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# Multi-Dispatching Integration Cooperated With Data Interaction Service

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**Keywords:** multi-dispatching and control system, data interaction, the concurrency control model
**Abstract:** To achieve distributed parallel computing of network analysis in the multi-dispatching and control system, under the architecture of existing smart grid dispatching and control system, the general requirements of data communication based on network analysis applied to wide area distributed parallel computing is proposed, and the concurrency control model of multi-dispatching integration cooperated with data interaction is presented, then the service software based on that model is designed and implemented. Final, built the simulation test model in the laboratory, compared with the traditional methods, the method proposed in this paper effectively improves the efficiency of data communication between each system of the network analysis application.

## Introduction

The mutual influence between the send-side and receive-side power grid is further increased, and the impact scope of ultra-high voltage（UHV）grid is global. Under this new and urgent situation, it's very necessary to improve the computing ability of integration network analysis application across the entire network analysis, to support the dispatching and control integration operation of interconnected power grid between the UHV AC and DC. However, except for National Dispatching and Control Center, it's still common in many sub-centers and provincial dispatching and control centers to use traditional simplified equivalent model of outer boundary to do computing of network analysis application, which is difficult for network analysis application to satisfy the dispatching and control integration operation, and to compute in a real-time, accuracy, integrity and consistency way.

Currently, the research on wide area distributed computing of multi-dispatching system is mainly based on the calculation model of decomposition-coordination, or using other modified calculation method [1,2]. In general, the result of calculation method depends on the data interaction between the dispatching systems at all levels. The more frequently the information interacts, the better the calculation results are. Of course, the higher requirement for communication is needed [3]. However, the current wide area distributed computing for smart grid multilevel dispatching and control system is lack of effective service support. The related research is mainly on how to build the model of multi-dispatching integration and how to achieve model sharing [4], which has realized many functions to strengthen the connection between the dispatching and control systems at all levels, such as the entire modeling of large power grid, distributed real-time database, and real-time remote view of graphics [5]. In terms of data interaction, the recent research is mainly about the message communication between different application in the system [6,7]. Message bus and service bus is based on subscription/release model, mainly used to serve the data interaction of different application in the system. Through the text files, the data interaction between all security zone and dispatching and control centers can be achieved by news mail. But, its interactive mode and real-time is difficult for network analysis application to satisfy the requirement of wide area distributed parallel computing.

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In order to achieve the wide area distributed parallel computing of multi-dispatching integration cooperated with network analysis application in the entire power grid, according to the situation of grid modeling in smart grid dispatching and control system and the requirement of data communication on how to achieve multilevel dispatching and control system integration computing, a concurrency control model of multi-dispatching integration cooperated with data interaction is proposed in this paper. And then, the service software based on that model is designed and implemented, which can be applied for current smart grid dispatching and control system to achieve multi-dispatching integration cooperated with data interaction services. The software can support data real-time interaction services, improve analysis ability of interconnection integration, and also effectively ensure the consistency of system analysis results at all levels.

## General Requirement

To realize the service of the node branch calculation model for entire computing analysis of interconnection large grid integration, it's necessary to send and receive some information, such as process start commands, process states, and computing intermediate results. Therefore, some data interaction modules are necessary to achieve real-time data interaction of computing model between multilevel dispatching and control system. And also, the modules carry out the control of the process of the wide area distributed computing services. As a result, the program of data interaction services should meet following requirements:

(1)Data communication method is using asynchronous unblock mode to improve the efficiency of data transmission. When an asynchronous procedure call is issued, the caller cannot get results immediately. Otherwise, after the module finishing the call, the result can be told the call through state, information and call-back. That's the meaning of asynchronous mode. Unblock mode is that if the function cannot get the result immediately, the function does not block the current thread and it returns immediately.

(2)The packet format of the data transmission in the network uses the variable length message packet, which makes the data interaction mode support the complete data interaction, the incremental data interaction and the intermediate result interaction.

(3)The data interactive interface program is only responsible for receiving message packets or sending message packets, and it's not responsible for identification of the type of message packets and handling of the content of message packets, so that any change in other application has no effect on the communication interface program.

(4)It can automatically recover when it detect the fault of itself, with a certain degree of fault tolerance.

(5)The data interaction module must have the concurrency processing capability, which can satisfy the parallel use of multi-dispatching and multi-user.

## Data Interaction Service Implementation

### Concurrency Control Model

The data interaction module must have the concurrency processing capability, which can satisfy the parallel use of multi-dispatching and multi-user.

The cooperative computing model of dispatching and control integration for the whole network unified analysis must satisfy the parallel use of multi-dispatching and multi-user. Therefore, the data interaction module must have the concurrency processing capability. Where $x$ is the number of the dispatching and control system in distributed topology analysis, where $y(t)$ is the number of service request to the model, clearly, the number of service request changes with the time of $t$. Where $P$ is the data interaction process set of the dispatching and control system, and $|P|=x$. The total number of service thread and client thread changes with the time, where $A$ is the service thread set of data interaction, and $|A|=x \times y(t)$, where $A'$ is the client thread set of data interaction, and $|A'|=x \times y(t)$.

Where $L$ is the connection set between data service threads, and $|L|=x-1$, where $L'$ is the connection set between service thread and client thread, and $|L'|=x^2$. Where $R_{AL}$ is the connection between service threads, client threads, and service thread and client thread, and as shown in Eq. 1:

$$G(R_{AL})=(A \cup A', L \cup L'). \tag{1}$$

When is $x=3, y=1$ , the data connection between threads is shown in Fig. 1.

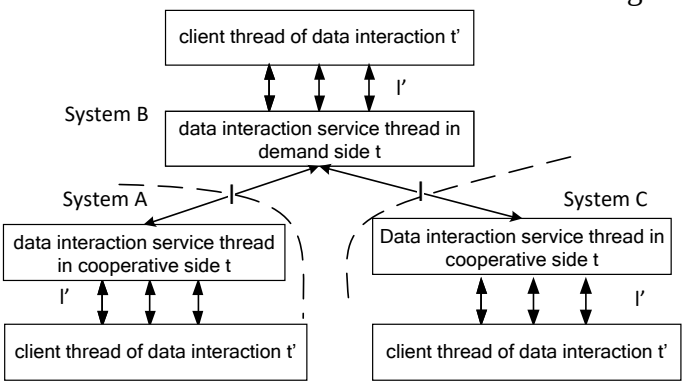


**Fig.1 The schematic diagram of data connections between threads**

When is $y(t)=1$, it can use set and relationship generated by Eq. 1 to finish data interaction. When is $y(t)>1$, if service requests send at the same time, they can be combined as one request, that is, the result will be broadcast to all dispatching and control systems which are initiated service requests after generating the integration computing model of the whole network. If service requests send at the different time, the set and relationship are generated independently by Eq. 1 according to the sequence of request time, in other words, it can use time sequence to divide the diagram of $G(R_{AL})$, and then data interaction is completed. The time sequence concurrency model generated by Eq. 1 can guarantee the data privacy between the service request of the computing model initiated at the different time, and it can also avoid data cross to influence the accuracy of data.

**Design of Data Interaction Program**

The main function of the data interaction module in cooperative computing model of dispatching and control integration for the whole network unified analysis is to make real-time data interaction between dispatching and control system at all levels come true, and to take control of the process of wide area distributed computing service. Based on the architecture of C/S and socket program of TSP, the process of data interaction service is deployed on the proxy server of the smart grid dispatching and control system. The Concurrency model called Epoll is used to implement the program of data interaction service. The program flow of data interaction service is shown in Fig. 2.

The dispatching and control system initiated the service request of computing model is named as demand side, and other system is called cooperative side. First of all, it is necessary to start the process of data interaction deployed on the proxy server of the smart grid dispatching and control system. The data interaction service is divided into process in serve side, client thread in demand side, client thread in cooperative side, and the network client thread in demand side. The specific steps of service side deployed on the proxy server are as follows:

Step 1: read the configuration files, and get node information of all dispatching and control system which is involved in the provision of the computing model service.

Step 2: wait for the client requests.

Step 3: receive client requests of data interaction service, and to determine the type of client request. If client request is from local demand side, then start the data interaction service of demand thread, and establish connection with client side. If client request is from demand side of other system, then receive call instruction sent by the analysis process in demand side. If client request is from cooperative client, then start data interaction thread in cooperative side.

Step 4: return to step 2.

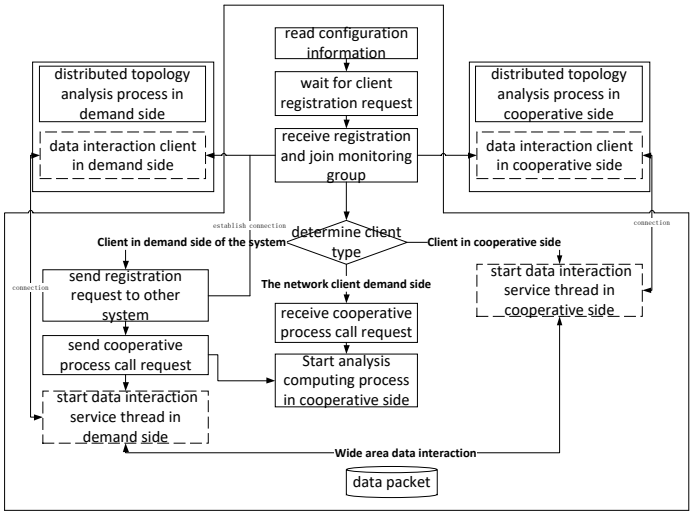


**Fig.2 The program flow of data interaction service**

## Simulation

### Testing Environment

Testing environment simulates the data interaction between two levels dispatching and control systems. The system network topology is as shown in Fig. 3, and the testing environment of hardware and software is as shown in Table 1. System A and System B respectively have the application server and proxy server, and each server is installed the Operating System (OS) of Linux and the basic platform of the smart grid dispatching and control system. The proxy server is deployed the program of data interaction services, and the application server is deployed the program of network analysis computing.

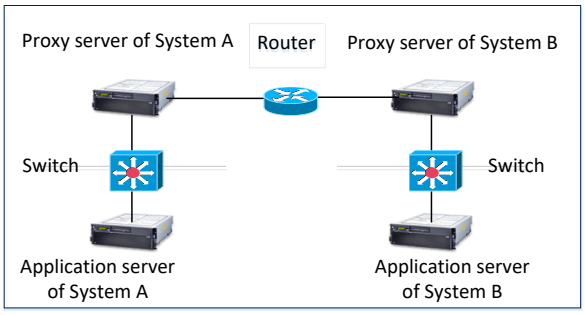


**Fig.3 The topology diagram of two levels dispatching and control systems**

**Table 1 Software testing environment**

| Number | Testing environment | Name | Explanation |
|---|---|---|---|
| 1 | Software environment | Operating system of Linux | Ningsi 4.2.32 |
| 2 | | Commercial database management | Dameng6.0 |
| 3 | | Basic platform of smart grid dispatching and control system | Smart Grid Dispatching and Control SystemV3.0 |
| 4 | Hardware environment | Workstation | ThinkServer RD650 |
| 5 | | CPU | 2*E5-2680(2*12) |
| 6 | | Memory | 16GB*4 |
| 7 | | Hard disk | 3*500GB SAS |

### Testing Results

Taking a certain moment of the whole network section for the test data, the grid includes:7012 stations, 21085 physical buses, 13884 lines, 4761 units, 20417 loads, 9127 transformers, 8974 parallel capacitor reactors, 124 series reactive power compensators, 82 DC converters, 36 DC lines, 269574 circuit breaker/switch. The total amount of data interaction, the rate of data interaction, and the time consuming of data interaction of the network analysis using the method of current and the method described in this paper are tested. The test results are shown in table 2.

**Table 2 Data size and transmission time consuming**

| Data Type | Size[MB] | Rate[MB/s] | Time consuming[s] |
|---|---|---|---|
| E file of state estimation | 56.95 | 11.7 | 4.98*3 |
| CIM/E of model file | 81.71 | 11.7 | 7.12*3 |
| Computation model | 13.79 | 28.59 | 0.48*3 |

Currently, the network analysis application in the smart grid dispatching and control system commonly uses state estimation E text or CIM/E model file to compute data interaction. Firstly, it is necessary to change model data into type of E file, and then send to other system by e-mail of small platform. Based on the method proposed in this paper, the amount of data interaction is far less than that of the E text due to data interaction in real-time way. The transmission time consuming for E text is about 15s, and the CIM/E file takes about 21s, while the transmission time consuming in the method proposed in this paper is only 1.5s. The reason is that data transmission in the conventional method is across two nodes and transmits three times per transmission. Contrastively, the method in this paper only transmit a small amount of process data, and owing to the form of concurrency data interaction mode, the model can directly complete data interaction from memory to memory. So there has a certain advantage in real-time way.

## Conclusions

The requirement for distributed parallel computing of multilevel dispatching integration cooperated with network analysis application to data interaction of multilevel dispatching and control system is analyzed. On the premise of satisfying the real-time, accuracy, integrality and consistency of the computation, the paper puts forward the concurrency control model. And then the service software based on that is designed and implemented. It can effectively improve the efficiency of data communication sharing between multilevel dispatching and control systems, and at the same time, it provides an effective support for network analysis application using wide area dispatching data network to implement distributed parallel computing.

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