Research on Key Technologies of Power System Automation Application under Smart Grid

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Abstract. With the continuous development of the scale of the power grid and the advancement of the integrated mode of regulation and control, the amount of real-time monitoring information in the power grid system has grown rapidly today, which has imposed a great burden on all levels of dispatch monitoring. The old alarm function of the power dispatching automation system has been unable to better meet the needs of efficient monitoring. Therefore, it is necessary to brush, analyse, process and summarize the alarm information of each link in the monitoring business, so as to improve the overall operation status of the power grid. Awareness and processing speed of abnormal faults. Based on this, this paper discusses and studies the smart alarms of the smart grid, analyses the overall architecture, and analyses several smart alarm technologies used in the smart grid system on this basis, with a view to the subsequent development of smart grids and alarms the technical research provides a theoretical reference.

1. Introduction
The smart grid dispatch control system dispatch plan application is based on an integrated basic platform, which can realize the unified coordination of the three-level dispatch plan of the country, the grid, and the province, and give full play to the optimal allocation of the extra-large power grid resources; realize the dispatch plan from annual, monthly, day to day, Real-time organic connection and continuous dynamic optimization to improve the lean management level of the entire process of dispatch planning. Dispatch plan applications can provide a variety of intelligent decision-making tools and flexible adjustment methods according to different dispatch mode requirements, support the visual display of dispatch plan panoramic information and quantitative analysis and evaluation of relevant factors, and realize automatic compilation and scheduling of multi-objective, multi-constraint and multi-period dispatch plans Safety check to achieve the coordination and unification of the safety and economy of power grid operation [1].

Dispatch plan applications mainly include applications such as declaration and release, forecast, maintenance plan, short-term transaction management, hydropower dispatch, power generation plan, assessment and settlement, and plan analysis and evaluation. In the design and development of smart grid dispatch control system dispatch planning applications, different models have been fully considered in the development of core technologies such as safety-constrained unit combination and safety-
constrained economic dispatch for different dispatch modes such as San Gong dispatch, energy-saving dispatch, and power market. Taking advantage of the introduction of energy-saving power generation dispatching methods, the National Power Dispatching Control Centre organized a number of domestic R & D units to focus on key technologies such as safety-constrained unit combination, safety-constrained economic dispatch, and safety verification, and achieved a breakthrough in power generation planning optimization dispatching software. Filled the domestic gap. At present, the dispatching plan suitable for San Gong dispatching and energy-saving dispatching has been widely used in power grids above provincial level in the country.

The Third Plenary Session of the Eighteenth Central Committee put forward major issues for comprehensive deepening of reforms, clearly deepening economic system reforms, and making the market play a decisive role in the allocation of resources. It is expected that the pace of power market reforms will be further increased, and the power market is likely to become the future the target model of power system development. This article analyses the development of smart grid dispatch control system dispatch plan application in the market mode from the aspects of the previous day market, intra-day real-time market, auxiliary services, safety verification, new energy consumption, and tie line optimization, and proposes specific applications. Models and development ideas in the new situation. The development model of the electricity market varies according to local conditions, and this paper takes a typical market model as an example to illustrate the adaptability of the smart grid dispatch control system's dispatch planning application function to the market model.

2. Real-time power grid monitoring and intelligent alarm

2.1. Introduction

Power grid real-time monitoring and intelligent alarms are the core functions of real-time monitoring and early warning applications of smart grid dispatching control systems, including steady-state monitoring of power grid operations, dynamic monitoring and analysis of power grid operations, online monitoring and analysis of relay protection equipment, online monitoring and control of safety control Management, comprehensive intelligent analysis and alarm functions to realize comprehensive monitoring of power system operation using power grid operation information, secondary equipment status information, and meteorological and water conditions, including steady state, dynamic, and transient state of power grid operation. In the process, the monitoring of power grid operation status is panoramicized and integrated with regulation and control, and through comprehensive analysis, online fault analysis and intelligent alarm functions are provided [2]. The composition of the real-time monitoring of the power grid and the intelligent alarm function and the logical relationship of the data are shown in Figure 1.
2.2. Parallel computing of dynamically allocated tasks

The safety check calls the parallel computing service of the smart grid dispatching control system, and realizes the interaction with the cluster computing resources through the standard interface. The parallel computing service supports two methods: pre-allocation and dynamic allocation. The amount of calculation for safety verification changes dynamically according to the needs of the application. The dynamic allocation method is adopted. After receiving the calculation request, the security verification server estimates the calculation amount according to the calculation content, and then determines the number of servers allocated to this calculation by combining the calculation priority and the parallel computer group resources, so as to support multi-task parallel calculation and fully utilize the computing power of the computer cluster [3].

The amount of calculation for safety verification is relatively large. First, the number of verification sections is determined by the calculation coverage period, and then for each verification section, a large number of various safety analyses based on the set fault set are performed. As shown in Fig. 2, the safety verification adopts example parallelism, which distributes the calculation tasks of the cross-section plan power flow calculation and the safety analysis fault scanning to each central processing unit (CPU) core of the parallel computer group.

3. Power dispatch power flow calculation

3.1. Difficulties in calculating the planned power flow

According to the dispatch plan and dispatch operation data, the planned power flow calculation generates a cross-sectional power flow that is checked for convergence and convergence for subsequent static safety analysis and stable check. Input data for planned power flow calculations include: grid model, system load forecast and bus load forecast, equipment status change plan (including equipment shutdown service plan and operation mode change plan), power generation plan, tie line plan, provincial total exchange plan and dispatch operation information [4]. The essence of planned power flow calculation is power flow calculation, and its power flow method is shown in equation (1).

\[
\begin{align*}
P_i &= U_i \sum_{j=1}^{n} U_j \left( G_{ij} \cos \theta_{ij} + B_{ij} \sin \theta_{ij} \right) \\
Q_i &= U_i \sum_{j=1}^{n} U_j \left( G_{ij} \sin \theta_{ij} - B_{ij} \cos \theta_{ij} \right)
\end{align*}
\]
Where: $P_i$ and $Q_i$ are the active and reactive power of node $i$; $j \in i$ represents the node connected to node $i$; $U_i$ and $U_j$ are the voltage of nodes $Fi$ and $j$ respectively; $G_{ij}$ and $B_{ij}$ are the elements of the node admittance matrix; $\theta_{ij}$ is the phase angle difference between nodes $i$ and $j$. First determine the topology of the check section based on the power grid model, equipment status change plan and dispatch operation information, that is, determine $G_{ij}$ and $B_{ij}$, and determine the node power injection $P_i$ and $Q_i$ according to other data, then solve the node voltage and phase angle according to the power flow equation, and finally determine Power flow distribution of the power grid.

3.2. Market Dispatch Electricity Cost Optimization Goal
When the minimum electricity purchase cost is the goal, a typical day-ahead market bidding optimization model is established. The objective function is as follows:

$$\min \sum_{i=1}^{N_i} \sum_{t=1}^{N_t} \left( B_{ij} (P_{ij}) + B_{on,ij} S_{on,ij} \right)$$

In the formula: $N_i$ is the number of quotation units; $N_t$ is the number of market hours before the day; $B_{ij} (P_{ij})$ is the quotation curve of the power generation of the $i$th unit in the $t$ period; $P_{ij}$ is the power generation of the $i$th unit in the $t$ period; $B_{on,ij}$ is the $i$th unit Start-up cost in the $t$ period; $S_{on,ij}$ is the start-up state of the $i$th unit in the $t$ period, the start-up is 1, otherwise it is 0. System power balance constraints:

$$\sum_{i=1}^{N_i} P_{t,i} = P_{LD,t}$$

In the formula: $P_{LD,t}$ is the system load in period $t$. Unit start and stop time constraints:

$$S_{on,ij,t} + \sum_{k=t+1}^{on,ij} S_{off,i,k} \leq 1$$

$$S_{off,ij,t} + \sum_{k=t+1}^{off,ij} S_{on,i,k} \leq 1$$

Where: $T_{on,ij}$ is the minimum continuous start-up time when unit $i$ changes from shutdown state to start-up state; $T_{off,ij}$ is the minimum continuous downtime when unit $i$ changes from start-up state to shutdown state; $S_{on,ij}$ is the start-up change state of unit $i$ at time period $t$ (0 or 1); $S_{off,ij}$ is the change state (0 or 1) of unit $i$’s shutdown during time period $t$.

4. Key technical analysis

4.1. Automated inspection technology
Taking the safety check calculation of a certain day as an example, four sets of calculation tests are carried out as shown in Table 1. The branch chooses whether to control the provincial cross-sectional power, whether to perform automatic adjustment of reactive voltage, and whether to perform intelligent
adjustment of non-convergence. The results show that each the application of an improved algorithm can improve the convergence of planned power flow calculation [5].

Table 1. Convergence of safety check calculation

| Serial number | Whether to control the provincial section power | Whether to adjust the reactive voltage automatically | Whether to perform non-convergent intelligent adjustment | Number of non-convergence periods |
|---------------|-----------------------------------------------|---------------------------------------------------|-------------------------------------------------------|----------------------------------|
| 1             | no                                            | no                                                | no                                                    | 6                                |
| 2             | Yes                                           | no                                                | no                                                    | 4                                |
| 3             | Yes                                           | Yes                                               | no                                                    | 2                                |
| 4             | Yes                                           | Yes                                               | Yes                                                   | 0                                |

The provincial power control algorithm plays a key role in improving the rationality of the planned power flow results. Figure 3 compares the planned power flow results of the provincial power control with the actual power flow. It can be seen that controlling the provincial power can improve the planned power flow Accuracy.

By perfecting the planned power flow algorithm and using practical technology, the monthly average planned power flow convergence rate of the National Electric Power Dispatching and Control Centre reached 100%, and the accuracy rate of the planned power flow gradually increased. It is currently stable at over 95%, as shown in Figure 4.
4.2. Multi-source alarm technology

Compared with hierarchical alarm technology, multi-source alarm technology is mainly developed based on the overall structure of horizontal intelligent alarm. Collecting alarm information from multiple sources, such as the acquisition of power grid operation monitoring information, the acquisition of total accident signals and the use of corresponding secondary equipment usage signals, on this basis, we must first strictly verify the multi-source alarm information. Verification requires corresponding verification results. Secondly, based on the obtained verification results, an effective online analysis of possible related faults is given, and the fault results are obtained through research and analysis. The third is to effectively integrate all the fault information based on the analysis of the fault and finally obtain a fault report. It can be said that this kind of alarm technology can collect alarm information from multiple sources and multiple sources. As long as the relevant alarm information conforms to the alarm rules, it can be effectively collected, thereby truly ensuring the reliability, validity and real-time nature of the alarm information. In addition, through multi-source alarm technology, the alarm information can be analysed and summarized layer by layer, which increases the scientific and effectiveness of the final fault report, and lays the foundation for improving the level of fault handling and the operational skills of the grid system business [6].

5. Conclusion

The real-time monitoring and intelligent warning technology of the power grid meets the requirements of the smart grid dispatching control system to monitor the steady, dynamic, and transient process of the power grid operation and intelligently alert, and supports the operation requirements of the integration of the dispatching and control integration of the power grid control agency. Based on the service bus of the smart grid dispatching control system, this paper designs a service-oriented security check function architecture, uses interface functions to implement the security check function customization, and uses a subscription-publishing service model to provide security check services for each application. Parallel computing technology based on dynamically allocated tasks implements multi-task simultaneous calculations and provides safe verification services for multiple users. Planned power flow generation is the foundation and key link of safety check. This paper analyses the difficulties of planned power flow calculation, proposes a planned power flow algorithm based on multi-section power flow control,
and uses automatic reactive voltage automatic adjustment and intelligent power flow non-convergence adjustment technology. Power flow convergence and rationality of results. At the same time, it puts forward the practical technology of multi-level dispatching plan safety check a few days ago, and improves the practical level of application through plan data verification and statistical technical indicators.

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