Scheme and research of realizing regional substation by using private cloud technology

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Abstract. In recent years, the technology of Internet of things and information communication technology have developed rapidly. With the construction of intelligent substation, the intelligent level of main equipment is constantly improving, and the power data network is constantly improving, which provides the basic conditions for the realization of regional private cloud. In this paper, the concept, advantages, implementation scheme, construction process and advanced application of regional substation are proposed. And the application mode and scenario are discussed.

1. Private cloud technology

1.1. Cloud technology
Cloud technology is a kind of hosting technology that unifies hardware, software, network and other resources in WAN or LAN to realize data computing, storage, processing and sharing. Cloud services can be divided into infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS)\cite{1} according to the service level of the cloud.

\textbf{IaaS}: Infrastructure-as-a-service is an infrastructure that consumers can access through the Internet from a complete computer infrastructure.

\textbf{PaaS}: Platform-as-a-service, PaaS actually refers to the software development platform as a service, submitted to the user in SaaS mode. Therefore, PaaS is also an application of SaaS mode\cite{2}. However, the emergence of PaaS can speed up the development of SaaS, especially speed up the development of SaaS applications.

\textbf{SaaS}: Software-as-a-service is a mode of providing software through the Internet. Instead of purchasing software, users rent Web-based software from the provider to manage business activities, written in the style of a submission to \textit{IOP Conference Series: Earth and Environmental Science}, show the best layout for your paper using Microsoft Word. If you don’t wish to use the Word template provided, please use the following page setup measurements.

1.2. Virtualization
Virtualization is the foundation of cloud services and an important feature of cloud services\cite{3}. Through virtualization technology, cloud service platform can integrate multiple servers into a linked cluster, forming a pool of resources to achieve common computing, sharing resources, and maximizing the use of idle computing resources within the system showing as figure 1.
1.3. Mass data storage

The traditional storage method uses a dedicated storage server (or directly use the application server) to store all data. The storage server becomes the bottleneck of the system performance, and can not meet the needs of large-scale storage applications[4]. Data is usually stored in place, with low security, limited scalability and weak sharing capability.

Figure 2 shows that mass data storage adopts scalable system structure, uses multiple storage servers to share the storage load, and uses addressing servers to locate and store information. It has high reliability, availability, access efficiency and is easy to expand.

1.4. Mass data storage

Big data refers to the data set that can not be captured, managed and processed by conventional software tools within a certain period of time. Big data technology refers to the ability to get valuable information quickly from all kinds of data. The basic characteristics of large data are huge volume, diverse data types, fast processing speed and low value density.

2. Regional Substation

2.1. Regional substation

The regional substation described in this paper refers to the monitoring center in a specific power supply area. Regional substation realizes the unified management and control of multi-entity substation and independent equipment in the area through high-speed communication network[5]. It needs to be clarified that the concept of regional substation is limited to the regionalization of control information system. The actual power supply system is still implemented in the traditional way.

2.2. Schematic diagram of structure(figure 3)
2.3. Advantage

2.3.1. Centralized equipment management, optimize resource allocation. The regional substation adopts centralized station building mode. All the servers and storage devices are centralized in the regional central computer room.

In this mode, virtualization technology is applied to virtualize all servers, building server resource pool to implement IaaS.

Traditional substation servers have low utilization rate of general resources. Individual high-utilization sites are prone to hardware failures, and uneven distribution of resources, failing to achieve resource sharing.

Local storage, which is stored on the hard disk of the application server or in a separate storage server, has a large amount of storage resources in a long-term idle state and low utilization rate[6].

The Table 1 compares the two modes for different server numbers. Suppose the single station resource average demand is 40, the single server resource is 100, and the resource warning line is 90%.

| The server | Resource demand | Traditional substation | Regional substation | Saving rate |
|------------|-----------------|------------------------|---------------------|-------------|
|            | Configure       | Utilize                | Configure          | Utilize     |             |
| 1          | 40              | 100                    | 40%                 | 100         | 40%         | 0%          |
| 2          | 80              | 200                    | 40%                 | 100         | 80%         | 50%         |
| 3          | 120             | 300                    | 40%                 | 200         | 60%         | 33%         |
| 4          | 160             | 400                    | 40%                 | 200         | 80%         | 50%         |
| 5          | 200             | 500                    | 40%                 | 300         | 67%         | 40%         |
| 6          | 240             | 600                    | 40%                 | 300         | 80%         | 50%         |
| 7          | 280             | 700                    | 40%                 | 400         | 70%         | 43%         |
| 8          | 320             | 800                    | 40%                 | 400         | 80%         | 50%         |
| 9          | 360             | 900                    | 40%                 | 400         | 90%         | 56%         |
| 10         | 400             | 1000                   | 40%                 | 500         | 80%         | 50%         |

Comparing with the traditional substation construction mode, the regional substation mode can save about 50% of the server resources. In the case of unchanged total investment, this 50% is the so-called...
system margin, which can be used as a hot standby resource to improve the reliability of the system operation.

In addition, from the budget point of view, the server budget is limited in the case of a single station, configuring the general server, with poor performance and reliability. In the regional mode, multi-server budget overlay considering the performance and reliability requirements, select better servers to improve the system performance and security quality.

2.3.2. Optimizing data aggregation scheme to reduce repeated investment in infrastructure projects.

As mentioned above, the traditional storage server has become the bottleneck of system performance, and can not meet the needs of large-scale storage applications.

In traditional substation, the hot standby mode of dual (multi) machines is generally adopted. The application can only use the performance of a single device[7]. The equipment in hot standby state can only realize the function of backup, failing to achieve performance overlap or load balance. Real-time generated data is sampled and stored in a fixed time (1 or 5 minutes), and the remaining data is disposed by discarding. The system does not have the ability of mass storage and analysis. When the main station side carries on the data analysis, data is send by convention. The timing collection point pattern obtains the original data. The network structure under this mode is as figure 4:

![Figure 4. Network structure diagram of traditional mode data acquisition.](image)

In the traditional mode, structured data upload can only be carried out by remote control. Unstructured data need to be encoded and processed before uploading, and the size of data is limited.

The regional substation mode can effectively solve this problem. Because of the high performance of the regional substation, it can completely meet the needs of distributed data processing[8]. In this mode, the distributed data storage mode is adopted to avoid a large number of data migration. The network structure at this time is as figure 5:

![Figure 5. Network structure of data acquisition for regional patterns.](image)

In regional mode, the master station only needs to obtain the original data from the center of the interval, or adopts the distributed computing model[9]. The calculation task is delegated to the calculation node in the center of the interval, and the results are fed back to the main station. The network communication between the plant and the regional center is direct, and the data is directly connected. As long as the network environment is stable and high-speed, there is no obstacle to data acquisition.
2.3.3. **Improving data sharing and interoperability and realizing regional big data analysis.** The Using the regional substation mode, the regional center is equivalent to the distributed data center for the main station. By establishing a high-speed Internet, the data interconnection between the regional centers and the regional center can be easily realized, which provides the basic conditions for distributed computing and large-scale data analysis. On this basis, the protection system at the regional level can be realized, even cross-domain, multi-domain linkage protection system.

*To achieve rapid recovery and system expansion, provide a unified disaster recovery plan*[^3]. By establishing a regional center, we can make use of the characteristics of virtual machine to provide perfect host hot standby, mirror, snapshot, support real-time migration, fast recovery, dynamic expansion and other functions.

Through regional interconnection, data can be backed up in different places, system redundancy, disaster preparedness and even system-level substitution in extreme cases can be realized. Compared with the traditional substation, the system-level redundant backup is realized, and the data RAID, multi-copy and remote backup are realized, which greatly improves the stability and availability of the system.

2.3.4. **Centralized operation and maintenance, reduce maintenance difficulty and costs.** Under the traditional mode, the operation and maintenance of substations are generally divided into one shift (operators), two shifts (telecontrol, relay personnel).

In the regional mode, because the system is built on the cloud, the secondary operators can easily access and maintain the monitoring system through a dedicated channel or VPN using the cloud terminal system. In addition to routine on-site equipment maintenance, the rest of the cases can be adopted.

In the future, the TT&C and protection equipment can also be moved to the regional center. All the data can be uploaded by intelligent terminals and merging units[^10]. At this time, the routine maintenance of the protection equipment can also be completed in the regional center.

In the regional center, operators can collect real-time data and video from cloud terminals and mobile devices for on-duty monitoring. Combined with intelligent push mechanism, when key information is generated, it can be pushed to personal mobile devices on time to reduce the link of information transmission, shorten the time of information transmission and improve the processing efficiency.

3. **Construction Process**

In this paper, according to the network construction and informatization level, the construction of regional substations is divided into four stages. The details are as follows:

3.1. **Centralized station, hardware virtualization**

In the first stage of the construction of regional substation, the centralization of monitoring system, server and storage equipment is mainly completed. The virtualization method is adopted to realize the private cloud, the hardware level without plant-station boundary, and the virtual machine technology is used to construct the monitoring system and storage system.

At this stage, no modification is made to the measuring and protecting devices at the scene. Only on-site servers and remote devices are cancelled, and all two devices are directly connected to the Internet.

3.2. **Two equipment centralization**

This stage mainly solves the problem that the secondary equipment in the first stage is still running in place. The realization of this stage depends on the construction of the network. It is necessary to build a communication network with high bandwidth and low delay.

The intelligent terminals and merging units are directly used in the scene. The protection and control devices are all transferred to the regional center, and data acquisition is achieved through high-speed communication network.

3.3. **Platform virtualization**
With the advancement of information technology, the main monitoring system should change the traditional single machine installation and operation mode, and enter the cloud platform operation mode. Operating system level is not divided into plant and station, plant and station logical isolation through the cloud platform software architecture to achieve PaaS or SaaS.

3.4. Platform virtualization

By further promoting the interconnection and interoperability of communication networks and combining with the implementation of PaaS/SaaS, data access and migration between regional centers become easier. At this time, the demarcation between regions is no longer obvious, and platform-level interconnection, interoperability, cooperation and disaster preparedness are realized.

4. Advanced Application

After the establishment of an interoperable regional center, you can use the resources of the cloud platform to implement some advanced applications, as follows:

4.1. Fault prediction

Through real-time acquisition and analysis of regional data changes, large data analysis technology has been adopted to establish a fault prediction model to achieve fault early warning.

4.2. Behavior analysis

Access personnel single soldier system, analysis personnel operation habits, data sampling induction. The warning is issued to discover violations, and to prevent improper behavior through linkage operation, so as to achieve intelligent five prevention.

4.3. Real time failover

By establishing snapshots, redundant backups, hot standby and other ways, the important systems are provided with real-time recovery, substitution and other support to achieve real-time failover.

5. Conclusion

The scheme has been successfully applied in many engineering projects. The practical operation has proved the feasibility of the scheme. With the development of Internet of things and network infrastructure, regional substation technology no longer has technical barriers. This paper discusses the concept, advantages, implementation scheme, construction process and advanced application of regional substation. Some viewpoints may not be mature, and are welcome to be corrected.

6. References

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