Research on integrated operation and maintenance acquisition and monitoring technology for new generation dispatching control system

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Abstract. Focusing on the intelligence demands of operation and maintenance for the new generation dispatching control system and the technical requirements of pre-monitoring, early warning and fault handling in the event, based on the architecture with the characteristics of physical distribution and logical integration, this paper designs a kind of integrated operation and maintenance acquisition and monitoring method. It first builds the full model of the automation equipment operation information, collects and summarizes the operation information such as resource pool, platform status, database, application and multi-activity consistency and data consistency, then achieves real-time data acquisition of various key indicators information for the operation of the new generation of control systems; Through the wide-area system service bus, the system operation information is gathered into the integrated operation and maintenance center to realize panoramic monitoring of the operation status for the multi-activity analysis decision center, the dual-active model data center and the dual-active monitoring system, and to comprehensively improve the intelligent level of operation and maintenance for the new generation dispatching control system.

1. Introduction
With the development of energy transformation, a new power system characterized by extensive interconnection, intelligent interaction, flexibility, security and controllability is emerging. At the same time, new requirements are put forward for the technical support capacity of dispatching control system, in the aspects of basic data support, analysis and decision architecture, application function expansion, user-friendly experience and so on. In order to meet the needs of the development of a new generation power system, State Grid Corporation proposed the idea of developing the new generation dispatching control system.

The new generation dispatching control system[1-5] is based on the architecture with the characteristics of physical distribution and logical integration, that is to say, the analysis decision centers are unified constructed, but the monitoring systems are oriented to the local scheduling and are deployed in various control centers. Under this architecture, local operation and maintenance systems and integrated operation and maintenance system are achieved two layers deployment to collect and monitor the operation status indicators online, and to ensure the reliable operation of the new generation dispatching control system, by using intelligent analysis and deep system defect mining technologies.

The new generation dispatching control system is different from the traditional dispatching systems, whether it is the change from the architecture or the application of a large number of new technologies.
As the relevance of various applications of the new system is enhanced, the application data scale has been expanded dramatically, and the operation and maintenance workload is increasing geometrically, so that the traditional single and isolated mode of operation and maintenance can no longer meet the needs of the operation and maintenance for the new generation control systems. Moreover, the design, construction and operation of the traditional dispatching control system are more considered from the user's point of view, and the operation and maintenance functions are hardly optimized too much. The operation and maintenance technical support for the reliable running of the control system is seriously insufficient. Therefore, in order to ensure the quality and reliable operation of the new generation dispatching control system, the efficient integrated operation and maintenance is very essential.

There have been some studies on operation and maintenance. Such as a design scheme for master station online monitoring and evaluation, which establishes a dynamic evaluation model based on the indicator system[6] and research on centralized operation and maintenance technical implementation scheme, functional architecture and key technologies of smart grid dispatching technology support system[7-9], and there are also studies on the bottom-up architecture of data access to business applications, the functional system of statistical analysis center, trend warning center, intelligent search center and visual display center[10]. The white paper on the development of big data on China electric introduces the rapid development of the smart grid industry in recent years and analyzes its application data characteristics. Large power data emerged as the times require, and therefore it has the characteristics of multi-source, high-dimensional and heterogeneous[11].

Therefore, based on the above background, a new generation system operation status acquisition and monitoring method is designed for the needs of the new generation maintenance architecture transformation in this paper. It has a wider and deeper acquisition and application scope, it is not only oriented to the single system or center, but also can monitor the status of cross-center and cross-regional systems, and evaluate the operation status of the new generation system from the overall point of view. It will effectively reduce the daily maintenance workload of automation personnel, meanwhile, because of the application of intelligent analysis and monitoring means, the hidden trouble and the root cause of the system can be found in time, the speed of solving system faults can be accelerated, and the impact of the faults can be reduced.

The paper structure is organized as follows: Section 2 presents the overall functional architecture of acquisition and monitoring, Section 3 introduces the key modules including automation modeling, acquisition and summary, software deployment, data storage and panoramic monitoring in detail. Section 4 gives a case study of integrated operation and maintenance acquisition and monitoring, last, Section 5 concludes the paper and points out the further work.

2. Functional architecture

In order to adapt to the "physical distribution, logical integration" architecture requirements, it is necessary to change the architecture of the operation and maintenance, the main requirements are as follows:

(1) Optimize the operation and maintenance monitoring function of the existing control system, then establish a process-oriented, rapid response, and distributed operation and maintenance system, form a comprehensive solution for the integrated operation and maintenance of the new generation dispatching control system;

(2) The system operation information acquisition and transmission mode and data storage design should conform to the design idea of the new generation control system.

The overall architecture of the acquisition and monitoring module is as Figure 1 shows:
3. **Key functional modules**

Acquisition and monitoring is the basic scenarios of the new generation dispatching control system, and it includes the following key functional modules: dispatching automation system modeling, system operation information acquisition and summary, and system panoramic monitoring.

The automation operation and maintenance personnel can view the current operation status of the control system in real time and query the operation status of the control system at any historical time according to the actual needs. When the alarm is generated by the new generation control system, the alarm information is quickly pushed for the automation operation and maintenance personnel.

### 3.1. Dispatching automation system modeling

Dispatching automation system modeling builds a full model of the configuration information and operational information for the automation equipment, and develops an automation equipment model specification. Based on the dynamic discovery technology of automation equipment, it can develop the access audit process of automation equipment to enable dynamic modeling of automation equipment and automatic updating of equipment transaction information.

This module should have the following features:

1. Provide automation equipment configuration information modeling capabilities;
2. Provide automation equipment operation information modeling function;
3. Provide an interface tool to build and maintain the automation system model;
4. Provide dynamic modeling of automation equipment and automatic update of device change information.

The input data of the dispatching automation system modeling module mainly includes:

1. System operation parameters and configuration information;
2. System hardware resource configuration and operation information, including physical machines, virtual machines, storage devices, network devices, security devices and so on.
3. Database configuration and operational information;

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**Figure 1.** Functional architecture diagram.
(4) Platform service configuration and application information;
(5) Automation business application configuration and operational information.

3.2. System operation information acquisition and summary

3.2.1. Range of acquisition. System acquisition and monitoring function module obtains various types of operational data through supporting platforms, database and operating systems:

1. Obtain resource pool information through the operating system, support platform, and related protocols, with a frequency of minutes;
2. Obtain database operation information through the database interface, with a frequency of minutes;
3. Obtain application operation information through system interface provided by the support platform, including monitoring control, analysis and decision, and planning market, with a frequency of minutes;
4. Obtain platform operation information through system interface provided by the support platform, including real-time library, message bus and service management, with a frequency of minutes;
5. Obtain system operation information from first/second level analysis decision centers, model data centers and provincial monitoring systems through wide-area service bus, with a frequency of minutes.

The detail acquisition indicators information is shown in Figure 2, and classified according to the types of platform information, application function and consistency information.

![Figure 2. The acquisition indicators information.](image)

The main process flow of this acquisition module is as Figure 3 shows.

1. Determine the acquisition range and frequency: determine the acquisition information of the system, and set the acquisition frequency as needed;
2. Determine the monitoring nodes: determine the machine nodes which needed to be monitored, customize different acquisition contents for the first/second level analysis decision center and the provincial and local monitoring systems;
3. Deployment acquisition and summary processes according to different types of monitoring nodes;
(4) Accomplish system operation information acquisition by reading real-time database, history database and operating system commands and so on.

(5) Calling service bus: each monitoring node forms a result file and transfers the file to the data server side through service bus.

(6) Store and parse: result files are parsed and stored in data server side.

(7) Summarize the data from the analysis decision center and monitoring systems to the integrated operation and maintenance center.

**Figure 3.** Acquisition and summary process flow.

3.2.2. Deployment requirements. The system operation information client acquisition software is deployed in each monitoring node. Take a provincial monitoring system as an example, as Figure 4. shows, the monitoring system includes application cluster servers and distributed storage and so on. The client acquisition software is deployed on the cluster servers, and the server summary software can be deployed separately.

**Figure 4.** Software deployment diagram.
3.2.3. Design of data storage format. According to the requirements and characteristics of system operation information, data storage mode is designed to provide support for data classification and display. The design of storage format is as Table 1 shows, it is a real-time database table for storing acquisition indicators information. This table is designed into several character domains, each of them represents the basic characteristics of the indicator, including the indicator name, weight, acquisition period and so on, and this data storage structure can meets the foundation platform requirements of new generation system.

| English name | Type       | Notes          | Remarks       |
|--------------|------------|----------------|---------------|
| id           | rtdbkey    | identification | key word      |
| name         | char(64)   | indicator name |               |
| period       | int        | acquisition period |            |
| weight       | float      | indicator weight |              |
| threshold    | float      | alarm threshold |               |
| idc_group    | rtdbkey    | group of indicators |         |
| type         | int        | indicator type |               |
| if_monitor   | uchar      | the indicator is monitored or not |       |
| if_veto      | uchar      | whether or not to set as a veto indicator? |   |
| if_alarm     | uchar      | whether or not to set alarm? |             |
| alarm_type   | int        | alarm type     |               |
| descr        | string     | indicator description |   |

3.3. System panoramic monitoring
This module is mainly responsible for the detailed display of the operation status of the control system through classification and hierarchical display technology. The operation and maintenance personnel can have a global view of operation and maintenance data to improve system operation and maintenance efficiency.

It can display the related operation and maintenance data such as operation indicators, service status and other impact factors intuitively through various graphics, and realize panoramic real-time monitoring of operating system, network, application, business and other information. It is convenient for operation and maintenance personnel to find problems in time from the visualized operation and maintenance graphics and improve the operation and maintenance efficiency.

(1) Support topological structure diagram, layered and partitioned display diagram, curve and list to display real-time operation of control system;
(2) Support multiple visualization methods, such as pie chart, bar chart and dynamic curve.

4. Application case study
At present, the new generation of dispatching control system is being developed and deployed. The scope of integrated operation and maintenance includes three analysis decision centers, two real-time data cloud platforms and seven monitoring systems. Taking data from integrated operation and maintenance as an example, the integrated monitoring of the running status is realized by deploying the acquisition and monitoring module on different server nodes, and some abnormal rules of the system are found out. In terms of hardware resources and application running status, the time period with high frequency of system abnormality is 0:00-2:00, the duration of CPU maximum occupancy abnormality of key processes is shorter each time, but the occurrence times are more, database servers sometimes have higher disk I/O due to frequent database reads and writes. In terms of consistency, there are inconsistencies in remote telemetry and remote signal data between stations with dual-channel sources. In terms of SCADA real-time library of main and standby machine
consistency, there are a lot of inconsistent in transformer winding table and ground disconnector table, details are shown in Table 2.

**Table 2. Application case study.**

| Hardware resources and application running status | Consistency |
|--------------------------------------------------|-------------|
| indicator with the largest number of anomalies  | CPU maximum occupancy of key processes (neteq_main) | data inconsistency |
| indicator with longest exception duration       | disk usage(SCADA servers, database servers) | partial telemetry and remote signal data in stations with dual-channel sources |
| read-write exception of database servers         | disk I/O operation | real-time library of main and standby machine inconsistency |
| other major anomalies                            | opening handle files abnormality (NAS server), message bus stacking (SCADA server) | data in transformer winding table and ground disconnector table |
| time period with high frequency of system abnormality | 00:00-2:00 |

We can provide pertinent suggestions for operation and maintenance through these analysis results. Such as checking the critical processes with abnormal CPU occupancy, cleaning up the disk space of the servers in time, optimizing the efficiency of reading and writing for the database server, and checking the inconsistent data of dual-channel stations and so on.

With the deployment and accumulation of integrated acquisition and monitoring, we will obtain more valuable system running data. Through in-depth analysis of these data, we will have a better understanding of the dispatching system operation rules, the consistency of multi-active systems, and the coordination of cross-regional operation systems, so as to improve the intelligent degree of system operation and maintenance, to accurately reflect the defects and weaknesses of the new generation dispatching control system.

5. Conclusions

Based on the architecture of "physical distribution, logical integration", this paper studies the on-line acquisition and panoramic integrated monitoring technology for the operational status indicators of the new generation control system, and grasps the operation status of the control system accurately to achieve panoramic monitoring and global resource sharing. The next step is to analyze and synthesize the massive operation status data by making full use of advanced IT technologies such as artificial intelligence, machine learning and data mining, to excavate the intrinsic information and long-term rules of the operation status of the new generation control system, and provide the optimized adjustment strategy of the new generation control system for the operation and maintenance personnel.

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