Design of Integrated Operation and Maintenance Monitoring System for Information Communication Network

Yongtong Ou *

Digital Grid Research Institute, China Southern Power Grid.

*Corresponding author’s e-mail: ouyt@csg.cn

Abstract: The existing monitoring system has the problem of imperfect database, which leads to low data processing efficiency. Therefore, a comprehensive integrated operation and maintenance monitoring system for information and communication networks is designed. Hardware part: effectively optimize the main control board of the system, connect the power interface and other accessories; software part: extract information and communication network characteristics, measure the distance between nodes, build an integrated comprehensive database, calculate data sampling frequency, establish operation and maintenance monitoring mode, and divide administrators. The permission level, combined with the relevance of the warning information, set the system warning function. The simulation experiment results show that the designed information and communication network integrated operation and maintenance monitoring system has higher data processing efficiency under different communication overhead data packet conditions, which proves that the actual application value of the designed operation and maintenance monitoring system is greater high.

1. Introductions

With the continuous maturity of big data technology, all sectors of the society give full play to the information advantages of the Internet to upgrade and transform the internal system. When the flow of data and information is increasing, the maintenance of the corresponding system becomes the focus of work. Foreign research on operation and maintenance monitoring system started relatively early. According to the maintenance needs, the corresponding software and equipment have been developed. The research focus is mainly on the management level, and the perfect management module has been constructed. At the same time, the user experience and business situation can be obtained in real time for comprehensive processing [1]. Domestic research on the monitoring system started relatively late, but has also achieved more fruitful research results. For example, a number of companies have developed products with visualization function, which can complete the monitoring and operation tasks well even in complex environment. Although domestic and foreign products have more perfect functions, in practice, different user groups have different requirements for operation and maintenance monitoring system [2]. Most of the early products focused on keeping the network unblocked and hardware equipment management, and emphasized that the hardware products could maintain operation without obvious failure. This development mode aiming at the underlying architecture is the initial form of operation and maintenance monitoring system [3]. In the period of information technology becoming more and more perfect, the basic goal has been unable to meet the needs of most users. The integrated operation and maintenance monitoring system of information and communication network emerges as the times require. This type of system pays more attention to the integrity and comprehensiveness, and can gradually transform from a single network to the integrated
management of the overall business [4]. At present, the academic literature on the integrated operation and maintenance monitoring system of information and communication network is not very rich, which needs to be further discussed.

2. Hardware design of integrated operation and maintenance monitoring system for information communication network

The integrated operation and maintenance monitoring system of information and communication network mainly includes the configuration of main control board, acquisition card, CPU core power supply, operation memory and circuit interface. The overall hardware function of the system is to realize the integration of network information receiving, transmission, storage, forwarding and fault information analysis, the overall structure of the hardware is shown in Figure 1:

Fig. 1 Hardware structure of integrated monitoring system

As can be seen from Figure 1, the main control board is the core of the whole system hardware, and the setting of this part determines the functional direction of the equipment, so this paper optimizes the main control board effectively. For the integrated monitoring system, it must be able to meet the needs of users' multi-channel acquisition. Therefore, it is necessary to set a large number of interface channels and ports above the PCI X4. At the same time, it is equipped with dual Gigabit Ethernet, and can collect multi-channel high-speed messages in real time. Due to the large number of lines and functional modules in the main control board and the complex functions, it is necessary to stack and impedance processing on the original basis. In addition, in the process of multi-channel high signal transmission, including your high-speed clock and Gigabit Ethernet card, its signal integrity is also the first. In the case of more functions, there are at least four kinds of internal level signals, which requires that the internal power layout of the hardware should comply with the equal length rule. As the core network equipment of integrated operation and maintenance monitoring system, the number of single board layers and stack layout must put the operation performance in the first place. Considering the number of signal layers and the structure of power layer, the top layer or adjacent layer of hardware components must be based on the ground plane to shield the electromagnetic interference in the process of signal transmission. On the basis of ensuring that the return path is the shortest path, we need to avoid too close the signal layer, otherwise crosstalk will occur. In addition, the stacking layout should aim at symmetrical structure and avoid warping. The wiring of memory module in hardware must be the maximum number of signal layers, otherwise it can not meet the needs of fast transmission. Because there is a certain electric field between the level voltage on the high-speed signal line and the ground plane, there is a high requirement for the dielectric constant of the material [5]. Especially in the process of high-frequency signal transmission, once the impedance is inconsistent, the signal reflection phenomenon will be more obvious, leading to the paralysis of the whole system. Therefore, the target of hardware single end impedance is 50 Ω, and the target of single end impedance is 100 Ω. On the basis of the above, three 72 bit DDR3 memory modules are used in this optimization. At the same time, the memory data line is controlled below 64, the address line and control line are combined into a
group, and the clock line fitting data is combined into a group. At the same time, a certain distance is set between adjacent data lines, and different signal layers are kept above three layers. For address line and control line with slow data transmission speed, the same signal layer can be selected. Based on the above description, the hardware design steps of information communication network integrated operation and maintenance monitoring system are completed.

3. Software design of integrated operation and maintenance monitoring system for information communication network

3.1. Feature extraction of information communication network

Information and communication network includes communication technology and network coding, most of which are used in the field of energy monitoring and power communication. Especially in recent years, with the wide application of intelligent devices, the information and communication network is more stable, and the operability is also stronger. The existing communication infrastructure, in most cases, can avoid the establishment of additional communication sites, which saves the corresponding human, material and financial resources. And the original measurement system can be expanded by using communication technology, even some technologies can be extended to wide area environment [6]. Using the communication technology of wire transmission data, we can establish the connection relationship with users in the communication network. Information and communication network has always been the first choice of low-voltage distribution network, which can save the corresponding human, material and financial resources. And the original measurement system can be expanded by using communication technology, even some technologies can be extended to wide area environment [6]. Using the communication technology of wire transmission data, we can establish the connection relationship with users in the communication network. Information and communication network has always been the first choice of low-voltage distribution network, which can meet the needs of both urban and system users. Affected by the nature of the power line itself, the infrastructure of the communication network has basically covered all regions, and its communication security can also be guaranteed in intelligent measurement and communication areas [7]. In the process of information transmission, it is easy to be affected by harsh environment, so the data and types of network transmission equipment need to have good performance to reduce the dependence of power line on signal quality. In some complex areas, such as extreme terrain and natural disaster prone areas, the quality of information and communication will be seriously affected. Therefore, it is necessary to establish corresponding ground base stations in special areas [8]. When the goal of forwarding decision is the flow rather than the destination, the forwarding device will forward the packets according to the same decision. Under the influence of network programming data, there is a higher degree of flexibility in network control and management, which is no longer limited by the specified information [9]. In the signal transmission process of unknown nodes, once the propagation time between two points can be measured, the direct transmission process between reference nodes can be intercepted under the condition of highly synchronous nodes. The time of two nodes is simplified as the time difference between sending and receiving signals, According to the theory of signal propagation speed, the calculation formula of node distance is obtained as follows:

\[ \delta = t \times (q_0 - q_1) \]  

In formula (1), \( t \) represents the signal transmission speed, \( q_0 \) represents the transmission time, and \( q_1 \) represents the receiving time. According to formula (1), in order to accurately estimate the signal arrival time, it is necessary to extract the node transmission time. The reader and the tag must be synchronized accurately when the network signal circularly intersects. Considering the two-way time measured by the transmitter, the measurement time between signal receiving and response is usually twice of the time delay, combined with formula (1), the expression formula of node distance is obtained as follows:

\[ l = \frac{t \times (q_0 - q_1)}{2} - \delta \]  

In formula (2), \( t \) represents the signal transmission speed, \( q_0 \) represents the transmission time, \( q_1 \) represents the receiving time, and \( \delta \) represents the time delay. The application scenario of
information and communication network can reflect its application characteristics to the greatest extent \[10\]. According to the characteristics of wide coverage, the performance requirements of the mobile terminal for the basic equipment are not particularly high, and it can basically break away from the functional limitations of the equipment. In the network architecture, because the data layer and the control layer are separated, only the network transmission needs to focus on the forwarding function, which can moderately reduce the complexity of the forwarding device. Based on the above description, the step of extracting information and communication network features is completed \[11\].

3.2. Construction of integrated database

In the face of large and complex data, data processing efficiency and storage security become particularly important. Whether from the perspective of processing efficiency or security, it is more in line with the needs of users \[12\]. By using the reader in the system, the propagation path of the wireless beacon signal is obtained, and the active tags and passive tags are classified and sent to the receiver in the way of backscattering. At the same time, the data are stored in different nodes in a decentralized way. Data accuracy is affected by many factors, the most important of which is the signal-to-noise ratio. In the process of practical application, the appearance of noise will make the measurement error of data larger, even the non-line-of-sight signal will be affected to varying degrees \[13\]. Generally speaking, the static frequency will not change the signal in the time threshold, but the sudden change of the moving state will make the overall signal reception and propagation quality worse. Starting from the physical storage mode, storing the data on different nodes will not increase the difficulty of the user's operation. The data in the database does not become scattered, and the whole calling process is the same as the traditional mode. Using the corresponding management structure, the stored data will be unified deployment, but this process will hide the system users, and will not increase the difficulty of the system operation. In addition, in the process of data processing, it is not difficult to find that some attributes of data and nodes are the same, and they are independent and related to each other, and the cooperation between data is obvious. The system administrator has the operation authority to the whole data, and the local node on this basis can also realize the self-control ability to the database. When the reader receives the same data twice, once the data interval is shorter than the system user's operation time, the calculation formula of data sampling frequency can be obtained as follows:

\[
W = \sum_0^h G(h) \tag{3}
\]

In formula (3), \(G\) is the normalized parameter and \(h\) is the total amount of data. In the face of data redundancy, it is necessary to filter and propose in time to ensure data security and improve data processing efficiency. Combined with the development trend of information technology, the cloud will divide the data hierarchy in detail, and divide the data deployed by users into top storage and bottom storage. In actual applications, only the underlying platform database is displayed to users. In addition, the database access process needs to be standardized, and there is no need to verify identity information or change access codes when users access. Based on the above description, complete the steps of constructing integrated comprehensive data \[14\].

3.3. Establish operation and maintenance monitoring mode

Establishing corresponding contact between operation and maintenance management and system users, including file type, data nature, folder path, creation date and other information, realize information deletion and basic data operation function. The administrator's authority is divided into three levels: the name of the main module, the name of the sub module, and the function options contained in the sub module \[15\]. Integrate the steps of adding, deleting, modifying, viewing and querying information into the basic information management module of the system \[16\]. The main function of operation and maintenance monitoring in the system software is to visualize the running state of the software and monitor the interface with the maximum number of connections in real time. According to the computing resources of system hardware and software, the operation and maintenance monitoring
mode is reasonably set to help the operation and maintenance management staff to obtain the latest information. According to the operation of the system, the abnormal threshold of the program is set. Once the abnormal situation occurs, it needs to be fed back to the administrator in time and the hidden trouble is removed [17]. In the operation and maintenance monitoring mode, add the function keys of task creation and task end, so that the system maintenance personnel can grasp the relevant information at any time. Targeted operation and maintenance mode can greatly improve work efficiency, so system management must be based on visualization. A large number of studies have shown that once a program in the system fails and causes abnormal shutdown, the CPU of the system will be occupied all the time. At this time, the operation and maintenance personnel can choose to end the program according to the displayed utilization rate. On the contrary, when the user needs to start a program in the system, we can choose to create a new task to achieve the goal. To sum up, the above operation is to view the overall number of programs in the system through the application monitoring program, select specific programs according to the different needs of users, and then choose to end the task or create a new task. The operation and maintenance monitoring mode is divided into five labels, including demand overview, memory, disk, CPU, and network. The computer resources in the system are integrated into the same interface for monitoring, and the separate interface and unified interface are set. From the perspective of resource monitor, the running status and CPU utilization of each program can be obtained. Even the number of active threads under complex conditions can be fully read. Based on this, the establishment of operation and maintenance monitoring mode is completed.

3.4. Setting system early warning function
According to the user configured scheduling index, the data acquisition cycle of the software is set, and the early warning function is designed. Combined with the traversal index object of the system, the time difference of system data acquisition is obtained. According to the judgment result, the data acquisition interval is set on the software. In the integrated operation and maintenance monitoring system of information and communication network, early warning is the most important function. The system with early warning function can grasp the operation information more timely, reduce the frequency of system failure, and improve the system user experience and system stability. The early warning function is divided into three parts: early warning trigger conditions, early warning compression and early warning notice. First, it judges whether the collected data meets the conditions for triggering early warning, then analyzes the information in detail to avoid repeated early warning and missing early warning information, and finally informs the operation and maintenance staff. The early warning function of the system needs to be based on expert experience and professional operation and maintenance business knowledge, add equipment indicators in the system, set corresponding thresholds, and then manage them [18]. Through the way of configuring indicators, the health status of indicators can be obtained regularly and compared with the safety threshold intuitively. If the situation exceeds the safety threshold, it is necessary to notify the operation and maintenance personnel in a user-defined way in time. After the completion of the data collection steps, in order to avoid the repeated early warning information causing interference to the operation and maintenance staff, the system needs to automatically compress the early warning information. Combined with the relevance of the early warning information, it adopts three compression methods: root, threshold and early warning confirmation [19]. In the communication network, there is the problem of phase shift, which will have a certain impact on the accuracy of triggering early warning, Therefore, the phase offset in information communication network is defined:

$$K = \frac{1}{2} (\eta - m)^{-p}$$  (4)

In formula (4), $\eta$ is the phase value, $m$ is the number of tags, and $p$ is the signal parameter. According to formula (4), if the collected indicators are already in the early warning state, there is no need to execute the early warning information. The default is that the indicators are the information after the early warning compression [20]. In order to smoothly enter the next collection cycle in a safe
state, it is necessary to set the early warning mode of the same type of indicators to a non exclusive state. Once the new collection cycle is abnormal, an early warning notice will also be issued immediately. In addition, we need to constantly strengthen the identification rules of system interface and early warning information, strengthen the system’s own troubleshooting ability, and appropriately improve the early warning level according to the user's needs. Integrate the event level, rule name, event category, receiving rule, delay rule and exclusion rule in the system, and set the early warning mode, time interval, early warning times and exclusion rule. Through the USB interface, connect to the server to realize SMS early warning. At the same time, email early warning, desktop early warning and giving early warning are more effective early warning methods. Based on the above description, the steps of setting system early warning function are realized.

4. Experimental analysis

4.1. Setting up experimental environment

In order to verify the effectiveness of the design system, the experimental test is carried out. According to the needs of the experimental test, the experimental environment is built. The development tools are QT creator, SVN and other auxiliary tools. Monitoring data collection uses Linux server. Using the corresponding detector to collect data, data filtering and analysis, application management are unified on the same server. The collected data is stored separately in a new server, and another hot standby machine for monitoring the server is prepared for unified management and maintenance. In addition, it also needs data server and eight probe servers. The main server model is HP DL 360G8, and the disk space is 600G-204T. At the same time, the main program and Agent of the monitoring system are running in Java. After the operation and maintenance staff log in to the system, the first thing they can see is the basic information interface, and the search bar is located in the center of the interface. After entering the search interface, first verify the user's permission information, and then pop up an information option with Modify button to operate according to the task requirements. In the above experimental environment, the experimental test is carried out, and the experimental results are obtained.

4.2. Experimental result

The experiment selects an integrated integrated operation and maintenance monitoring system based on wireless sensors and an integrated integrated operation and maintenance monitoring system based on Web. The experiment is compared with the monitoring system designed this time, and the three types are compared under different communication overhead data packet conditions. The data processing efficiency of the system, the higher the processing efficiency, the better the system performance. The calculation formula of data processing efficiency is:

\[
F = \frac{r}{\sum_{i=1}^{s} S_i} \times 100\% \quad (5)
\]

In formula (5), \( r \) represents the data processing result, \( s \) represents the node, and \( i \) represents the perception data. According to formula (5), the experimental results of the three systems are shown in Table 1-3:
Table 1 Communication overhead 500 packets

| Number of experiments (Group) | Integrated operation and maintenance monitoring system based on wireless sensor | Integrated operation and maintenance monitoring system based on Web | Design of integrated operation and maintenance monitoring system |
|-------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------|
| 1                             | 74.453                                                                          | 68.779                                                          | 86.448                                                        |
| 2                             | 76.554                                                                          | 69.887                                                          | 87.229                                                        |
| 3                             | 69.547                                                                          | 72.009                                                          | 88.334                                                        |
| 4                             | 71.032                                                                          | 71.648                                                          | 85.084                                                        |
| 5                             | 69.558                                                                          | 70.225                                                          | 81.320                                                        |
| 6                             | 73.223                                                                          | 73.115                                                          | 85.615                                                        |

Table 2 Communication overhead 1000 packets

| Number of experiments (Group) | Integrated operation and maintenance monitoring system based on wireless sensor | Integrated operation and maintenance monitoring system based on Web | Design of integrated operation and maintenance monitoring system |
|-------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------|
| 1                             | 59.665                                                                          | 58.461                                                          | 90.184                                                        |
| 2                             | 63.414                                                                          | 55.374                                                          | 92.123                                                        |
| 3                             | 58.335                                                                          | 51.336                                                          | 91.471                                                        |
| 4                             | 55.419                                                                          | 52.097                                                          | 90.997                                                        |
| 5                             | 56.130                                                                          | 62.007                                                          | 92.130                                                        |
| 6                             | 60.004                                                                          | 56.116                                                          | 93.202                                                        |

Table 3 Communication overhead 2000 packets

| Number of experiments (Group) | Integrated operation and maintenance monitoring system based on wireless sensor | Integrated operation and maintenance monitoring system based on Web | Design of integrated operation and maintenance monitoring system |
|-------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------|
| 1                             | 42.165                                                                          | 40.741                                                          | 95.337                                                        |
| 2                             | 44.319                                                                          | 42.008                                                          | 96.106                                                        |
| 3                             | 46.058                                                                          | 43.619                                                          | 98.558                                                        |
| 4                             | 50.225                                                                          | 42.801                                                          | 94.069                                                        |
| 5                             | 47.306                                                                          | 43.665                                                          | 95.442                                                        |
| 6                             | 42.114                                                                          | 42.257                                                          | 96.369                                                        |

According to Table 1, under different communication overhead data packet conditions, the data processing efficiency of the information and communication network integrated operation and maintenance monitoring system designed in this paper is more than 90%, which is higher than that of the integrated integrated operation and maintenance monitoring system based on wireless sensors. The data processing efficiency of the integrated integrated operation and maintenance monitoring system based on Web is high.

5. Conclusions

Through the experimental test, the design of information and communication network integrated operation and maintenance monitoring system has good performance. At the same time, it provides a new feasible idea for the research of operation and maintenance monitoring system. Due to the limited research conditions, the designed system has not been tested for different monitoring objects. In the future, we will continue to work on related research and make great progress.
References

[1] Li S, Pozzi M. What makes long-term monitoring convenient? A parametric analysis of value of information in infrastructure maintenance[J]. Structural Control and Health Monitoring, 2019, 26(5):e2329.1-e2329.18.

[2] Bi H. Research on On-line Monitoring Technology of Partial Discharge of High Voltage Electrical Equipment[J]. World Scientific Research Journal, 2019, 5(8):52-55.

[3] Salau J, Krieter J. Analysing the space-usage-pattern of a cow herd using video surveillance and automated motion detection[J]. Biosystems Engineering, 2020, 197(13):122-134.

[4] Ye O, Deng J, Yu Z, et al. Abnormal Event Detection via Feature Expectation Subgraph Calibrating Classification in Video Surveillance Scenes[J]. IEEE Access, 2020, PP(99):1-1.

[5] Markowski P M, Gierczak M, Dziedzic A. Temperature Difference Sensor to Monitor the Temperature Difference in Processor Active Heat Sink Based on Thermopile[J]. Electronics, 2021, 10(12):1410.

[6] Jiandong L I, Zhang Y, Sheng M, et al. Concepts and trends of information communication networks[J]. Scientia Sinica Informationis, 2019, 49(8):949-962.

[7] Xia Q, Jornet J M. Expedited Neighbor Discovery in Directional Terahertz Communication Networks Enhanced by Antenna Side-Lobe Information[J]. IEEE Transactions on Vehicular Technology, 2019, 68(8):7804-7814.

[8] Barolli L, Kryvinska N, Enokido T, et al. Lecture Notes on Data Engineering and Communications Technologies] Advances in Network-Based Information Systems Volume 22 (The 21st International Conference on Network-Based Information Systems (NBiS-2018)) // A Graphical Front-End Interface for React.js[J]. 2019, 10.1007/978-3-319-98530-5(Chapter 79):887-896.

[9] Maksimova E A, Sadovnikova N P, VV Baranov, et al. Robot technological system of analysis of cybersecurity information systems and communication networks[J]. Journal of Physics: Conference Series, 2020, 1661(1):012119 (8pp).

[10] Hagedorn P A, Kirkendall E S, Spooner S A, et al. Inpatient Communication Networks: Leveraging Secure Text-Messaging Platforms to Gain Insight into Inpatient Communication Systems[J]. Applied Clinical Informatics, 2019, 10(03):471-478.

[11] Kim B S. Emerging Information Technologies for Next Generation Communications and Networks[J]. Applied Sciences, 2021, 11(2):812.

[12] Pinto J A, Kumar P, Alonso M F, et al. Kriging method application and traffic behavior profiles from local radar network database: A proposal to support traffic solutions and air pollution control strategies[J]. Sustainable Cities and Society, 2020, 56(1):102062.

[13] Japab C, Pk C, D M, et al. Coupled models using radar network database to assess vehicular emissions in current and future scenarios[J]. Science of The Total Environment, 2020, 761(1):143207.

[14] Ma Y, Zhang J, Xu R, et al. Research on Evaluation Indicator System of Urban Public Security Video Surveillance[J]. International Journal of Social Science and Education Research, 2019, 2(9):127-133.

[15] Arai K, Bhatia R, Kapoor S. Smart Video Surveillance[J]. 2019, 10.1007/978-3-030-02683-7(Chapter 10):118-126.

[16] Mosaif A, Rakrak S. A New System for Real-time Video Surveillance in Smart Cities Based on Wireless Visual Sensor Networks and Fog Computing[J]. Journal of Communications, 2021, 16(5):175-184.

[17] V Vasudevan. Abnormal Activities Detection from Video Surveillance Using the Auction Optimization Based LPBoost Convolution Neural Network[J]. Solid State Technology, 2020, 63(3):1474-1484.

[18] Tian D, Xiong X, Xiao C. Early Warning and Inhibition of HVDC Subsequent Commutation Failure during Recovery Process under Grid Fault[J]. IEEE Transactions on Power Delivery, 2020, PP(99):1-1.
[19] H Zhang, Xu W, Lei Y, et al. Early warning and basin stability in a stochastic vegetation-water dynamical system[J]. Communications in Nonlinear Science and Numerical Simulation, 2019, 77(OCT.):258-270.

[20] ZHANG Mei-yu. Simulation Research on Distributed Electric Emergency Rescue Command and Control[J]. Computer Simulation, 2019, 36(2): 75-78.