The Exploration and Application Research of Emerging Technologies in Operation and Maintenance of Large Power Grid Enterprises

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Abstract: The new round of information technology revolution represented by big data, cloud computing, internet of things, artificial intelligence and mobile internet has created conditions for the application of operation and maintenance services in power grid enterprises. This paper deeply analyzes the development status and trend of the application of emerging technologies and its impact on power grid enterprises. This paper analyzes the problems existing in the application of emerging technologies in operation and maintenance services, such as the low level of intelligence of power grid equipment, the low level of intelligence of state detection, the management data of operation and maintenance specialty to be integrated, and the poor connection with materials, marketing and other specialties, etc., and puts forward the key points and directions of the application of emerging technologies in power grid enterprises' operation and maintenance services.

1. Introduction

1.1 Big Data

Big data is a breakthrough in traditional business intelligence and data mining technology. It uses powerful analysis tools to select, sift, process and mine huge data sets, and can visually display the results to users through data visualization and other technologies. Big data can provide a large number of high value-added services for both inside and outside the industry, which is of great help to the improvement of enterprise profitability and management control level. Big data is not only a technical means, but also a brand-new development model for the operation and development of enterprises. Under the background of big data, effective use of business data and in-depth data mining will promote more scientific decision-making and provide necessary method guarantee for meticulous management. Therefore, the current enterprises should adapt to the environment of the big data era, strengthen the innovation of management mode, rely on data for operation and decision-making, and use innovative technical means to promote the innovation of enterprise data management.
1.2 Cloud computing
Cloud computing is a strategic emerging information technology that has revolutionary impact on national economy and social development. It complements big data. Cloud computing virtualizes a large amount of hardware resources to provide users with computing resources at the bottom and supports big data processing at the top. For power grid enterprises, cloud computing integrated power grid information platform can improve the utilization rate of resources and reduce maintenance costs. At the same time, the information management platform based on cloud computing enables power grid management to break through the limitation of time and space, and information maintenance can be carried out at anytime and anywhere, and massive data in the power grid forms massive information flow under the cloud computing platform, so that different information is highly integrated, and rationality and scientificity of decision-making are improved to the greatest extent. The application of cloud computing service platform enables the integration and sharing of different information resources, which can realize the on-demand use of information resources, improve the utilization rate of information resources and the availability of the platform, and ensure the continuity of business.

1.3 Internet of Things
The Internet of Things is an important component of the new generation of information technology. Its core is the perception of data, the transmission and analysis of things and "people and things". It plays an important role in promoting industry and management. Take the condition-based maintenance technology of power grid enterprises as an example. Condition-based maintenance is a comprehensive decision-making process. This maintenance method began to be applied in the United States in the 1960s, has been popularized and applied in the nuclear power industry since the 1980s, and has rapidly developed into the power equipment maintenance management in the power industry. It is different from the previous methods of post-fault maintenance and regular maintenance in that it uses preventive experiments, on-line monitoring, historical records and other data of the whole process of similar equipment family defects to comprehensively evaluate the current state of equipment and predict the development of the situation through a variety of technical and economic means such as state evaluation and selection of the best strategy, so as to formulate the equipment maintenance plan, which is a dynamic optimization process. Compared with post-fault maintenance and regular maintenance, condition-based maintenance can save a lot of equipment maintenance funds and downtime maintenance time, so that the existing operating equipment can create greater safety and economic benefits. According to relevant statistics, after the implementation of condition-based maintenance, the equipment failure rate can be reduced by 75%, and the comprehensive maintenance cost can be reduced by 30%~50%. Through the exploration and implementation of state grid corporation system on condition-based maintenance, this equipment maintenance management strategy has obvious social and economic benefits.

1.4 Mobile Internet
Mobile Internet is a combination of mobile communication and Internet. It refers to the general name of the activities that the Internet technology, platform, business model and application combine with mobile communication technology and practice. The opening of 4G, the future 5G era and the prominence of mobile terminal equipment will surely inject huge energy into the development of mobile Internet. Mobile Internet plays a significant role in the operation and management of power grid enterprises. One is to increase the convenience of equipment maintenance. Equipment maintenance is an important link in power grid operation and maintenance. The application of substation inspection robots and mobile engineer stations is conducive to improving the efficiency of equipment maintenance and overcoming the regional limitations of equipment maintenance. The second is to enhance customers’ experience of using electricity and shorten the response speed of emergencies. Through mobile Internet, two-way communication can be carried out with customers, and various wireless electrical appliance application products can be developed to enable users to realize wireless operation. At the same time, the mobile Internet platform can meet the needs of
customer information viewing, enhanced functions and other requirements, and promote power grid enterprises to innovate marketing models.

2. Current Situation and Problems of the Application of Emerging Technologies in Operation and Inspection of Power Grid Enterprises

According to the new requirements of power grid operation safety, advanced communication technology, information technology and control technology are needed to construct a new mode of operation and inspection featuring informatization, automation and interaction, so as to realize the intelligent goals of intelligent monitoring and fault diagnosis of power grid operation state and ensure the safe operation level of power grid. Looking at the future, the following aspects of intelligence and informatization of operation and maintenance still need to be improved. Mainly reflected in the following four aspects:

Firstly, the intelligence level of some traditional power grid equipment needs to be improved, the perceived level of equipment state information is insufficient, and the key state information of some equipment cannot be obtained in real time. Secondly, the intelligence level of state detection needs to be improved. Conventional live detection instruments have low integration level, data sharing and weak data diagnosis capability, which is not convenient to carry out multi-method comprehensive diagnosis. The data accuracy and stability of the online monitoring system are insufficient, and the online monitoring technology for the important state quantity of main equipment has not yet achieved a comprehensive breakthrough. Thirdly, the integration and mining application of management data of operation and maintenance specialty need to be improved. The degree of information interaction and fusion between different information systems and different units is poor, and there are isolated islands of information. The analysis, application, mining and diagnosis of data still need to be strengthened. Fourthly, it needs to improve its internal connection with materials, marketing and other specialties as well as the construction of an extended operation and maintenance ecological system. From the perspective of power grid enterprises, there is currently no open sharing among materials, transportation, inspection, marketing and other systems, and there is a lack of open interfaces, real-time data processing and big data application analysis for interconnection and intercommunication under various application and service scenarios. The development of intelligent operation and maintenance needs to take operation and maintenance specialty as the core link of connecting materials and marketing. However, on the one hand, the current depth of data mining is limited to a certain extent due to the fact that the data of power grid equipment transformation, faults and other data are not linked with 95598 and other marketing data. On the other hand, information such as equipment failure and information such as equipment suppliers, delivery dates and product batches in material bidding and purchasing have not been traced upward. Therefore, it is urgent to take the operation and maintenance major as the key node, to realize the connection of information from the source to the end, and to build an open and shared data architecture within the power grid enterprise system. From the external extension of power grid enterprises, the operation and maintenance specialty has not yet played a pivotal role in the operation and maintenance ecosystem.

3. Focus and direction of the application of emerging technologies in the operation and maintenance business

Firstly, from the source, intelligent equipment information interconnection and access are realized based on Internet of Things technology in terms of data and information access. We will promote the deep integration of Internet of Things technology and equipment intelligence to provide equipment identification and state perception for intelligent operation and maintenance. Through the research on the grid information physical integration system and its key technologies, we will finally promote the grid equipment to form a networked physical equipment system with deep integration of computing, communication and control capabilities. Implementation of equipment status information management based on electronic tags. Formulate specifications for information content and format of various types of equipment, and use RFID cards, smart chips and other technologies to make electronic identity tags,
so as to realize the integration and lifelong of equipment and electronic tags. Through the application of equipment electronic identity tags, timely, accurate and comprehensive access to equipment ledger information in the whole life cycle, to achieve accurate identification of equipment and life cycle management, to lay the foundation for intelligent management and control.

The second is to promote the efficient integration of information system and physical system in terms of data and information collection, so as to realize real-time sensing and online monitoring of equipment status and channel environment. For power grid equipment, online monitoring and real-time perception of equipment status are realized, and efficient integration of information system and physical system in measurement, calculation, control and other multifunctional links is promoted. For example, to strengthen the operation and maintenance of on-line monitoring devices and systems for power transmission and transformation equipment, to carry out research on new technologies such as transformer winding deformation monitoring and multi-parameter optical fiber sensing technology, to expand the on-line monitoring range of equipment state quantity, to improve the reliability of on-line monitoring devices, to improve data quality, to realize the practicability of on-line monitoring technology, and to monitor the key state parameters of various main equipment in real time.

For important transmission channels, efforts will be made to improve the intelligent level of environmental monitoring and early warning for transmission channels. Strengthen cooperation with meteorological departments, develop and utilize modern satellite remote sensing and radar telemetry technologies to realize real-time monitoring of important transmission channels; Further use advanced multimedia interactive technology, use graphics and images to show the channel environment operation status, and realize the status assessment and disaster warning of important transmission channels based on real-time data. Strengthen coordination with planning and design to realize intelligent management of important transmission channel environment.

Thirdly, in terms of data information processing and application, intelligent decision-making and control are realized through big data mining analysis. Comprehensive utilization of emerging technologies such as big data and cloud computing will enable the in-depth integration of information and data of various operation and maintenance related systems, build a production management information system covering the entire process of equipment operation and maintenance business and an intelligent analysis and control system for power grid operation and maintenance, deepen the interconnection of all kinds of information in operation and maintenance work, promote the optimal allocation of operation and maintenance resources, and realize the intellectualization of operation and maintenance management and production command decision-making. Relying on the "cloud computing" architecture, build a shared resource pool and cloud platform for operation and maintenance data. In-depth analysis and put forward massive video, images, real-time equipment and environmental status data access requirements, the real-time status of equipment, environmental monitoring and early warning, mobile intelligent terminal management and other production auxiliary systems are integrated, the data are accessed into the operation and maintenance management information system, the interconnection and exchange of data source information of power grid enterprise system production-related systems are realized, the distributed operation and maintenance data sharing resource database is established, and platform support is provided for realizing intelligent management and control of operation and maintenance work. Construction of intelligent analysis and control system for power grid operation and maintenance. To form a fast response, unified and efficient intelligent management and control system for operation and maintenance, and realize advanced application functions such as multi-dimensional visual display of operation and maintenance information, state analysis, monitoring and early warning, fault diagnosis, auxiliary decision-making, risk management and control, intelligent resource allocation, production command, etc. Aiming at the multi-source heterogeneous data related to operation and maintenance on integrated platforms such as dispatching automation, human resource management, production management, environmental (mountain fire, thunder, ice, etc.) early warning, unified video, and equipment manufacturer remote diagnosis system, the large data method is adopted to intelligently analyze and mine massive multi-source heterogeneous data, thus realizing scientific and optimal allocation of operation and
maintenance resources. Scientifically determine the best repair interval and provide reasonable repair strategies. Referring to IBM's cognitive transformation and other relevant artificial intelligence technologies, the preventive maintenance is dynamically planned and optimized according to the working conditions of the equipment.

Fourthly, in the application of operation and maintenance technologies, new technologies are used to realize intelligent operation and maintenance work and greatly improve operation and maintenance efficiency. Through the popularization and application of new technologies such as live detection, intelligent patrol inspection, intelligent wearable equipment and mobile terminals, the operation and maintenance resources are optimized and integrated to realize real-time diagnosis, visualization and remote sensing of equipment status. Using robots, helicopters and unmanned aerial vehicles to push inspection technology intellectualized. To further promote the application of intelligent robot inspection. Improve the software and hardware technologies of robots, strengthen the application of mobile interconnection, GIS and Internet of Things technologies, improve the meter identification rate under severe weather and dirty meter conditions, and improve the intelligent identification ability for oil leakage of equipment, loose broken wires, foreign matters, etc.; To further promote the application of helicopter patrol inspection. Establish a helicopter patrol operation database, improve defect analysis and diagnosis functions, improve patrol efficiency, implement airborne intelligent embedded data preprocessing technology, and automatically identify high-priority defect and hidden danger information in real time; To further promote the application of UAV patrol inspection. Air patrol of power equipment on designated routes is realized to provide real-time on-site image data for power grid dispatching, disaster prevention and mitigation, operation and maintenance. Promote the application of intelligent wearable equipment. Development of head-mounted, wrist-mounted, and overalls integrated patrol inspection equipment, with infrared temperature measurement, ultraviolet detection, partial discharge ultra-high frequency, ultrasonic detection and other detection means, to achieve 3G/4G private network communication, WIFI hotspot, Bluetooth docking, GPS/ Beidou dual-mode positioning, intelligent analysis, automatic data correlation, data storage and other functions, and to achieve large data APP based on intelligent patrol inspection of key equipment, providing real-time background data automatic correlation display, query and big data service functions for patrol inspectors. Using google glass to realize remote monitoring and guidance of operation. To realize visualization of operation and maintenance. To strengthen the 2-D/3-D visualization of the substation to realize the dynamic visualization of the whole substation scene. The three-dimensional model of the real size of the equipment is constructed, and the information such as the state and defects of the equipment are correlated, and the key safety distance and other information are measured and calculated in the three-dimensional model to realize the three-dimensional visualization of the state of the equipment. Speed up the display of equipment ledger and status in three-dimensional scenes, and support three-dimensional roaming and patrol in substations/converter stations. In addition, the visualization of power transmission inspection should be strengthened. Mobile equipment with GPS positioning function is used for power transmission line inspection, and track recording function of inspection equipment is used to establish standardized account for information such as line direction, inspection path and road direction, so as to realize visualization of inspection path of power transmission line.

4. Conclusion
At present, power grid enterprises are in a critical period of comprehensively strengthening the construction of power distribution networks, promoting coordinated development of power grids at all levels, and accelerating intelligent upgrading of power grids. During the transition period of UHV AC/DC hybrid power grid construction, the operation characteristics of the "stiff and weak AC" power grid and the mutual influence between the power grids at the sending and receiving ends pose a great threat to the safe and stable operation of the power grid. At the same time, the operating environment of the power grid is also more complex and changeable. Especially with the construction of interconnection projects with neighboring national power grids, compared with traditional power grids,
the operation risk probability of future power grids is greatly increased.

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