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Design and Analysis Unified Resource Management Platform of Grid Dispatching System Based on Virtualization Technology

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Abstract

As the command center of Strong Smart Grid, the safe and stable operation of the power grid dispatching automation system is the firm guarantee of electric power supply. And dispatching platform is the foundation platform of the power grid dispatching automation system. To make full use of the computing resources and enhance the availability and flexibility of system, this paper puts forward the construction of uniform resource management platform for power grid dispatching automation system based on virtualization technology, thus to provide required computation, storage, network and other resources. With the introduction of virtualization technology including server virtualization, storage virtualization, network virtualization and other technologies, and the construction of corresponding resource pool, the paper designs uniform resources management platform based on virtualization technology and provides new architecture for power grid dispatching automation system. The new system can allocate and dispatch the resources as a whole, thus to enhance the availability and flexibility of system and realize on-demand allocation and high efficient utilization of resources.

Keywords*: power grid dispatching automation system, virtualization technology, uniform resource management*

1. Introduction

To give full play to the optimum resources allocation of power grid and meet the comprehensive, coordinated and sustainable development requirements of our economic society, Sate Grid Corporation of China (SGCC) presents the plan of Strong Smart Grid. As the important constituent part of smart grid, dispatching is closely related to other parts and the important guarantee of the safe, high quality and economic operation of Strong Smart Grid. With the formation of “San Hua” extra-high voltage power grid and the construction of northeast large sending end power grid, the characteristics of power grid has changed from area model oriented to general model oriented and raised new demands on integration operation. The construction of “large operation” system will become the development trend of future power grid dispatching. The integration of power grid characteristics requests the all in one cooperative control of dispatching operation and has high demands on technology support means. Therefore, critical equipment for smart grid dispatching should be developed to meet the construction demand of Strong Smart Grid, thus to enhance the capability in dispatching and driving large power stations and the equipment level of dispatching technology. There are also higher demands on the power grid dispatching automation system.

Power grid dispatching automation system plays an indispensable role in the safe and economical operation of electric power system. It has experienced the development of 4 generations up till now. Current extensive use of power grid dispatching system has realized high degree of integration and distributed processing of partial applications, but still hasn’t achieved the physical resources uniform management of overall system. It is still the stationary type of physical machine or simple combination of physical machines, which cannot meet the

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on-demand resources allocation and flexible resources management. It causes a great loss of resources and cannot play the overall resource advantages of physical server cluster.

Now, with the rapid development of computer technologies, especially the virtualization technology, cloud computing technology, etc, has provided new means for power grid dispatching automation system. Cloud computing technology is developing rapidly at present, has been widely applied in many fields [1, 2]. Virtualization technology, as a kind of revolutionary technology, can achieve uniform dispatching and highly efficient utilization of heterogeneous physical resources, flexible allocation and transparency of power grid dispatching hardware resources. What's even more important is that it can enhance the availability and reliability of system. Flexible resources management built on virtualization technology can realize on-demand allocation and recycle of resources for the real flexible utilization of resources. At present, most of the research institutes and companies related to cloud computing has used virtualization technology as break-through priorities and improved technologies of cloud computing. The paper builds a new generation basic resources uniform management platform of smart power grid dispatching automation system with the use of virtualization technology to provide transparent computation, storage, network and other resources for upper-layer application and system with advanced functions like resources supervision, dynamic migration of virtual machine and load balance. In the meantime, the system also has high availability and fast fault recovery.

2. Virtualization Technology and Resource Pool Construction

Virtualization concept was firstly put forward by IBM. The image of host machine, the most original virtual machine, was realized in the laboratory of IBM research center in the seventies of last century. IBM interpreted virtualization as physical equipment that can be used as many virtual resources (partition), or makes the behaviors of multiple heterogeneous resources like a large asset. The essence of virtualization is to partition the underlying resources to provide specific and diverse execution environment for upper-layer.

In a broad way, virtualization technology mainly includes server virtualization, network virtualization, storage virtualization, etc. It can convert the physical resources to logically manageable resources and break through the barrier among the heterogeneous physical resources. In cloud computing environment, resources are transparently applied in various kinds of physical platform and managed in a logical way for complete implementation of on-demand allocation of resources.

2.1. Server Virtualization Technology

Server virtualization technology is one of the virtualization technologies, and its abstraction granularity is the entire computer. Server virtualization is virtualizes a physical computer system into one or several virtual computer systems through virtualization technology. Each virtual computer system, referred as virtual machine, has its own virtual hardware including virtual CPU, virtual memory, virtual I/O devices to provide an independent virtual machine execution environment for application systems. Through the simulation of a layer of virtualization, operating system in the virtual machine thinks itself still exclusively runs a system. In the same physical server, the operating system of virtual machine can be completely different, and their execution environment is completely independent. The virtualization layer is called as the Virtual Machine Monitor (Virtual Machine Monitor, VMM).

In view of implementation, x86 architecture of the virtual machine is divided into two kinds. One is full virtualization and the other is para-virtualization. Full virtualization mode does not need to modify the client operating system, but para-virtualization mode needs to modify the client operating system, so which is only suitable for open source operating system that can modify the kernel. The former is represented by ESX Server of VMware, and the later is represented by Xen. VMWare company launched a virtualization suite of Virtual Infrastructure [3]. Among them, Virtual Center is a set of management software of Virtual architecture and administrators can manage Virtual machine pool through it. There are also some management software for Xen virtual machine, University of Cambridge in UK realized virtual machine migration mechanism based on Xen. In Xen virtualization, University of Cambridge developed Parallax system for multiple virtual machine management [4]. ISR (Internet Suspend/Resume) projects cooperated by Carnegie Mellon university and Intel realized transferable user

computing environment based on virtual machine technology [5, 6]. Based on virtual computing device of virtual machine technology, in the collective project of Stanford University, professional personnel configure computing environment according to various application and adopt all kinds of optimization method to maintain cache version of user computer with the minimum storage and transmission cost. Users can choose different virtual computing devices as needed [7, 8]. And some domestic scholars had also done much research of virtualization in high availability system, service network, collaborative simulation, configuration of virtual computing environment, disaster tolerant system, and so on [9-11].

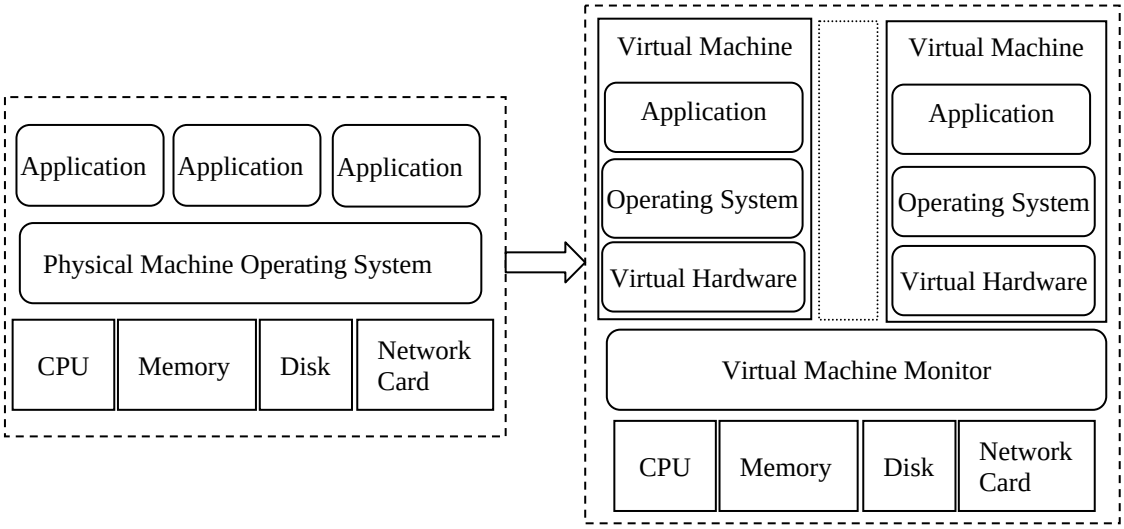

Figure 1. Server Virtualization Technology

Server virtualization technology method as shown in Figure 1, application environment of application program is turned into virtual machine after server virtualization and with characteristics of partition, isolation, packaged. Running multiple operating systems in a physical machine can make full use of server resources. The virtual machine, encapsulated into a file irrelevant to hardware configuration, can snapshot the virtual machine at any time, and migrate virtual machines through a simple file copy to realize the load balancing system. Virtual image copy can also conveniently deploy power grid dispatching automation system platform of multiple dispatch center.

2.2. Storage Virtualization Technology

In the simplest terms, storage virtualization is the abstract representation of storage hardware resources that integrate a (or multiple) target service(s) or function(s) with other additional functions to provide useful comprehensive functional services uniformly.

The concept of storage virtualization is to separate the logical image of resources from the physical storage and centralize the management of multiple geographically scattered and heterogeneous storage devices, thus to form a uniform storage pool represented as a logically single storage device providing a simplified seamless resource virtual view for system and administrator. To users, virtual storage resource is like an enormous “storage pool”. Users won’t see any concrete disc or tape, and do not have to care which route their data are going to went through and which storage device to go. From the perspective of management, virtual storage pool adopts centralization management and dynamically allocates storage resources to each application as per specific requests. The advantages of storage virtualization lies in the integration of scattered storage resources, the increase of overall utilization, the hiding of the complicated details of heterogeneous device management, the break-through of the capacity limit of single physical equipment, and the realization of uniform management and on-demand allocation of storage device.

2.3. Network Virtualization Technology

Different from the virtualization based on host machine and storage system, virtualization based on network is completed in the internal internet device. The realization of specific virtual functions can be achieved by controlling the route of network equipment. In environments of physical resources virtualization, network can be extended to virtual machine granularity. The virtual machines in the same physical machine can be divided into several subnets or the virtual machines across the physical machines into virtual subnets. Each subnet can be allocated with separate security policy to solve the dynamic regulation problem of virtual subnet boundary, which can be adjusted dynamically for the requirements of elastic computing. Security allocation policy can be migrated with virtual machine image without resetting. And the switchboard terminal can also be virtualized to greatly increase the utilization of network equipment.

2.4. Building Resource Pool

Computing resource pool is made up of virtual machine clusters generated by large amounts of heterogeneous physical server with server virtualization technology. It can be allocated to virtual machine with different configuration according to the requests of application. Storage resource pool consists of large amounts of storage equipments, including disk array, server hardware, etc. Network resource pool is composed of physical router, switchboard, network strategy configuration, etc, to form multiple virtual subnets of cluster system.

3. Uniform Resource Management Platform Design

Uniform resource management platform implements the united management and use of resources and supervise resource load of cluster at the same time to provide flexible, fast, dynamic and diversified resource services for power grid dispatching automation system, and foundation architecture for uniform system resource management. Uniform resource management platform is made up of resource physical layer, resource service layer, resource management layer, etc. Structural chart of uniform resource management platform is shown in Figure 2.

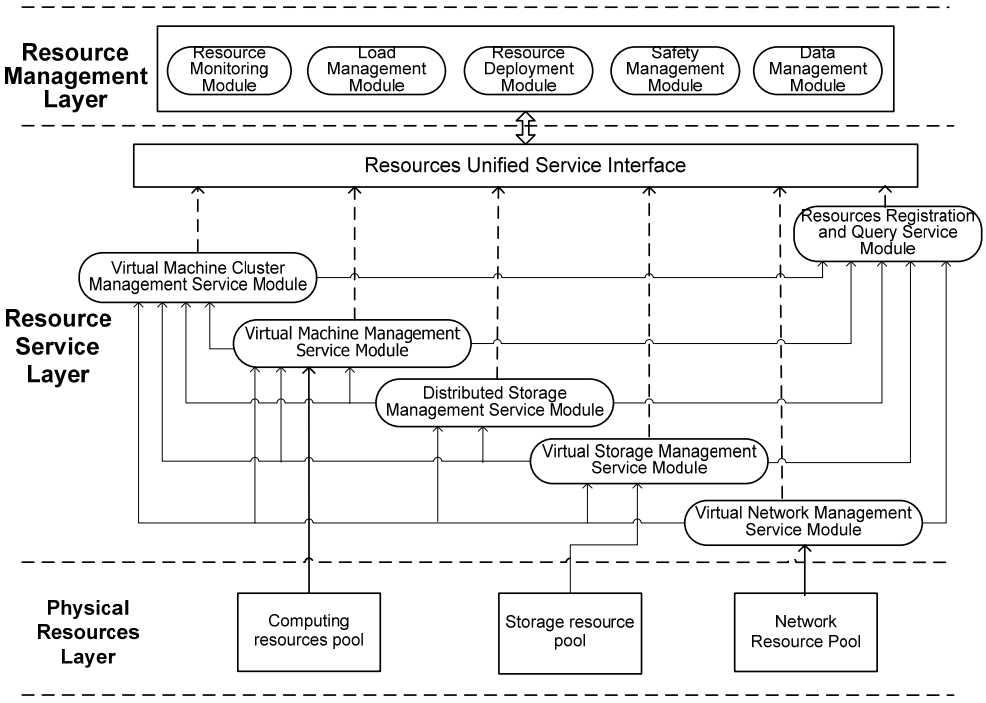

Figure 2. Structure of the Uniform Resource Management Platform

Resource physical layer is composed of pooled virtual resources, including computing resource pool, storage resource pool, network resource pool, etc. Computing resource pool consists of cluster virtual machine generated from heterogeneous physical server through server virtualization. It can be allocated to virtual machines with different configuration according to the application requests. Storage resource pool is made up of various storage equipments including disk array and server hardware to save the image of storage virtual machine and mass data generated from power grid dispatching system. Network resource pool includes physical router, switch board and network strategy configuration to constitute multiple virtual subnets of cluster system.

Resource service layer servicizes the provision of physical resources and provides servicized physical resources to resource management layer for management via service interface. It is made up of virtual network management service module, virtual storage management service module, distributed storage management service module, virtual machine management service module, virtual machine cluster management service module, and resource registration and query service module. Virtual network management service module manages virtualized network resources and provides network resources and services to upper layer. Virtual storage management service module manages virtualized storage and provides storage resources and services to upper layer. Distributed storage management service module to realize the huge amounts of data distributed storage, meet the demand for mass data storage and management of the upper. Virtual machine management service module manages the life cycle of virtual machine and provides computing resources and services to upper layer. Virtual machine cluster management service module manages virtual machine cluster and provides clustered service to upper layer. Resource registration and query service module manages virtual resources utilization uniformly and provides service for upper layer.

In response to the resource request of upper application, resource management layer realizes resources allocation and supervision, load balance and other functions, and achieves management of data and security at the same time. Resource management layer includes resource supervision module, load management module, resource allocation module, security management module and data management module. Resource supervision module supervises platform physical resources and virtual resources, collect them in real time, and present them in friendly way. Load management module achieves load balance of platform according to the load condition of physical server. Resource allocation management module implements the uniform management of resource demand and allocation. Security management module provides security audit and authority management to ensure the safety of platform of resource usage. Data management module realizes the management of key data. Solid line with arrow represents that the lower layer provides virtual resource to upper layer, and the dotted line means the lower layer provides service to upper layer.

4. Power Grid Dispatching Automation System Based on Uniform Resource Management Architecture

At present, it is far from enough to meet the resource request of power grid dispatching automation system only by several or small number of machines. Large scale of computation needs cluster of numerous servers to complete. With the in-depth application of cloud computing in other industries, electric power industry had also made some explorations and applications for power grid dispatching automation system with large scale of computation. In the near future, cloud computing will certainly be used to raise the supporting capacity of power grid dispatching automation system. For large scale of cluster or cloud computing technology, various kinds of heterogeneous hardware resources has to be integrated to realize transparent, on-demand and elastic resource utilization for upper layer system and application. Uniform resource management platform is adopted to manage cluster resource and support each application of power grid dispatching automation system. The new architecture of power grid dispatching automation system is shown in Figure 3.

The architecture is made up of physical resource layer, uniform resource management layer, application system layer and user layer. Physical resource layer is composed of large amounts of server, storage device and network equipment. It is the actual operation carriers of the overall system and provides services of computation, storage and network for each application of power grid dispatching automation system. Uniform resource management layer

achieves the deployment, allocation, supervision and management of resources by resource abstraction and virtualization. System application layer is each supporting application of power grid dispatching automation system, includes Scada, network analysis, security check, dispatching plan, DTS, and other applications.

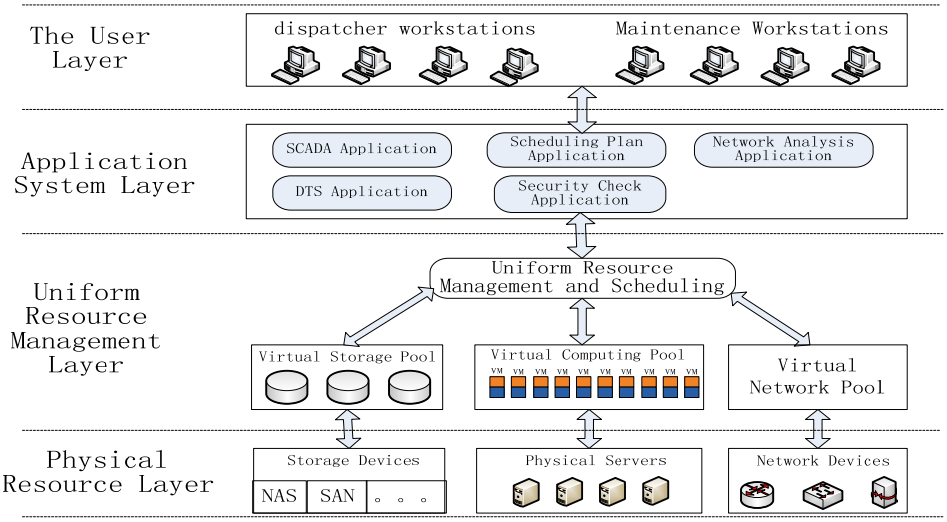

Figure 3. Architecture of the Power Grid Dispatching Automation System Based on Uniform Resource Management

5. System Analysis

The adoption of virtualization technology for the infrastructure construction of power grid dispatching automation system can comprehensively allocate and dispatch resources to achieve on-demand allocation and highly efficient utilization of resources. It focuses more on the deployment of virtual machine and the configuration of virtual machine module in resource deployment, and has many advantages compared to the traditional architecture.

The building of uniform resource management platform can achieve comprehensive allocation and dispatching of resources to realize on-demand allocation and highly efficient utilization of resources. After the virtualization of physical resources, encapsulation and isolation of the virtual machine can be used for better deployment and management of various kinds of applications of power grid dispatching automation system. The real time migration technology of virtual machine helps improve the availability of power grid dispatching automation system application and achieve load balance among the servers at the same time.

Virtualization technology can well implements resource abstraction and uniform resource management. However, there are still problems for further improvement and settlement. System virtualization includes processor virtualization, memory virtualization and IO virtualization. Since virtual layer is added to application program and physical hardware, the use of software to simulate hardware will certainly cause the drop of performance. The current processor virtualization and memory virtualization is very close to the physical machine, but IO virtualization performance still has some difference with physical equipment. Therefore, for power grid dispatching automation system with high requirements of availability and large scales of computation, the use of virtualization technology is still a big challenge. With the continual development of virtualization technology, related issues will also be solved correspondingly.

6. Conclusion

The paper makes use of server virtualization, storage virtualization, network virtualization and other virtualization technology to construct computing resource pool, storage

resource pool and network resource pool for the provision of physical infrastructure to the operation requirements of power grid dispatching automation system. Uniform resource management platform based on pooled physical resources was designed to provide necessary resources for the dispatching of each application and achieve on-demand allocation, load balance, high utilization and high availability of resources.

With the application of computer technology, especially the virtualization and cloud computing technology, new generation of power grid dispatching automation system can better support the power grid development and enhance the capacity in driving large power grid.

Acknowledgements

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