Innovative Design and Intelligent Manufacturing
L.C. Jain et al. (Eds.)

doi:10.3233/FAIA241142

The Application of Digital Technology in Modern Smart Distribution Network Management Model

Diyu CHEN [a,1], Linmei WANG [a], Qiu LIANG [a] and Yuqing ZANG [a]
[a] *State Grid Taizhou Power Supply Company, Taizhou 318000, China*

Abstract. In order to solve the problems of inaccurate investment management and extensive process control of distribution network projects, the application of digital technology in modern intelligent distribution network management mode was proposed. Based on the SG-UAP platform, the basic data and safety management and control content in the construction process of distribution network engineering are integrated, and the design idea of lean management and control system for distribution network engineering is proposed. The test results show that only one of the concurrent transactions operated by 50 users failed to be simulated; The longest and average response times reached 9s and 3s respectively, and the CPU utilization reached 60%. When simulating the concurrent transaction operations of 100 users, only 4 failed. The maximum and average response times were 14 seconds and 7 seconds, respectively. The CPU utilization reached 68%.

Keywords. whole process, engineering safety, digitization, smart distribution grid

1. Introduction

In the face of the energy revolution and the digital revolution, the State Grid Corporation has put forward the strategic goal of building an "internationally leading energy Internet enterprise with Chinese characteristics", which provides favorable opportunities for the all-round transformation of the traditional power grid to improve its management, and also poses a serious challenge for the grid enterprises to increase their efficiency and improve their services [1]. Distribution network is located in the end of the grid, in the face of more personalized, high-quality, diversified customer demand for energy, there is an urgent need to enhance the level of digital operation and maintenance management. This paper adheres to the "non-stop service is the best service" concept, explore the crack distribution network operation and maintenance management barriers to digital drive management value-added, and strive to achieve a win-win situation for customers, power supply enterprises and society [2].

Smart distribution network actively responds to the national strategy, practicing the mission of the State Grid, and serves the local construction policy, taking the prevention and resolution of blackout risk as the core, based on the operation and maintenance management of the distribution network, which is the field that is the most closely related to the people's production and life, focusing on the "digitalization + big service", and

[1] Corresponding Author: Diyu Chen, State Grid Taizhou Power Supply Company,
E-mail: chendiyu@tz.zj.sgcc.com.cn

targeting at the goals of "small scope of blackout, fast restoration of the non-faulty area, and fast repair of faulty equipment". Area restoration fast, faulty equipment repair fast" as the goal, through strict "five passes", tighten the "five grips", strict control beforehand, during the incident, after the incident, comprehensively enhance the distribution service capacity, and strive to achieve customers, power supply enterprises, The three-way win-win situation [3]. The establishment of flexible research team, strengthen the distribution network operation and maintenance "three-dimensional" management [4]. Relying on the operation and inspection department, marketing department, control center, optimize the formation of power supply service command center (distribution network control center). Establishment of camping, distribution and transfer of power supply service resources unified deployment command platform, integration of distribution automation, distribution network control, distribution network equipment monitoring, quality of service control and other professional work, drive network structure improvement, three levels of protection with the defects of closed-loop management of the "three carriages" go hand in hand [5].

2. Literature review

In the past few years, some excellent big data stream computing frameworks have emerged. Rathor et al. proposed the MapReduce software architecture, which can perform distributed parallel computing on large-scale or even super large-scale datasets [6]. The subsequent Hadoop is based on the inspiration of GFS distributed file system and MapReduce software architecture to solve the problem of big data storage and processing. Up to now, it is still a common framework for computing large-scale datasets.

Various power load control systems and meter reading systems are the main sources of the distribution network monitoring and management system, which are composed of power generation, distribution and power transportation to ensure the safe and economic operation of the entire power system. In the United States, as early as the end of the 20th century, the informatization connection between various federal power monitoring agencies and state power monitoring agencies was completed, realizing the coordination of power monitoring throughout the country. Many developed countries in Europe have completed the project establishment of various power facility supervision informatization construction projects at the beginning of this century, and after several years of construction, the integration of multiple data and the linkage construction of supervision mechanism have been realized [7]. Japan, in view of the serious impact of the earthquake in Japan, began to deploy information technology for monitoring power facilities in response to earthquake disasters as early as the 1980s, and has become the most complete and reliable region at present [8]. Australia and other countries. The main power companies in Italy have transformed and installed 30 million smart meters, involving most regions of China, and many cities have completed intelligent power metering [9]. Many power enterprises in France are aware of the advantages of smart meters, so they have replaced a large number of ordinary meters with smart meters to supervise and control the electricity consumption of users. To know the electricity price at the first time, the methods can include E-mail, telephone, etc., and change the way of measuring and querying the company's electricity consumption [10].

With the development of the economy, countries are using more and more electricity, power supply services are also constantly upgrading, in the context of the

increasingly rapid development of information technology, Italy, the United States as the core of the developed countries have formulated a "strong smart grid" strategic policy, and its realization is the establishment of an important basis for the smart distribution network control system. As a platform for communication and interaction between power grids and customers, its main tasks are distribution network monitoring, real-time monitoring and efficient sharing and processing. With the standardization of power metering as the goal, it has been implemented in some leading enterprises, so that the informatization level of such enterprises has been continuously improved and the comprehensive strength of national power control has been continuously strengthened.

3. The research methodology

3.1. Analysis of needs for digital management of distribution network projects

3.1.1. The need for accurate investment in distribution network projects

As part of the transformation of the distribution network and the effectiveness of the incomplete grasp, so there is the same line multiple transformation, repeated transformation phenomenon [11]. At the same time, the health of the current distribution network equipment can not be fully mastered, can not accurately locate repeated tripping, long-term heavy overload, low voltage and other distribution network weak equipment, resulting in the lack of sufficient data to support the establishment of distribution network project, can not be realized to put the limited funds to the urgent need to solve the problem.

3.1.2. The need for safety control over the construction of distribution network projects

Distribution network project has a wide range of points, geographically dispersed, complex working environment and other characteristics, the process of on-site operation is more cumbersome, personnel mobility is also larger [12]. Construction unit safety awareness is weak, the level of operation is also uneven, resulting in construction site safety measures control is not in place, the site operators do not know enough about the safety risks and hidden dangers, barbaric construction and so on.

3.1.3. The need for lean control of the whole process of distribution network engineering

Distribution network engineering projects, long process, due to the lack of necessary technical support means, so can not grasp the real-time procurement of materials and services, the actual construction progress, etc., to meet the lean management requirements. At the same time, the construction unit of the construction process standardization implementation is insufficient, the current use of manual sampling method of quality control, for the quality of hidden works and technology is unable to assess, resulting in the construction quality is difficult to control.

3.2. Lean control system design for distribution network engineering

3.2.1. System architecture design

The lean control system of power distribution network engineering is mainly composed of the underlying data layer, platform layer and application layer based on the platform layer, of which the data layer includes two parts of data integration and data fusion. The system architecture design is shown in Figure 1.

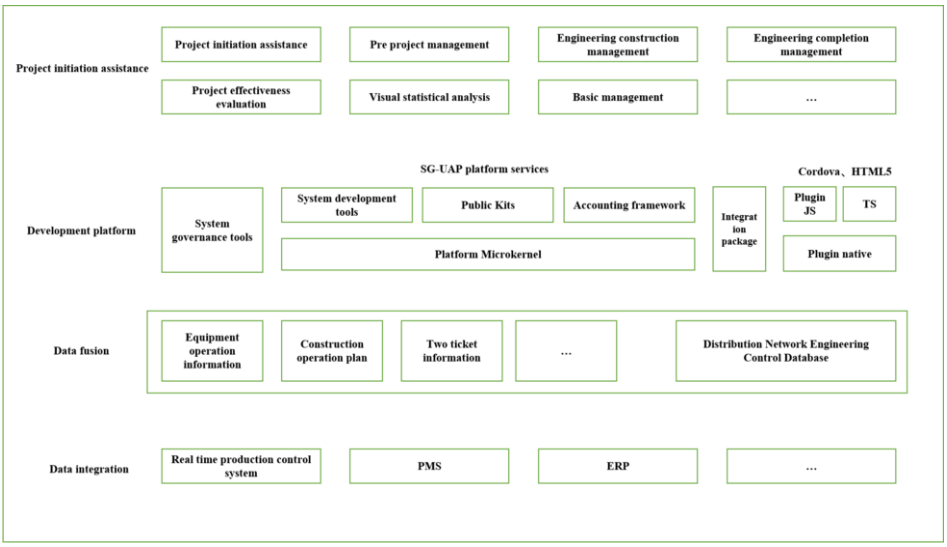

Figure 1. System architecture diagram.

(1) Data integration. Integrate the data of production real-time control system, PMS, ERP, GIS, standardized design management system and on-site operation safety control system.

(2) Data fusion. Oracle database is used to provide database services for the system. Conduct data fusion with the integrated system to obtain or push the operation data and event information of distribution lines and distribution transformers, equipment account, demand library project, plan library project, material/service procurement information, GIS model information, design results, construction plan, information on participating units, personnel and qualifications, and two ticket information [13].

(3) Development platform. BEA WebLogic middleware server is used to provide application services, and graphic plug-ins, GIS plug-ins, workflow services, report services, and message services based on SG-UAP platform provide applications for the system.

(4) System application. Application layer is oriented to specific applications, the use of a unified interface management, rights management and authentication platform, to achieve the integration and sharing of relevant information, to provide each unit with the full cycle of project management and analysis, including project support, project management, project management, construction management, project completion management.

3.2.2. Functional design of system personnel and role privileges

Distribution network project has a large number, the number of project-related personnel, personnel mobility and other characteristics, in order to provide efficient, stable, professional account and role rights management functions, this paper applies a special login control module to identify and identify the logged-in users, and at the same time, according to the different roles of the business granting different operating privileges [14]. System personnel and role privilege function design is shown in Figure 2.

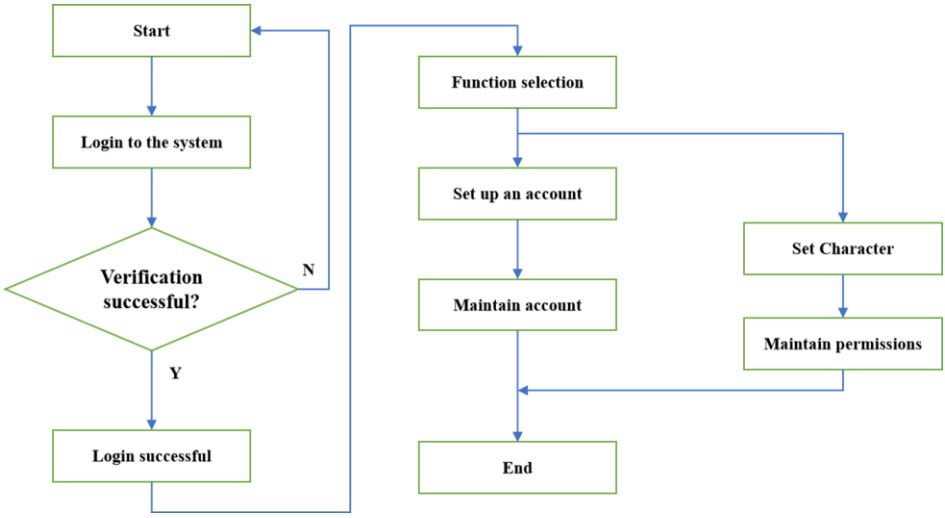

Figure 2. Functional design diagram of system personnel and role permissions.

(1) Construction personnel. Maintain the pre-construction information before the construction plan is reported, including the review of the record, the management of the two votes, site investigation. After the plan is issued, the site implementation of the project is completed in accordance with the construction process time, including site environment checking, construction start, pre-shift meeting, start application, post-shift meeting, and construction end [15]. Upon completion of the project, self-acceptance is applied online.

(2) Supervisors. On line to carry out supervision audit license, supervision side station, supervision in place, supervision to see, etc Supervision audit permit including day plan implementation permit and pre-construction data audit, supervision day plan implementation audit including supervision of the start of work permit, hidden works acceptance audit, problem rectification to create a set of permits, etc., supervision can view the demolition of old materials, boarding permits, engineering briefings, etc

(3) Owner personnel. View all kinds of basic project information, process information, you can view the overall situation of the project, the day plan, two votes, ten systems, a single, etc Audit hidden works and problems rectification situation and to the post punch card and so on.

3.2.3. The technical route of the system

The technical route of lean management and control system of distribution network engineering follows the Java EE technical system, adopts component-based and dynamic software technology, uses consistent sharable data model, and realizes the collaborative

work and integration of various interface components in the enterprise through the application integration of integrated enterprise level platform, and realizes data sharing and reuse to meet business needs.

4. Analysis of results

4.1. Application practice of lean control system for distribution network engineering

Based on the real-time data of the distribution network, establish the index system to assess the power supply capacity and operation level of the distribution network, utilize the weight score evaluation method to evaluate the distribution network frame and equipment health level, etc., and include the weak equipment of the network in the renovation project pool, so as to provide scientific reference basis for accurate investment and renovation [16].

4.2. Test environment

The system test environment consists of various elements: mainly including the hardware environment of the computer system and the software environment formed by other system software. The database used by the system is SQLServer2008, and the operating platform is NET platform, the browser is IE 10.0, and the web server is IIS 6.0. At the same time, the central processor selected for the database is P4 2 GHz, and the hard disk is 200G.

4.3. Performance testing

The scenarios were defined as the querying of the operating status of the equipment in the system, and the scenarios were implemented with incremental startup and uninterrupted operation for half an hour after the startup. The following two scenarios were repeatedly tested to clarify the performance of the system at this stage. The following two scenarios have been tested repeatedly to clarify the performance of the system at this stage

Regardless of the limitation of hardware conditions, the power monitoring system will have a greater impact on the operating efficiency of the system in terms of server model selection, coding and program settings. For the system in this paper, the system response delay is an important tool to evaluate the system structure design, operating environment, and code writing level [17]. The system response time comprehensively reflects the level of comprehensive development of the system and is a very important evaluation index. LoadRunner is a widely used system testing tool. Test the system performance by simulating the system user's operation needs to find out the problems existing in the system operation. In the process of testing, we can use a combination of manual and system methods to carry out testing.

1. Test environment:

1) CPU：4*2GHz。

2) Memory: 8GB.

3) Storage: 4 * 500GB hard disk.

4) Operating system: Windows server 2003.

5) Application server: IIS includes NET framework 3.0.
6) Database: SQLServer 2005.

2. Test steps:
1) Virtual User Generator creation script.
2) Create scripts and check them critically. The
3) Employ its controller to handle scripts. The
4) Create a scenario, set the total number of people to 500, select a script, and set the schedule to add 50 requests per minute until 500 people are full.
5) Run the script.

The results show that in Scenario 1, there were 7,362 successful transactions and 2 failures for 50 users, 8,765 successful transactions and 6 failures for 100 users. In scenario 2, there are 11,324 successful transactions for 50 users and 1 failed transaction, and for 100 users, there are 12,673 successful transactions and 4 failed transactions. One of the failed transactions is because of the response timeout, before the server timeout is set to 5 seconds, currently set to 10 seconds, there is no more failed transactions. The following is the list of failed transactions

During the performance test of the system, the concurrent transactions operated by 50 users were simulated, and only one failed; The longest and average response times reached 9s and 3s respectively, and the CPU utilization reached 60%. When simulating the concurrent transaction operations of 100 users, only 4 failed. The maximum and average response times were 14 seconds and 7 seconds, respectively. The CPU utilization reached 68%. From this result, we can see that the system has a very high transaction success rate, the longest response time does not exceed 20 seconds, and the CPU is operating normally, meeting the expected expectations.

5. Conclusion

In the distribution network project safety management, should be closely combined with the new requirements and new methods, increase the "Internet +" technology in the distribution network site safety management in the application of the development and design of the distribution network project lean management and control system, to promote the digital management of information, project transparency management, real-time management of the scene, to truly realize the distribution network project site safety Management can be prevented and controlled, and effectively improve the quality and efficiency of project management. Finally, the functions realized by the power monitoring system are tested, and the performance test is carried out to ensure that the system can meet the requirements and guarantee the performance of the system.

References

[1] Dileep, G. J. R. E. (2020). A survey on smart grid technologies and applications. Renewable energy, 146, 2589-2625.
[2] Butt, O. M., Zulqarnain, M., & Butt, T. M. (2021). Recent advancement in smart grid technology: Future prospects in the electrical power network. Ain Shams Engineering Journal, 12(1), 687-695.
[3] Liu, J., Zhao, Z., Ji, J., & Hu, M. (2020). Research and application of wireless sensor network technology in power transmission and distribution system. Intelligent and Converged Networks, 1(2), 199-220.

[4] Sadeeq, M. A., & Zeebaree, S. (2021). Energy management for internet of things via distributed systems. Journal of Applied Science and Technology Trends, 2(02), 80-92.
[5] Esenogho, E., Djouani, K., & Kurien, A. M. (2022). Integrating artificial intelligence Internet of Things and 5G for next-generation smartgrid: A survey of trends challenges and prospect. IEEE Access, 10, 4794-4831.
[6] Rathor, S. K., & Saxena, D. (2020). Energy management system for smart grid: An overview and key issues. International Journal of Energy Research, 44(6), 4067-4109.
[7] Chamoso, P., González-Briones, A., De La Prieta, F., Venyagamoorthy, G. K., & Corchado, J. M. (2020). Smart city as a distributed platform: Toward a system for citizen-oriented management. Computer communications, 152, 323-332.
[8] Wang, J., Wang, X., Ma, C., & Kou, L. (2021). A survey on the development status and application prospects of knowledge graph in smart grids. IET Generation, Transmission & Distribution, 15(3), 383-407.
[9] Jiang, X., Zhou, Y., Ming, W., Yang, P., & Wu, J. (2022). An overview of soft open points in electricity distribution networks. IEEE Transactions on Smart Grid, 13(3), 1899-1910.
[10] Bazmohammadi, N., Madary, A., Vasquez, J. C., Mohammadi, H. B., Khan, B., Wu, Y., & Guerrero, J. M. (2021). Microgrid digital twins: Concepts, applications, and future trends. IEEE Access, 10, 2284-2302.
[11] Yi, X., & Wu, J. (2020). Research on safety management of construction engineering personnel under "big data+ artificial intelligence". Open Journal of Business and Management, 8(3), 1059-1075.
[12] Fung, I. W., Tam, V. W., Chu, J. O., & Le, K. N. (2022). A Stress-Strain Model for resilience engineering for construction safety and risk management. International Journal of Construction Management, 22(12), 2308-2324.
[13] García-Fayos, B., Arnal, J. M., Sancho, M., & Ruvira, B. (2020). Process safety training for chemical engineers in Spain: Overview and the example of the polytechnic university of Valencia. Education for Chemical Engineers, 33, 78-90.
[14] Japs, S., Anacker, H., & Dumitrescu, R. (2021). SAVE: Security & safety by model-based systems engineering on the example of automotive industry. procedia CIRP, 100, 187-192.
[15] Sanni-Anibire, M. O., Mahmoud, A. S., Hassanain, M. A., & Salami, B. A. (2020). A risk assessment approach for enhancing construction safety performance. Safety science, 121, 15-29.
[16] Bunner, J., Prem, R., & Korunka, C. (2020). How do safety engineers improve their job performance? The roles of influence tactics, expert power, and management support. Employee Relations: the international journal, 42(2), 381-397.
[17] Sanni-Anibire, M. O., Mahmoud, A. S., Hassanain, M. A., & Salami, B. A. (2020). A risk assessment approach for enhancing construction safety performance. Safety science, 121, 15-29.