Design of an Online Monitoring System for Intelligent Power Network Based on Cloud Computing Technology

Jianjun Wang

School of Economics and Management
North China Electric Power University
Beijing, China
wangjianjunhd@126.com

Cunbin Li

School of Economics and Management
North China Electric Power University
Beijing, China
liuding644@163.com

Abstract —With the transformation of the traditional power grid to a smart grid, intelligent sensors and related data in online monitoring system are increasing fast, therefore, the service demand in the smart grid should be faster in the future. Cloudy computing, seen as a representative of the emerging information technology, provides computing solutions for intelligent management of the power grid. Emerging the cloudy platform of all levels in power grid enterprise will be gathered into online monitoring and service analysis system in the future smart grid. This paper designs the architecture of the intelligent power grid online monitoring system according to the related concepts and characteristics of the cloudy computing technology, the system is including Infrastructure-as-a-Service(IaaS), Platform-as-a-Service(PaaS), and Software-as-a-Service (SaaS) three aspects. At last, based on the cloudy computing technology, the influences of the intelligent power grid on-line monitoring and analysis system are analyzed from economic benefit, security and social benefit. The proposed system design in this paper can further improve the operation reliability of power grid control automation and it also provides a new way of thinking and useful technical reference for the construction of smart grid's control automation system.

Keywords- cloudy computing; smart grid; online analysis; system design

I. INTRODUCTION

With the rapid development of the smart grid and the application in Internet, cloudy technology, mobile technology and other new technologies are all integrated in the power grid, which makes the power grid enterprises rely on the informatization closely. A whole new information system and digital operation application will gradually enter into the smart grid under the environment of the power grid enterprise business, and it will bring improvements and innovations to power grid enterprises in terms of management benefits and work processes. The relevant requirements of smart grid environment challenge the current power grid online analysis service system.

In the smart grid environment, information technology, computer technology, communication technology and the distribution infrastructure will be highly integrated. The energy Internet transmission system which is linked by the smart grid has the advantages of improving energy efficiency, improving power supply security, reducing environmental impact, improving power supply reliability, reducing power loss of transmission network and so on[1-2].The concept of the smart grid is through access to more users to know how to use and optimize the electricity production, distribution and consumption in smart grid. The information collection, processing, measurement, control, protection, measurement, online monitoring, and other basic functions will be automatically proceed[3]. According to the requirements support the power grid real-time automation control, intelligent regulation, and online analysis, the decision-making and collaborative interaction and other advanced features[4] will be provided.

Compared with the traditional power grid, smart grid contains distributed generations of active network with the characteristics of large scale, complex structure and wide range. It is a kind of nonlinear and open complex intelligent system with multiple targets, multiple constraints and multiple operation characteristics. The control object of intelligent power distribution network has the characteristics of nonlinearity, time variation, and uncertainty, which can not easily have processed in the traditional control. In the environment of smart distribution network, big data and cloudy computing will realize the intelligence distribution by parallel computing. The distributed intelligence has the characteristics of autonomy and coordination, which can simplify deal with the complex problems effectively. Using cloudy computing and big data can make the decision making self-organization, which can provide technical means for solving the complex system control problem. At present, the application of cloudy computing in power grid has been studied in the field of intelligent sensing service analysis, load forecasting and power scheduling analysis[4-7].The application of cloudy computing analysis will be bound to have a profound impact of the Power Grid Corp.

At present, increasing clean energy usage is a hot issue of all of the world's energy plan. In China, an effective method is changing other energy types into electricity, it need to improve the smart operation and coordinated

control in the power grid. For this challenge, it needs enhance the system for online analysis and calculation of the integration control capabilities, information technology support capabilities and resource sharing capabilities. Therefore, it is necessary to design the intelligent power grid online analysis system based on the cloudy computing technology and analyze the impact of the system.

II. ANALYSIS OF PLATFORM MODEL BASED ON CLOUDY COMPUTING TECHNOLOGY

Cloudy computing is a delivery and usage model of the service, which can be used to obtain the required services by the network in order to be easy to extend. Cloudy computing delivery models include Infrastructure-as-a-Service(IaaS), Platform-as-a-Service(PaaS), and Software-as-a-Service (SaaS). Based on the cloudy computing model, this paper analyzes the platform model based on cloudy computing technology as follows.

A. Infrastructure-as-a-Service(IaaS)

Infrastructure-as-a-Service(IaaS) is a service mode for the end users to obtain the physical resources of the package through the network from the service provider. In general, the physical resources obtained by users include the computing resources and storage resources. In general, the physical resources obtained by users include the computing resources and storage resources. Computing resources are generally packaged and provided to the user through the virtual machine, which is for the user to provide an independent, customizable and include a certain number of CPU and memory resources of virtual hardware environment, users can deploy the system software and application software in the environment, and complete the task of computing the custom. The storage resource is generally available to the user through the network file system, users in the web browser as the operation of the local file operate as a network file system to complete the corresponding storage operation. It will be in the calculation of the need from a network file system transferred or deposit file corresponding to the network file system. IaaS enables the service provider to make full use of the current physical resources, but also for the user to avoid the acquisition and maintenance of resources, capital costs and management costs.

Cloudy computing platform technology is based on personal virtual machine, and its physical architecture design is shown in Figure 1, the whole system is composed of three parts: Master, Slave and Web service layer.
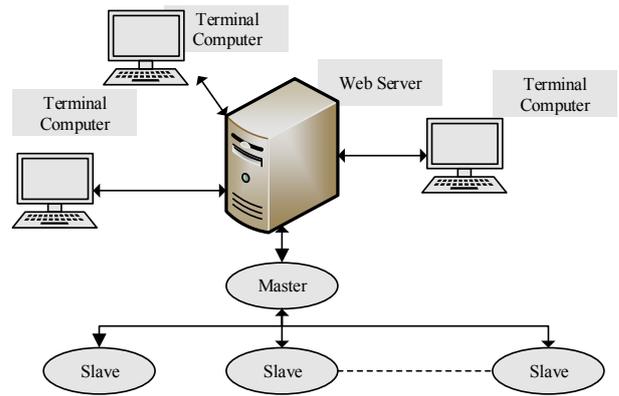

Figure 1. The physical architecture platform design of the virtual computing resources

The Web server, providing Web service, is responsible for displaying the state of virtual machine to the user, and to provide users with the operation of the interface. Web service records the user information and other static information of each virtual machine, the user submitted the virtual machine operation order will be processed first through the Web service, and then submitted to the Master for execution. In addition, the Web server will regularly grab Master to maintain the load information and display to the user.

Master node is the only main node in the whole system. It is responsible for maintain the load information of each physical node and running on the virtual machine by information, the node receives the user's request and select appropriate slave request forwarding, and responsible for load balancing and error recovery.

Slave nodes are located on each physical node. It is responsible for receiving the instructions of the Master, in which the physical node to complete the corresponding virtual machine control operation. It also regularly gets the physical nodes' status of the virtual machine, and sent information to the Master node.

B. Platform-as-a-service

Platform-as-a-service (PaaS) refers to the software development platform as a service. The PaaS service provided by the intelligent power grid online analysis system based on cloudy computing includes the service of parallel computing platform.

Parallel computing service platform is the cloudy center to provide a service platform, users can upload a program to the center and then the cloud server resources and parallel computing platform will run the program so as to accelerate the calculation speed. Users can assign the executable files, specific library files, configuration files and the parameters needed to implement the program. Users also can specify the number of resources needed to use.

The data flow of the parallel computing platform is shown in Figure 2, which contains the user front end, the WebServer part and the parallel computing platform, and

After the task is finished, WebServer sends the result of the task to the user's browser.
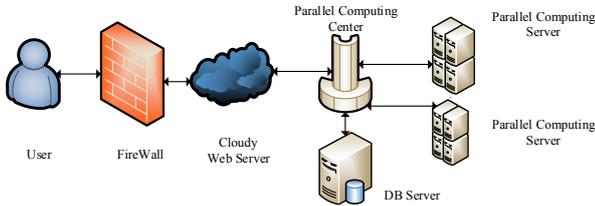

Figure.2. The flow chart of the parallel computing platform

Cloudy Web Server receives the user submitted tasks, then calls remote call (RPC) and transfers the data and files to the parallel computing platform, in which is the Master node exists. Then, the execution state of the task is detected regularly, once the task execution finished state is detected, the result file is obtained from the Master node of the parallel computing platform, and the end of the user task execution is informed.

When the Master node receiving the task of Web Server, it will send to all the tasks to the related various nodes, and the implementation of dynamic library will load into the operating system cache and other operations. The task related data will write to the database, and its execution status is set to queuing state. The task will be sent to the real computing nodes and start running the task program, and then the database in the state of the task to change update to R in the implementation. After the completion of the task, the recovery of the implementation of the results, according to the task of withdrawal, the status of its update in the database for the C (success) or E (failure).

Parallel computing platform must also respond to the Check of the task state from the Web Server, Web Server can not directly access the task list database, only the parallel computing platform Master nodes can access.

C. Software-as-a-Service

Software-as-a-Service(SaaS) refers to providing various applications of services to the users. The SaaS service mainly includes online network analysis service. Network analysis application service is to package the network analysis application software as a service for the man-machine system or the external application call. It needs to infrastructure and platform management layer to provide commercial service library, case service, service bus, process scheduling service, the process of communication services, calculation analysis of environmental services, rights management services and man-machine interface service technical support.
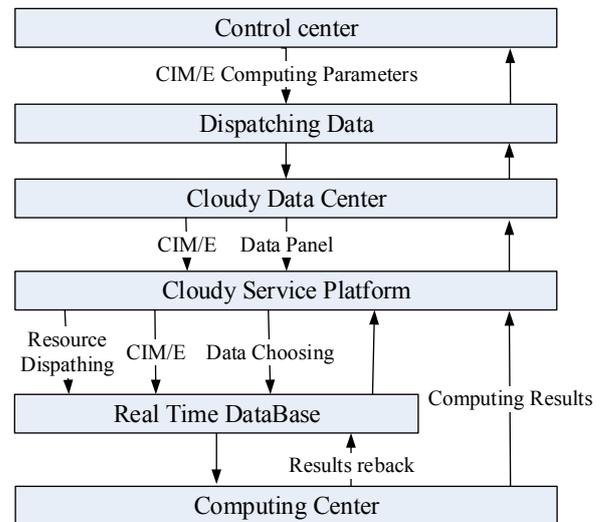

Figure 3. Network analysis software cloudy service model

Combined with the technical characteristics of smart grid and the cloudy computing technology described above, combined with the new technical features of the smart grid platform of cloudy computing technology are including the following:

1) According to the characteristics of power scheduling, cloudy computing technology is used to form the "physical distribution and logical concentration" concept. The new platform is based on cloudy computing technology for the smart grid online analysis system, through the use of wide area dispatching data network, the construction of power dispatch, "private cloudy nodes", to press, easy to expand, to provide grid control integration management mode of professional application service.

2) Cloudy computing technology to build a new platform is a set of resource management, data services and business support in one of the hierarchical scheduling cloud platform, to achieve three levels of infrastructure, platforms and applications of cloud services online, and provide support for key business forced online, an important business with the need to enable the service management tools; end users can according to need to customize all kinds of cloud services. Scheduling cloud platform uses a flexible and scalable hierarchical architecture, including virtual resource pool, basic software layer, service layer, application support layer, application service layer and safety protection component, which virtual pool of resources and infrastructure software layer provides infrastructure services, Basic service layer and application support platform to provide platform level services, and application services to provide application level services, security throughout the various levels.

3) Combined with the cloudy computing technology, the integration of power grid platform is able to achieve rapid deployment of business system and resource flexibility; through the virtual machine technology and cluster technology, can realize the control system

integration of heterogeneous multi deployment models, the realization of the system of automatic flexible expansion, and to support the underlying systems and resource management and integration of centralized maintenance.

4) Integrated cloudy computing technology and virtualization, distributed technology and parallelism can be under the environment of distributed server + client to create a series of cloud services platform based software, including virtualization software as a service, parallel real-time database service, distributed database services, communications services middleware aliquots layered service integration system platform, the realization of parallel computing.

5) Based on the cloudy computing platform can provide more services and computing resources, implement for the state estimation, dispatcher power flow and static security analysis and online analysis software, the dynamic extension support multi-level scheduling in distributed joint computation and computing resources, based on the cloud platform of distributed computing deployment scenarios and easy to deploy applicable in wide area network state estimation of Jacobian matrix of parallel computing method can improve the precision and the speed of the whole power system state estimation.

After the integration of cloudy computing technology, the new power grid platform can be established covering the physical environment and hardware equipment, operating systems, data, network, application of multiple levels of security system. And to achieve from the virtual resource pool virtualization security layer to software based data storage security, to the application support layer of privilege management and access control management a series of layered service management means, it is able to implement unified authentication and hierarchical authority of data, applications, user, realize flexible, fine-grained grid service control.

III. DESIGN OF SMART GRID'S ONLINE ANALYSIS SYSTEM ARCHITECTURE WITH CLOUDY COMPUTING

A. Framework analysis

Based on cloudy computing, smart grid online analysis system is covering the main grid scheduling basic function outside, on the basis of scheduling, on-line monitoring of the expansion virtualization, distributed, high performance calculation, collaborative computing, and data concentration advanced cloudy computing technology support. And create the system operation mode using the service oriented system deployment and operation mode, providing the infrastructure, platform and online analysis application services for the private cloud users of smart grid terminal. Cloudy based intelligent power grid on-line analysis system is deployed in the scheduling data network, to provide special software services to the private cloudy nodes. Cloudy center deployed in the system based on virtualization technology to build a virtual resource pool, internal widely used technology in cluster and distributed, providing massive data storage and processing capabilities, provides a parallel computing ability, have

from the center to the application of the unified management system, the system architecture diagram as shown in Figure 4.
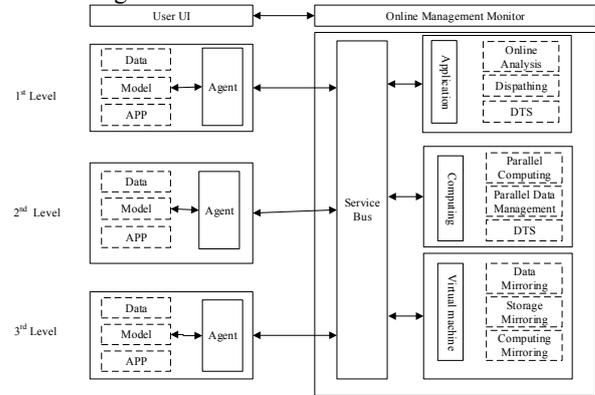

Figure 4. Framework of smart grid online analysis system based on cloudy computing

System based on the overall service bus integration, the service bus is responsible for the overall service registration, release of service management, service based data synchronization and service access rights management and so on. Center network platform business at all levels to service agents deployed in the service bus on the external release, the third party vendors developed universal software to service bus middleware services on the external release. The cloud platform online monitoring system of smart grid is built on the virtual resource pool, which provides the virtual computing resources, storage resources and network resources. Cloud services platform based on distributed data management, distributed data storage, parallel computing environment and flexible resource management platform for the operation of the environment, providing a large amount of information distributed processing, parallel processing capabilities. The whole network oriented intelligent scheduling application is deployed on the basis of the platform, which makes full use of the computing power of the basic operation environment and the ability of mass information processing. Intelligent cloud platform provides a series of friendly management and monitoring interface.

The core technology and function of intelligent power grid on-line analysis system based on cloudy computing technology are as follows:

1) Hierarchical structure of scheduling cloud platform

Different from the traditional cloudy computing architecture that provides services directly to Internet users, scheduling cloudy platform for power dispatching business characteristics, the use of wide area dispatching data network connection control system in physical distribution business subsystems, and with the help of the service bus integration of power dispatching in existing all kinds of services and cloud platform provides a new service. So as not to change the original power scheduling business system based on the core software, to build a private cloud platform control.
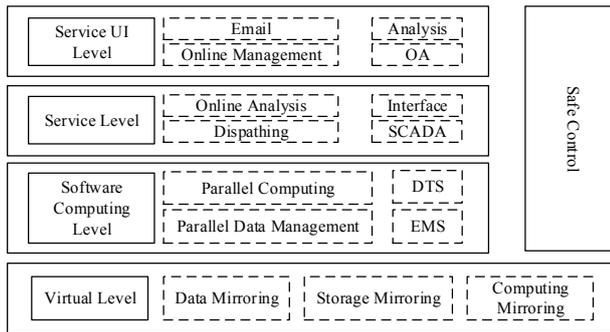
Figure 5. Cloudy platform software hierarchy for supporting online analysis of smart grid

2) Cloudy computing services Virtualization Management

The use of virtualization technology to integrate physical resources, including computing, storage, network and other resources, respectively, to build computing resources pool, storage pool and network resource pool and so on. Based on the full virtualization technology, the virtual machine's dynamic creation, dynamic migration, on-demand use and release, to achieve the implementation of the environment and physical environment, and it has the ability of rapid deployment of applications, support for dynamic optimization of the basic server resources and rapid expansion of the configuration. Cloudy platform computing resource pool is composed of a large number of heterogeneous physical servers through server virtualization technology generated virtual machine cluster, which can be deployed in accordance with the requirements of the application into different configurations of the virtual machine. The storage pool is composed of a large number of storage devices, including disk array, server hard disk and so on. The storage pool is used to store a large amount of data generated by the virtual machine's image and dispatching automation system.

3) Real time Distributed parallel database

Real-time distributed parallel database software in smart grid dispatching controls the system real time, distributed database, parallel database technology, in which contains the data indexing technology, multi node data distribution model and parallel processing mechanism, realize large-scale real-time data distributed storage and parallel access.

4) The cloudy computing environment

Application software is to help dispatch personnel to monitor, analysis and control of power system is an effective tool, along with the enlargement of power grid scale, the computational efficiency of the system, when in fact more and increasingly difficult to meet the real-time requirements, there is an urgent need to research and application of software and technology, network application software of high performance calculation and analysis in power system online analysis. In the cloudy platform, the parallel computing environment is developed for the on-line analysis and calculation of smart grid,

which supports the high performance computing of network analysis and other advanced applications. The parallel computing environment provides a flexible resource management module with high reliability, which can realize the resource isolation, dynamic resource management, resource allocation, fault tolerance mechanism and resource monitoring.

5) Service management

System service management in the platform based on the global service bus and standard of loosely coupled application model achieve a reliable and efficient data transmission and function message transfer between applications and services. It can be extended for easy management and easy monitoring of and support software online upgrade and flexible deployment. The service management platform should shield the underlying communication technology and the application process of the data exchange, which can support the application request information and the transmission of the response result information. Bus services in the form of interface function for the application to provide service registration, release, request, subscriptions, confirmation and response information interaction mechanism, while providing a service description, service broker and service management functions to meet the application functions and data in the wide range of use and sharing.

6) State estimation of the whole network based on cloud platform

Cloudy computing Center online analysis software calculation and analysis of cross section is not limited in a specific area under the jurisdiction of a specific scheduling center, different levels of dispatching center operators when using online analysis software to carry on the analysis and calculation, target section is not fixed, it must be provided to different users of different network section analysis calculation and provide computational results.

IV. CONCLUSION

The online system design is studied with cloudy computing technology for the smart grid online analysis system, the system uses the heterogeneous backup technology, virtualization technology, innovation in the workstation terminal network model and integration of cloudy computing innovative technology. The smart grid with the system can further enhance the operation reliability of the power grid dispatching automation and lay a solid foundation for the security of smart grid intelligent operation, which is to provide new ideas and useful technical reference for the new power control automation system construction, it will provide the good effects of whole society.

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