengthen the database system, server operating system, application middleware and system source code of cloud platform, improve the overall safety of the system and ensure the normal operation of the system.

Intrusion monitoring system is set up in the cloud platform system to monitor the server operating system, prevent virus from entering the server and affect the cloud platform, prevent illegal personnel from operating, and regularly analyze and check the alarm information.

Strengthen the security of local network, design the network structure rationally, devide the system according to the importance of information, separate the general server and the core server by logical isolation, adopt higher security strategy in the control process, set up corresponding access control rules, and reduce the safety risk of the cloud platform.

According to the actual needs, configure and optimize the cloud platform system, deploy security software on the cloud platform to protect the relevant information of the cloud platform system.

Strengthen the internal audit work, establish and improve the application of security audit platform to ensure that illegal operations are tracked, traced and evidenced.

4 CONCLUSIONS

The fault diagnosis and PHM system based on big data cloud platform achieves Internet of Things of switch equipment by information sensing, distributed acquisition and wireless communication. Multiple status data of switch equipment are collected, stored and analyzed. based on PHM, expert system and artificial intelligence and combined with specific failure modes such as external locking block, closure adjustment and indication adjustment, a mathematical model to characterize the corresponding relation between switch equipment work state and fault modes can be established. On one hand, the system can locate fault position and diagnose fault causes, and guide on-site maintenance. On the other hand, the health status of switch equipment can be predicted, and the condition-based predictive maintenance strategy can be effectively executed.

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