Research on infrastructure of cloud computing for power application

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Abstract. The key development directions of state grid corporation of China, such as smart grid and centralized data centre, all put forward a lot of demands for cloud computing. In general, it is necessary to build a more flexible, convenient and secure information support platform through cloud computing virtualization, distributed, parallel computing and other technical means. Finally let hardware, software to the direction of centralized service evolution.

1. Introduction

Cloud computing is an internet-based computing model of mass participation. Its computing resources (including computing power, storage capacity, and delivery capabilities) are dynamic, scalable, virtualized, and delivered as services. This new mode of organization, distribution and use of computing resource is conducive to rational allocation of computing resources and improving their utilization rate, promoting energy conservation and emission reduction, and achieving green computing. Cloud computing includes several key technologies such as virtualization, distributed storage, distributed data management, distributed programming, etc. Its outstanding advantage is to improve the computing power of hardware and software while improving resource utilization, so as to facilitate the implementation of distributed computing and parallel computing. For large-scale, complex, parallel computation, such as massive data processing, information acquisition, search engine, simulation calculation, multi-linear high-precision numerical calculation model has a good application value [1].

The State Grid Corporation informatization experienced the rapid development stage of the 1980s with the focus on dispatching production automation and individual management information systems, and the rapid development stage of enterprise informationization in the 1990s and the Tenth Five-Year Plan period. During the "eleventh five-year plan" period, remarkable achievements have been made in the informatization of SG186 engineering and communication network construction. The information system has become the basic means for the daily grid business of the company's employees, and has played an increasingly important role in power grid production control and company management. However, with the promotion and deepening application of a large number of information systems within the company, the accumulated data and services tend to be massive, user experience requirements continues to grow, the data is massive, the distribution is heterogeneous, the processing is complicated, the use is cumbersome, and the maintenance is difficult. Cloud computing technology is an effective solution to solve the above problems. At the same time, cloud computing can also provide a solid foundation and strong support for power grid, power grid planning and design, unified search platform, collaborative work platform, intelligent electricity huge amounts of information processing and analysis, decision support system, unstructured data storage system, and mass real-time data storage and disaster recovery systems and more Grid business scenarios [2-6]. At present, under

the new situation of the State Grid Corporation building a strong smart grid and SG-ERP project, under the general direction of building a "one strong three excellent" modern company, fully utilizing the current advanced cloud computing technology can effectively help the intelligent transformation of power grid operation and the intensive transformation of enterprise operation. Specific needs can be reflected in the following aspects:

1.1. Information collection, storage and processing technology

With the large-scale construction of information systems and the large-scale implementation of the Internet of Things, information collection is developing towards a wider range, more types, higher frequencies, and more precise directions. At the same time, higher requirements are put forward for information processing and storage technology. As the source increases, the type of information becomes more complex. Real-time, non-real-time, structured, semi-structured, unstructured information will be flooded in various business systems, and the amount of information will show a big explosion. According to statistics, after the completion of the SG186 project, the average daily data growth of the eight business applications reached more than 50 million (144G); with the construction of the smart grid and SG-ERP, the company's data growth rate will be repeated several times. Ultra-large-scale composite information storage, retrieval, backup and disaster recovery will become important technical fields. The construction effect of data center and disaster recovery center will directly affect the continuity of the overall business. Cloud computing pools computing resources and storage resources, and can dynamically expand as demand increases; through distributed computing, parallel computing and other technologies can significantly improve the efficiency of information processing; through distributed storage and normal backup, you can achieve high reliability and parallel read of storage [7, 8].

1.2. Unified architecture, unified deployment, unified operation and maintenance, and unified management

The information system of State Grid Corporation has the problems of complex architecture and low operation and maintenance efficiency [9]. The standards and specifications of the existing IT infrastructure are not perfect. The IT architectures within the provinces and the provinces are not uniform. The existing application systems all configure hardware and software resources according to their respective business needs, and various heterogeneous hardware and software flooded in the machine room. The utilization of software and hardware resources of information systems is insufficient, and the complexity of deployment and operation and maintenance is high, and personnel consumption is large. Through hyper-scale virtualization, cloud computing can realize hardware and software resource integration and centralized management, and uniformly allocate and centralize tuning are carried out according to the characteristics of specific applications. The way in which hardware and software equipment are configured according to the needs of a single business application will be improved to the way of unified planning and design of the overall architecture, overall arrangement of equipment procurement and configuration on demand.

1.3. Energy saving and emission reduction, building a green data center

Building a data center is an important measure for the construction of State Grid Corporation's informatization, but the data center is also a major energy consumer that is unanimously recognized by the industry. Traditional data center must purchase large server queues according to the peak demand of the enterprise; in fact, enterprises have their computing needs ebb and flow, and don't always need so many servers. According to statistics from Internet, the average utilization rate of software and hardware for large enterprises is only about 10%. However, traditional servers, even in idle state, power consumption is also 60% of the peak. The power consumption of idle devices and the energy consumption of cooling equipment in data center will increase energy consumption by 50% to 100%. Green IT is an important way to save energy and reduce emissions, and data center energy conservation bears the brunt. Cloud computing abstracts IT resources and services from the underlying architecture. Computational resources, storage resources, and network resources are all integrated into a virtualized resource pool to provide highly scalable on-demand services over IP networks in a multi-

user and resilient environment. The traditional resource full operation mode is changed to the on-demand operation mode, and the temporarily unnecessary hardware resources are turned off, thereby effectively reducing energy consumption.

1.4. Business management strategy

In the next 5 to 10 years, it is a key period for the company to deepen the management requirements of "two transformations" and "three episodes and five majors" and realize the "one strong and three excellent" modern company. At present, the main business applications of the State Grid adopt two-level deployment and three-level application, while the future needs to adopt one-level deployment. According to the SG-ERP plan, between 2010 and 2015, more than 50% of the application systems will be deployed in a centralized manner. Realize the first-level deployment of enterprise core applications,and build a set of integrated comprehensive management platform that can not only meet the business needs of the corresponding business departments, but also can stably operate ,improve the management level of business departments, and achieve intensive management objectives, which can strengthen the management and control of the headquarters. Enhance data reliability, save investment costs, and reduce operation and maintenance workload, but at the same time put forward high requirements for the reliability, load capacity and dynamic balance of the operating environment. Cloud computing technology can realize the dynamic expansion of operating resources with capacity load, which can provide strong support for the first-level deployment of applications.

In order to make better use of cloud computing for power system services, based on the overall overview of power cloud computing, this paper analyses the power application cloud platform reference architecture from the perspective of development status, key technologies and reference architecture.

The rest of the paper is organized as follows: Part 2 focuses on the development status; Part 3 introduces the key technologies of the power cloud platform; Section 4 gives its platform reference architecture; Section 5 summarizes and looks forward to it.

2. Development status

2.1. Technological development

In recent years, the cloud computing market has grown rapidly, industry standards have been gradually established, technology levels have been continuously improved, and the industrial environment has gradually matured. Cloud computing has experienced a development process from small to large, from hype to maturity, and is entering the 2.0 era of great change. The cloud computing 1.0 era is mainly used by the Internet or start-ups, but with the continuous development of cloud computing, enterprise customers are gradually realizing the huge advantages of cloud computing and starting to use cloud computing. In the era of cloud computing 2.0, all cloud computing enterprises are building an ecosystem with their own core or an ecosystem with open source as the core.

In the era of cloud computing 2.0, OpenStack and CloudStack are typical open source cloud computing management platforms, which promote the rapid development of cloud computing. Among them, OpenStack is a free software and open source project licensed by NASA (National Aeronautics and Space Administration) and Rack Space. It provides computing services, object storage services, virtual image services, and 7 types of service components, such as dashboard, authentication and authorization service, network service, and data block storage service, covering various aspects such as network, virtualization, operating system, and server. OpenStack supports almost all types of cloud computing environments, and its goal is to provide a cloud computing management platform that is simple to implement, scalable, rich, and standardized. OpenStack provides Infrastructure as a Service (IaaS) solutions through a variety of complementary services, each providing APIs for integration. In addition to the strong support of Rack Space and NASA, OpenStack also has the contributions and support of heavyweight companies such as Dell, Citrix, and Cisco.

CloudStack was originally developed by Cloud.com and is divided into commercial and open source versions. The open source version is licensed under the GPL General (3) license, and after Citrix acquired Cloud.com in 2011, the entire code will be available. Open source, and in 2012, will

contribute CloudStack to the Apache Software Foundation as an Apache incubator project, and change the license agreement to a more relaxed and business-friendly Apache license agreement. CloudStack was upgraded to Apache's official project in March 2013. CloudStack is an open source, high-availability and scalable cloud computing platform that provides highly available, highly scalable open cloud platforms for large-scale virtual machine deployment and management, supporting the management of most mainstream hypervisors, such as KVM. XenServer, VMware, Oracle VM, Xen, etc.

In summary, OpenStack and CloudStack are currently typical open source cloud computing management platforms. Technically, OpenStack and CloudStack have their own advantages.

With the development of cloud computing technology and the clear demand, the virtual container engine Docker technology came into being in March 2013, which opened the curtain of the transformation of the product release method based on the cloud computing platform. Docker is a PaaS provider dotCloud open source LXC (Linux Containers)-based advanced container engine, source code is hosted on Github, based on the language and Apache2.0 protocol open source. Currently, Docker is very popular in the industry, including DotCloud, Google Compute Engine, and Baidu Application Engine (BAE), which all use Docker. Docker is a container engine built on top of LXC technology by Docker. Inc. The source code is hosted on GitHub, based on Go and Apache 2.0.

2.2. Standard development

The wide application of cloud computing can affect a large number of products, systems and services, and the standard will lay a solid foundation for it. Since 2008, cloud computing has become one of the hotspots of standardization in the world. There are 33 standardization organizations and associations at home and abroad to carry out cloud computing standardization work from various angles, including: ISO/IEC First Joint Technical Committee (ISO/IEC JTC1), the International Telecommunication Union Telecommunication Standardization Sector (ITU-T), the National Institute of Standards and Technology (NIST), and the European Network and Information Security Agency (referred to as the European Network and Information Security Agency, ENISA), Distributed Management Task Force (DMTF), Storage Networking Industry Association (SNIA), Cloud Security Alliance (CSA), China Communications Standards Association (CCSA) which are among the most important organizations. The release of cloud computing standardization organizations and standards research at home and abroad.

In addition, the International Organization for Standardization (ISO), the International Electro-technical Commission (IEC) and the International Telecommunication Union (ITU) jointly developed the international cloud computing standard ITU-T Y.3500 and ISO for the first time in the field of cloud computing in 2014: ISO/IEC 17788 "Overview and Vocabulary for Information Technology Cloud Computing" and ITU-T Y.3502, ISO/IEC 17789 "Information Technology Cloud Computing Reference Architecture". Among them, "Information Technology Cloud Computing Overview and Vocabulary", including cloud computing overview, terminology and definitions, provides the basic standards for cloud computing; "Information Technology Cloud Computing Reference Architecture", which specifies cloud computing reference architecture specifications, including cloud computing roles and activities, functional components and their relationships.

2.3. Application development

Cloud computing related standards system is gradually established, technology has become increasingly mature, and risks are controllable. Large enterprises at home and abroad have developed cloud computing applications, built internal cloud and achieved obvious social and economic benefits.

Foreign countries, such as United Energy Corporation, France Gas Suez Group, and Korea Power Company have achieved positive results through cloud computing applications. United Energy Corporation manages self-service orders and other and repetitive IT services by implementing a private cloud, reducing the cost of corporate IT services, reducing annual IT services by about 12%, and achieving higher IT service reliability. IT departments have won business. The trust of the department; the French gas Suez Group, through the private cloud to build a "free cooling" data center, and the definition, implementation and maintenance of the group's internal IT services, improve the

ability of IT collaboration and sharing, reduce IT Service cost; Korea Electric Power Company, implementing the "Cloud Computer" project to convert office computers into virtualized terminals, is expected to reduce spending by more than 5 billion won, improve the convenience of employees, and reduce the risk of data leakage.

Domestically, cloud computing has been listed as a national strategic emerging industry. Several ministries, provincial and municipal governments have successively introduced relevant policies to promote the development of cloud computing. The Ministry of Industry and Information Technology and the National Development and Reform Commission jointly issued Beijing, Shanghai, Shenzhen, Hangzhou and Wuxi as cloud computing. Pilot demonstration city first, "China Cloud" industrial development plan approved by the State Council. In addition, some large domestic enterprises and institutions, such as State Grid Corporation, China Mobile, China Telecom, PetroChina, and Sinopec, have built private clouds for enterprise applications. State Grid Corporation, built the company's power cloud, cloud computing has become the core operating model of the company's management and service information systems, realizing the innovation of IT infrastructure, the concentration of business application systems and providing innovative IT service capabilities; China Mobile, built IT Supporting cloud, business cloud, and public service cloud three cloud computing platforms, realizing the rational allocation of resources within the network, providing external IT services, reducing the overall cost of construction and operation and maintenance, and improving the utilization and reliability of IT systems and networks. Improve the sustainability of infrastructure; China Telecom, cloud computing main business mainly includes IDC and CDN, and cloud hosting and cloud storage based on these IT infrastructure resources, which reduces the overall cost of construction and operation and maintenance, and improves Infrastructure sustainability.

3. Key technologies for power cloud platforms

The key technologies involved in cloud computing include: virtualization technology, parallel computing, distributed technology and cloud computing security.

3.1. Virtualization technology

Virtualization refers to the abstraction of resources, the logical representation of resources, and is not subject to physical constraints. It is divided into server virtualization, storage virtualization and network virtualization. Virtualization is the foundation of resource pooling, which can effectively improve the level of resource management.

Table 1. Key Lifting Points and Optimization Contents of Virtualization Technology.

Key lifting point	Optimize content
Centralized deployment and refined management of IT resources	The use of virtualization technology to improve the control accuracy of the entire life cycle of information resources, real-time centralized monitoring of resource status, to provide accurate decision-making basis for the overall planning of information resources.
Low coupling between system construction and physical resources	Realize resource pool management of IT infrastructure such as servers, storage, and networks, quickly allocate resources as needed, and realize rapid and automatic installation and configuration of the operating environment, effectively improving operation and maintenance management efficiency and human investment costs.
Application high availability	Realize server fault automation management, applications running on failed servers are automatically migrated to idle servers in the resource pool, reducing application downtime from hours to minutes.
Resource application configuration is not exclusive, high resource utilization	Dynamically allocate resources such as computing, storage, and network available in the resource pool, and supply them to new applications and applications that need to expand resources, which can greatly improve the efficiency of server resource utilization.

The technical advantages of virtualization technology are mainly reflected in the following four aspects: (1) reducing IT hardware investment costs; (2) simplifying server operation and maintenance management, reducing operation and maintenance management costs; (3) improving the flexible adaptability of IT architecture for business applications; (4) supporting the integration of heterogeneous environments and the continuous operation of business applications. After the introduction of virtualization technology, the key lifting points and optimization content are listed in Table 1.

3.2. Parallel computing

Parallel computing is based on serial computing, which refers to the process of using multiple computing resources to solve computational problems. It is the main way to implement high-performance, high-availability computer systems.

The technical advantages of parallel computing are mainly reflected in the following three aspects: (1) improve the computational efficiency for massive data processing; (2) improve the concurrency of data processing, simplify the difficulty of parallel programming; (3) provide efficient, flexible, and scalable computing service capabilities for customized development. After the introduction of parallel computing technology in cloud computing, the key lifting points and optimization contents are listed in Table 2.

Table 2. Key Lifting Points and Optimization Contents of Parallel computing technology.

Key lifting point	Optimize content
high performance	Use a variety of computing resources to quickly solve large complex computing problems and provide high-performance cloud computing services.
High concurrency	Computation of computational task decomposition and integration of computational results through concurrent work mode, while simplifying the difficulty of parallel programming, while having high throughput, low latency computing tasks concurrent processing performance advantages.
High availability	Improved Parallel Computing Task Allocation Mechanism based on Resource Dynamic Scheduling Mechanism, realizing the dynamic joining of resource nodes and the repair and exit of the effective nodes to ensure the high availability of cloud computing services.
Highly scalable	Use PC servers, blade servers, etc. to replace large computers, overcome the limitations of the scale expansion of mainframes, and use the network to connect computing resources to work together, which with flexible expansion capabilities.

3.3. Distributed File System

The distributed file system is the core of the storage system. It provides a unified and object-oriented access interface to the user through the abstraction of the storage space managed by the operating system, and shields the direct operation and resource management of the physical device.

The technical advantages of distributed file system are mainly reflected in the following four aspects: (1) providing efficient information integration, exchange, storage and access services, and realizing centralized management of data services; (2) effectively integrating data to achieve centralized management of data, improving cross-regional and inter-departmental information sharing; (3) forming a reasonable data layout, reducing data interaction costs of service terminals, and concentrating superior resources to improve service performance; (4) forming a physically dispersed and logically centralized IT architecture to effectively improve the efficiency of system operation and maintenance and management. After cloud computing introduced a distributed file system, the key lifting points and optimization contents are listed in Table 3.

Table 3. Key file system lifting points and optimization content.

Key lifting point	Optimize content
Virtuality	Further improve the parallelism of work and the level of collaborative autonomy, and enhance system operational reliability and system transparency.
Availability	Improve the continuous availability of file service capabilities and reliable data service capabilities in a distributed environment.
Scalability	Increased performance scalability and management scalability, the performance growth of the system is linear with the scale expansion, and the expansion of system size will not bring about an excessive increase in management complexity.
safety	Improve data storage security and trust management to protect data in the file system from being stolen, tampered and destroyed.

3.4. Cloud Computing Security

Cloud computing security is a new technology, which accompanying the development of cloud computing. It is the innovation and deep development of traditional information security technology in the cloud computing environment, including the security between cloud computing internal security and cloud computing. With the development of cloud computing and the popularity of applications, the importance of cloud computing security has gradually increased, which is the basic premise and guarantee for the construction and promotion of cloud computing.

4. Platform reference architecture

Combining the functional and non-functional requirements of the cloud platform of the power industry, as well as the cloud computing implementation cases and experiences of the State Grid Corporation, through the organic combination of the traditional IT architecture system and the newly expanded cloud computing model, build a reference architecture for the next-generation power industry application cloud platform (as shown in Figure 1), it effectively supports cloud computing data center to be efficient, flexible, and scalable, and promote innovative development of IT services and business models.

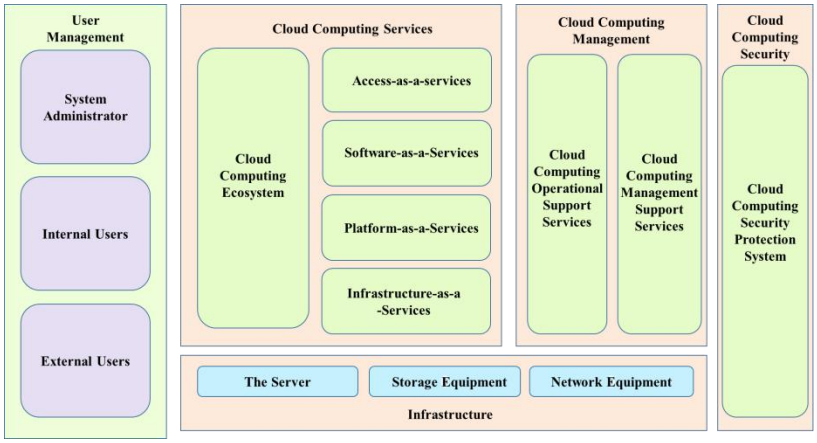

Figure 1. Power application cloud computing reference architecture.

The cloud computing reference architecture provides basic principles, technical routes, application modes, etc. for the construction of the cloud computing platform, and can effectively guide the definition, design, implementation, and application requirements of the application of the cloud computing platform by the Chongqing Electric Power Company. The technical architecture and deployment architecture are described in detail below.

4.1. Technical Architecture

Based on the above cloud computing reference architecture, according to the overall architecture of the State Grid Corporation (SG-ERP), combined with the cloud industry application requirements of the power industry, the hardware resource pool, the data resource pool, and the application resource pool are taken as the core to form a power application cloud platform technical architecture, which is shown in the Figure 2.

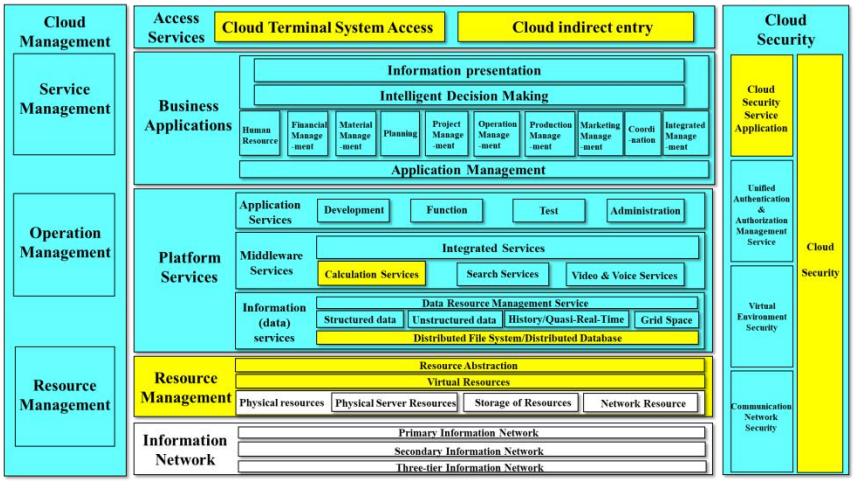

Figure 2. Technical architecture diagram.

4.2. Deployment Architecture

The entire power application cloud platform should support distributed deployment, centralized management mode, and has strong scalability.

4.2.1. Storage domain. The storage domain is the basic data support environment of the cloud computing platform, and it can adopt the SAN storage architecture and the distributed storage architecture hybrid mode. SAN storage architecture. From the perspective of application types, storage is based on high-performance grid storage arrays that support scale-out, while taking into account the need for large concurrent external user access, hardware-based storage virtualization systems are used to store different types of storage in the network. The devices work together to provide data storage and service access functions.

4.2.2. Computing domain. The computing domain is the core environment for the cloud computing platform to support application services. It can be divided into traditional application pools, x86 physical pools, and x86 virtual resource pools.

4.2.3. Network domain. The network domain is the basis for connecting various functional domains to implement intelligent data storage and high-performance computing. It is recommended to adopt dual-system cluster, 10 Gigabit fibre backbone, and 10 Gigabit to PC server configuration.

4.2.4 Management domain. The management domain mainly carries the cloud computing service platform service management, including resource management, service management, portal management, security management, etc. It can flexibly allocate resources dynamically, define data security access, storage, and backup mechanisms, and support unified management to multiple virtualization technologies and heterogeneous storage.

4.2.5 Security domain. According to the information system security protection requirements, information security protection includes four levels: boundary protection, network protection, host protection, and application protection. The power industry application cloud platform security service

domain is designed for network security, host security, virtual machine security and application security.

5. Conclusion

Cloud computing marks an important transition of information technology from product to service, and it is the inevitable development direction of integration and intensification of enterprise information construction. The State Grid Corporation's information support platform needs to introduce cloud computing technology to achieve more flexibility, simplicity and security, and realize the gradual evolution of hardware and software to centralized services. Based on the construction of power cloud platform, this paper focuses on the power application cloud platform reference architecture from the three aspects of development status, key technologies and reference architecture, and provides technical support for the cloud computing construction of State Grid Corporation.

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