Research on System Architecture of Internet Data Center Construction in Substation based on Ubiquitous Function

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Abstract: Substation has the advantages of having spare area, close to users, rich communication resources, reliable power supply. By releasing substation site resources, data centers and cloud services can be provided to the society. Construction of Internet Data Center (IDC) with the idle substation resources to realize multi-station integration will economize on social costs and accelerate the development of the digital infrastructure. In this paper, we analysed the participants involved in the expansion data center of the substation. Explore relations among Grid Company, Telecom Operator and User. According to the time sequence of the development of multi-station fusion business, the business time sequence diagram of the substation extended data center station covering the whole business process was designed. Considering the business flow, information flow, and energy flow flows between each section, the dynamic sequence diagram was built. We build the system architecture of business implementation including construction, operation, settlement and other links.

1. Introduction

With the construction and development of distributed power grid, and the increased demand for quality and stability of power, it is necessary to solve the balance of electricity supply and demand, reliable power grid, reliability problem, energy efficiency and other problems. As an important measure to accelerate the effective implementation of energy internet construction, the multi-station fusion project can transform the original substation into a data center station, changing station, energy storage station, 5G base station, photovoltaic station and other multi-station integration. It can improve the efficiency of data perception and analysis, and further strengthen the integration development of internet of things and smart grid. Using cloud computing, big data, artificial intelligence and other information means to build a direct interaction channel between the power generation side and the user side, so as to develop multi-station integration of value-added services and realize integrated operation.

With the development of 5G and the growing demand for mobile Internet, Internet Data Center (IDC) will translate from “core computing” to “edge computing” to solve the problem of network transmission nearby\cite{1-2}. At present, edge data center is in the early stage of development, telecom operators, Internet giants and competitive IDC servicers have begun their technical distribution\cite{3-4}. There is a strong correlation between the available substation resources and the needs of edge data center, so the construction of IDC based on substations that are user friendly, extensively covered and electrically supported can provide new profit growth point for company; on the other hand, the
satisfaction of users’ demands for services such as electric power, computing power, storage and connection nearby can also provide IT infrastructure resources for Ubiquitous Power Internet of Things (UPIOT) to connect the physical with the digital, so as to drive the future development of new industries such as edge computing and 5G[5-6].

2. The connotation of ubiquitous
With the construction of ubiquitous power internet, the energy internet can gradually connect the power users and their equipment in the links of power generation, transmission, distribution and users. It will be connected from the power industry equipment to equipment, people to equipment, and gradually extended to families, enterprises, urban internal intelligence. It provides industrial, commercial and residential users with a wide range of business services to realize the ubiquitous function of the energy internet. In the field of commerce, through the integration of energy and information infrastructure, the electric power facilities and commercial information facilities are interconnected. In physical form, resource sharing can extend the boundary of energy Internet to commercial information facilities. In terms of service form, data and informatization business ability can be lowered to commercial users. Based on the analysis of the ubiquitous fusion and penetration process of energy Internet in the commercial field, the multi-station fusion (data center station of substation construction) was selected as the research object, and the typical realization scenario of ubiquitous function was designed. The connotation of ubiquitous function is analyzed, as shown in Table 1.

| typical scenario | ubiquitous function | connotation of ubiquitous function width | connotation of ubiquitous function depth |
|------------------|---------------------|----------------------------------------|----------------------------------------|
| Multiple Station Fusion | Industry Drive | With the construction of data center station in the substation as the means, the ubiquity of data center in geographic space is realized, and the ubiquity of cloud service in data center in service space is realized | Based on the scale effect of large-scale and distributed distribution points, it realizes the nearby storage and processing of data, drives the development of edge computing, cloud computing and other industries, and expands the industrial economic benefits. |

3. Extract key elements
Firstly, various market entities that participate in the expansion of IDC business in substation are sorted out, the roles and business entities of each entity are defined, the correlation relationship and business functions among each entity are analyzed, and the static relationship diagram is constructed. Secondly, based on the static diagram and according to the time sequence of business transmission, build the dynamic time sequence diagram of substation expansion IDC. Thirdly, considering the logic fusion process of information flow, business flow and energy flow, the third flow fusion diagram is constructed. Finally, based on the multi-station fusion physical form, the system architecture of "cloud, edge and terminal" coordination and interaction is constructed.

IDC construction in substation mainly involves telecom operators, Content Delivery Network (CDN) operators and Internet companies. Subjects of the IDC construction in substation are extracted and business activities are described according to the actors.

Substations/distribution rooms are widely distributed, highly dense and close to the user side and data sources, and the construction of IDC to provide edge computing services can reduce the delay in
computing and the pressure on bandwidth, which provides better support for real-time and bandwidth-intensive services. Substations close to the user side are selected for IDC construction, with cabinets, servers and other IDC equipment installed in the spare space of substations, so as to give play to the geographical advantages of substations and provide near-end intelligent services for users.

IDC construction in substation mainly involves the four services of Server Co-Location, Value-Added Service, Cloud Service, and Edge Computing. Server Co-Location means that site, electric power, network and other resources are provided to obtain the co-location service charge and differential prices from electric charge and bandwidth cost in contract; it can be divided into wholesale and retail based on the co-location scale and the provision of cabinets; Value-Added Service means that services such as server equipment, software and dedicated bandwidth are provided for users to obtain the appropriate rentals; Cloud Service means that services such as cloud host, cloud storage and cloud computing are provided for users to obtain the cloud service charges; Edge Computing means that near-field computing services are provided for CDN, Internet of Things (IoT), autonomous driving, Internet of Vehicles (IoV), 5G Base Station and VR/AR (augmented reality/virtual reality) to obtain the edge service charges.

At present, considering the role of operators in network bandwidth, users from governments and enterprises and other resources, IDC construction in substation requires cooperation with telecom operators to share resources to solve problems such as 5G and edge computing architecture design.

4. Business relation model

4.1 Static relation diagram

Static relation diagram of business is built based on the preliminary analysis of business entities and activities. Cases contained in business roles (Grid Company, telecom operator and business enterprise) and relations between them are described from the perspective of actors, as shown in Figure 1.

![Figure 1. Static relation diagram of IDC construction in substation](image-url)
4.2 Dynamic sequence diagram

Sequence diagram of IDC construction in substation is built based on the above static relation diagram and the sequence of business. IDC users, such as Internet companies, make their demands on Grid Company for server co-location, edge computing and cloud services, and Grid Company evaluates and designs IDC construction scheme and cooperates with operators to complete the configuration and installation of hardware equipment. Internet companies pay for Grid Company based on the purchased services, and the proceeds are distributed according to their cooperation agreement. The dynamic sequence diagram of IDC construction in substation as shown in figure 2.

5. Three-flow integration model

IDC construction in substation is conducted based on the local conditions and user demands, focusing on the demands from the site selection and design in the early stage to the construction and operation in the medium stage. In the early stage, Grid Company fully investigates and evaluates the available substation resources such as land, electric power and bandwidth based on the user demands, and determines the services and time through business negotiation with users before they enter into a contract; makes comprehensive analysis for the internal and external environment such as geographical location and type of substation, local policies and regulations and market, and makes plan and design for the IDC construction; cooperates with operators in the construction and configuration of software/hardware equipment, completes the equipment debugging and simulation operation according to user demands.

IDC construction in substation is operated by different actors. Grid Company is responsible for the daily operation and maintenance of external equipment such as electric power, fire protection, cabinet and air conditioning, and IDC users are responsible for software services such as server and data. For
example, problems such as data loss and video delay due to a server problem are handled by professional IDC operation and maintenance staff.

Data loss, packet loss or other problems may occur due to unstable power supply, insufficient bandwidth or poor heat dissipation in the provision of IDC services. Grid Company should compensate IDC users for the loss according to contract after evaluation of service quality. Finally, settlement is completed according to the service charge standard and compensation standard. The process of IDC construction in substation as shown in figure 3.

![Figure 3. Process of IDC construction in substation](image)

IDC construction in substation builds the edge computing cluster through substation interconnection, and supports the complex business architecture demand of “cloud-edge-terminal” with edge data center and network in cloud service to deliver the business capacities of IDC to the users.

Substation resources have a high matching degree with the demand of edge computing sites, which can not only provide them with address, channel, power and other services, but also be the main application of edge computing. It mainly provide three products, IDC, cloud services and edge computing. IDC service includes hosting, cabinet rental, bandwidth rental, etc. With professional management and operation, it can serve customers with products such as site, machine room environment, equipment resources, network bandwidth rental, etc. Clouding service provides IT
resources of data center to customers. Through the unified resource service platform, it provides IaaS public cloud services including network, storage, computing, and PaaS enterprise common application service platform and other related cloud services. Edge computing fully mix IDC, cloud services, the existing ability of industry informatization product, provide integrated solutions for any kinds of enterprises, industrial internet, smart city, the public security and medical. Specifically including security tools, data migration and backup. The system architecture of IDC construction in substation as shown in figure 4.

![System architecture of IDC construction in substation](image)

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