The Research of Online Analysis Computing Mode Considering the Integrated and Cooperative Multi-Level Dispatching Systems

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ABSTRACT: According to the wide distribution and regional stratification features of China's power dispatching automated system, this paper presents a framework and its application processes of online distributed computing in integrated and cooperative multi-level dispatching systems, which is based on the smart grid scheduling technology support system, and it briefs the basic service units for supporting the framework to achieve. This scheme presents the process communication strategy, work collaborative management strategy and the acquisition method of integrated grid model, which will support our future integration scheduling control system and provide solutions for achieving integrated and cooperative multi-level dispatching systems.

INTRODUCTION

There are new demands for dispatching services with the Formation of UHV AC/DC Interconnected Power Grid and trans-regional power transmission, However, China power grid uses the layering and zoning dispatching mode, So that the dispatch center does not have the ability to online analyze the entire power grid calculation. The traditional computing model of partial grid online analysis is increasing unable to meet the needs of dispatch services. While the online distributed computing in integrated and cooperative multi-level dispatching systems can ensure the accuracy of the analysis results, meet the power integrated operation and the integrated dispatching demands for online power grid analysis, enhance the intelligence grid of dispatching control system, support our future integration dispatching control system and provide solutions for achieving integrated and cooperative multi-level dispatching systems[1-4].

According to the wide distribution and regional stratification features of China's power dispatching automated system and fully consider the dispatch center integrated operation demands for large power grid online analysis application computing scale and real-time, this paper presents a framework and its application processes of online distributed computing in integrated and cooperative multi-level dispatching systems, which is based on the smart grid dispatching technology support system.

THE SUPPORT OF SMART GRID DISPATCHING TECHNOLOGY SUPPORT SYSTEM

In the multi-level dispatching institution in China power grid, most important function of grid operation involved is implemented at the provincial and district dispatching institution, national dispatching center is responsible for the coordination between different large region grids and the national subcenter is responsible for the coordination between different provincial power grids. Our smart grid dispatching technology support system is hierarchical construction according to the dispatching institution. Each system has its own computer cluster and among these clusters are connected by electric power communication network, as shown figure 1.

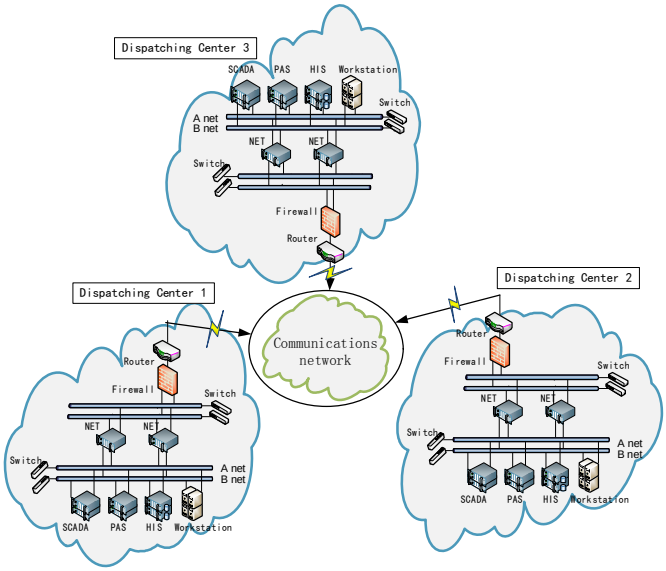

Figure 1. Computer cluster distribution

The computer cluster is base platform hardware resource of smart grid dispatching technology support system, which is composed of computer resources, network resources, storage resources, and so on.

The current smart grid dispatching control system uses a service-oriented frame, and it provides support for each application by real-time database service, commercial database service, middleware, message bus, service bus, model service, man-machine interface and other services modules, but it still can't meet all the support services demands of large grid online distributed computing in integrated and cooperative multi-level dispatching systems.

SOLUTION OVERVIEW

According to the wide distribution and regional stratification features of China's power dispatching automated system and fully consider the dispatch center integrated operation demands for large power grid online analysis application computing scale and real-time, it presents a framework and its application processes of online distributed computing in integrated and cooperative multi-level dispatching systems, which is based on the smart grid dispatching technology support system. The framework is widely distributed, parallel cluster computing model, each dispatching automation system provide integrated and collaborative computing service for other dispatching center within the wide area network, and the framework as shown figure 2.

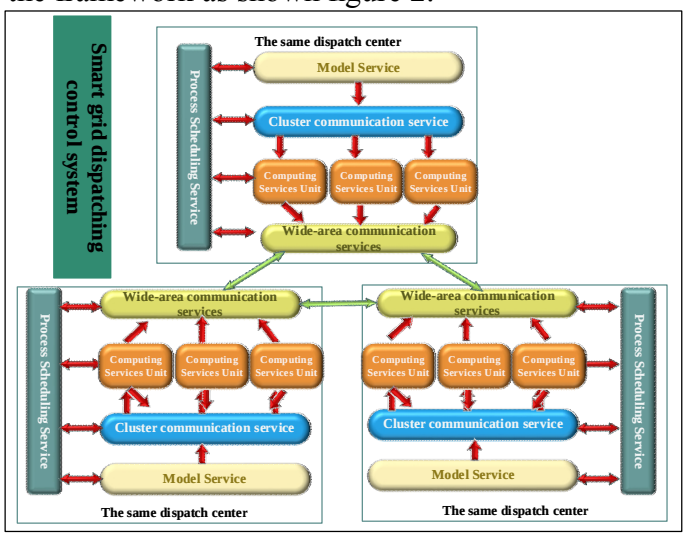

Figure 2. The framework of Online Distributed Computing in Integrated and Cooperative Multi-level Dispatching Systems

According to the distributed parallel algorithms of large grid online analysis and the feature of input grid model data, the online analysis computing services unit break down the computing tasks and input data. The model service provides local data. The distributed integrated and collaborative running of multi-level dispatching computing services unit is achieved by process scheduling service, cluster / WAN communication services and platform services, and ultimately the online distributed computing in integrated and cooperative multi-level dispatching systems can be implemented.

THE BASIC SERVICE UNITS

The distributed computing mode of power grid analysis based on this framework needs a variety of services to support, and according the supply source it is divided into two categories. One is supplied by smart grid dispatching control system and for short platform services, including database services (real-time database, distributed database, commercial databases, etc.), basic communication services (small messages, message bus and service bus), resource management services, man-machine interface service (G files, visualization, etc.). The other is support services for grid distributed computing, including process scheduling service, cluster / WAN communication service, grid data and model service and online analysis service. This paper only introduces some basic service units.

The database services

The database services is supplied by smart grid dispatching control system and for short platform services, including real-time database, distributed database, commercial databases, etc, which provide data storage services for online distributed computing in integrated and cooperative multi-level dispatching systems.

The data and model service

The data and model service includes two functions[5]: (a) With integrated and cooperative mode to achieve the modeling, maintenance, stitching and sharing of the power grid physical model, which is supplied by the basic platform of smart grid dispatching control system. (2) With integrated and cooperative mode to achieve the stitching of the power grid calculation model (including power grid model and operation mode data), which is power grid distributed topology analysis.

During the topological analysis and power system analysis process, frequently keyword matching and lookup takes a lot of time. Therefore, it is necessary to do power grid model preprocessing before the topology analysis, and that is doing model verification to form the logical relationship model which represents the relationship with the object logical number.

The large grid distributed and parallel topology analysis includes two steps: wide-area distributed parallel grid model validation and wide-area distributed parallel network topology analysis. Wide-area distributed parallel grid model validation includes the bus validation of power station, area model validation and area boundaries model validation. Wide-area distributed parallel network topology analysis includes the bus analysis of power station, area power networks analysis and area boundaries power network analysis.

The purpose of the grid model and data preprocessing is to form the logical relationship of “area - power station - equipment”, and the grid model and data is divided into blocks by area and power station and search the area tie lines by the logical relationship, then the physical grid model is converted into an undirected graph represented by abstract data structure of graph. Make use of the topological search function, the bus analysis of power station form calculation bus model by the node physical model according to the opening and closing state of switch and breaker. Area topology analysis function forms the area sub-island by the calculation bus connected by closed branch. Boundaries power network analysis function analyzes the area sub-island connected by closing tie lines and forms the whole grid electrical island. The number of tie line between the areas is small and the topology analysis computational amount is small, thus the fourth function is calculated using the serial mode, and the other function is calculated using the parallel mode.

According to the hierarchical model relationships of “area - power station- equipment”, each equipment and its node only belongs to one power station, so the bus analysis of different power stations

can do in parallel processing. There are no overlap power stations in sibling area, so the network topology analysis of sibling area can do in parallel processing. The overall framework of power grid distributed and parallel topology analysis is as figure 3.

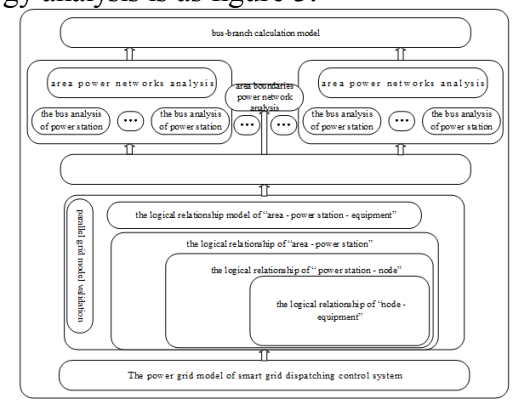

Figure 3. The overall framework of power grid distributed and parallel topology analysis

The online analysis service

According to the demands of online analysis technology demands, and take advantage of the service encapsulation technology, the encapsulation of each main function can be a part of the online distributed computing system in integrated and cooperative multi-level dispatching. Such functions called large power grid online analysis service encapsulation, which is the minimum sub function, including admittance matrix, Jacobi matrix, matrix inversion, factorization, elimination iterative solver equation, solving equations with constraint, topology analysis, N-1 fast calculation, and so on. On this basis and according to the specific needs of the application to achieve user-oriented online analysis services encapsulation, including state estimation, scheduling power flow, static security analysis, sensitivity calculations, short circuit calculation, static security correction, power generation program, load forecasting, and they provide larger power grid online analysis calculation services for the users by visual man-machine interface, which service in the smart dispatching. The implement of integrated and cooperative online analysis services in multi-level dispatching systems needs to do task division. The first is the division of the input data, then is the division of the task and the design of data block processing method.

Communication service

In addition to the small messages, message bus, service bus and other data communication services supplied by smart grid dispatching control system, it still needs data exchange communication management services to support the online distributed computing in integrated and cooperative multi-level dispatching systems. The data exchange communication management services send and receive data between multiple processes function, including wide-area communications services and Cluster communication services. Cluster communication service providers data exchange service between multiple processes in the same cluster, and wide-area communications services providers data exchange service between multiple processes in the wide area network.

Process scheduling service

The integrated and cooperative process scheduling service are divided into three levels: wide-area process scheduling, clustering process scheduling and process scheduling service unit. The wide-area process scheduling service schedules and monitors the work and status of wide-area process scheduling service in other dispatching automation system, and it also schedules and monitors the work and status of computing services unit. The clustering process scheduling service schedules and monitors the work and status of process scheduling service unit. The process scheduling service unit schedules and monitors the work and status of computing services unit. The process scheduling service unit of the initiating computing dispatching automation system (the management side) is assigned by the clustering process scheduling service, and other process scheduling service unit of the participation computing dispatching automation system(the coordinated side) is assigned by the wide-area process scheduling service.

THE WORK FLOW

The work flow of online distributed computing in integrated and cooperative multi-level dispatching systems is as figure 4:

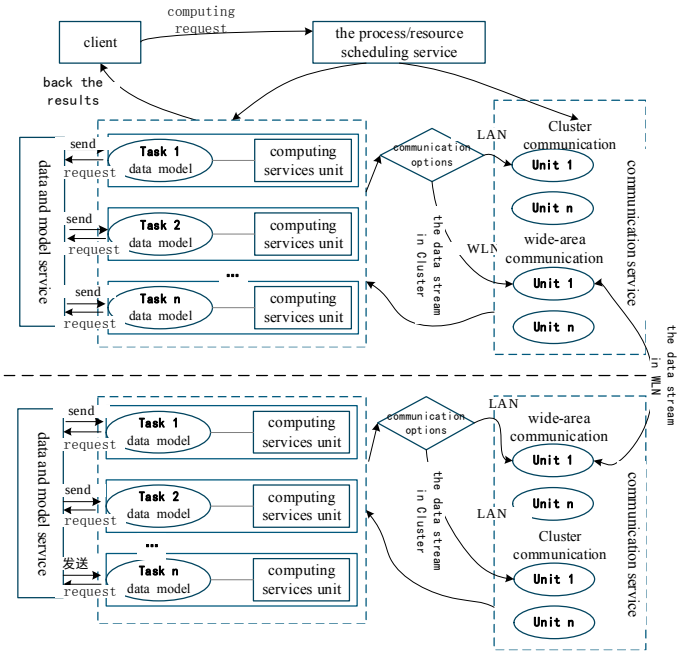

Figure 4. The work flow of online distributed computing in integrated and cooperative multi-level dispatching systems

The specific steps are as follows:

Step1. The user initiate the computing request of integrated and cooperative online distributed computing.

Step2. The process/resource scheduling service gets the computing request, and according to the configuration to send commands to the process scheduling service unit. The process scheduling service unit receives the commands and starts the cluster computing services unit. The wide-area communications services send the computing request of integrated and cooperative online distributed computing to the other dispatching automation system, and the computing services units are assigned wide area globally numbers. Computing services unit is divided into local units and wide collaborative units, and the relevant information will be sent to each integrated and collaborative computing services unit and communication services unit.

Step3. The computing services unit assign the task. Task assignment is divided into two levels. The wide collaborative units do the first level task assignment (according to the data and model resource allocation, that is the modeling range of dispatching automation system), and the local units do the second level task assignment (the realization way is specified by the programmer).

Step4. Computing Services Unit integrated the communication service client and process / resource scheduling service client. The communications service client services need to do Service Registration to the cluster communication service units and wide-area communications service units, and the dispatching service client need to do Service Registration to the process / resource scheduling service.

Step5. Computing services unit get the power grid data and model from model service.

Step6. Computing services unit do the tasks. When need to do data exchange with other units, the computing services unit sends message header and packet of data communication request to the communications service.

Step7. The communications service parse the message header of data communication request, and the message header need to be done multi-level parsing. The first-level parsing is done by the communications service client. The second-level parsing is done by the communications server. The third-level parsing is done by the wide-area communications server. The whole process is controlled

by the communication service, and the programmer only needs to specify the wide-area global number of the destination computing services unit.
Step8. After the computation request is completed, the database services and human-machine interface services of smart grid dispatching control system storage and display the result information.

CONCLUSIONS

This paper presents a framework of online distributed computing in integrated and cooperative multi-level dispatching, and briefs the online power grid analysis application processes based on this framework. The scheme presents the strategies of process communication and work collaborative management for the multi-level dispatching systems, and it also provides a program to get the integrated grid model, which support our future integration scheduling control system and provide solutions for achieving integrated and cooperative multi-level dispatching systems.

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