Service Interoperability System Architecture and Service Extension Method

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Abstract. With the development of power grid, the amount of data and calculation generated by network edge devices is increasing rapidly, which brings the pressure of data analysis and storage, service interoperability and model expansion. Traditional edge cloud collaboration mode uses user-defined model manually, and then downloads the model from the cloud to the edge for execution to expand the model. This method relies heavily on human experience and is difficult to ensure the efficiency of model expansion when the amount of data is large. Based on the analysis of three basic capabilities of service interoperability system, this paper innovatively proposes an automatic construction method of service extension. Firstly, the model is described as a tree structure, and then the model is automatically added from the edge to the cloud as a branch. Finally, a complete industry interoperability model library is formed in the cloud.

Keywords: Edge Computing, Cloud Computing, Service Interoperability, Semantic Model

1. Introduction

Service oriented interoperable network data architecture refers to encapsulating resources into relatively independent network services through a unified modeling language. This service belongs to a specific model library to realize resource sharing and interoperability. The architecture can manage resources in cloud edge efficiently and safely, and has the ability to update and expand the model base. According to the principle and method of power grid industry production, the application function is decomposed into services, and the application is flexibly organized according to the needs of customers. Combined with semantic modeling technology, resource management and resource allocation are realized to realize cloud and local collaborative design. Therefore, the traditional research on service interoperability system focuses on the service interoperability system, which should have perfect semantic modeling management technology, functional microservice division and
edge cloud collaborative deployment capability. However, this ignores the need for architecture to automatically expand the model. In practical application or academic research, large emerging cloud platforms often need to be able to store and parse interoperability models covering multiple industries to meet the needs of various applications. Therefore, the service interoperability system needs to have the ability to automatically expand the model in addition to the above three basic capabilities.

This paper first summarizes the research progress of service interoperability system at home and abroad, and concludes that the service interoperability system should have three basic capabilities: semantic modeling, micro service division and edge cloud collaboration, and elaborates the three capabilities in detail; then, it gives the description of the ability of automatic extension of the model and the corresponding multi tree expansion method; finally, through the experiment The results show that the timeliness and accuracy of the method can reach certain application standards.

2. Related Work
As one of the important technology engines of Internet plus application, network interaction includes the boundless interaction between human, information physical system CPS, business content in the real world, web pages content, model, data and hardware and software resources in virtual space [1]. Because the service value and meaning derived from this kind of interaction are more easily recognized, this kind of omni-directional interaction demand has emerged [2]. However, the related software engineering technology has not been attached great importance and has not become a hot spot of current research [3].

Software engineering technology supporting network interaction should include loosely coupled semantic interoperability and governance and management methods of its capabilities [4]. In fact, scholars at home and abroad have a long history of understanding and attention to interoperability technology [5]. In 2009, Nelson emphasized the openness and interoperability of cloud in his paper "building an open cloud" published in science [6]. Giles put forward ten challenging questions in Social Sciences in nature, in which question 3 and question 5 both mentioned "technologies looking forward to solving interaction and collaboration"[7]. In 2008, the book "network software" proposed and discussed the requirement guided loosely coupled interoperability method [8]; at the same time, the technical standard ISO / IEC 19763-3 "ontology registration meta model" [9] proposed the semantic enhanced interoperability theory, method and interoperability meta model framework supporting data, metadata and software models.

With the rapid development of the Internet, software engineering technology supporting "Internet plus" is undergoing a transformative development. Especially in the modern service industry and service computing, the ubiquitous network interaction between the service supply side and the demand side is becoming the focus of academic and industry research and attention. [10] This paper puts forward a "return type" service relationship model of service computing, which uses the service resources and capabilities of the subject on the service supply side to deliver valuable and meaningful services to the object to meet its needs.

3. Semantic Service Interoperability Architecture Based on Edge Cloud Collaboration

3.1 Architecture Overview
In view of the three problems in the service interoperability environment summarized above, this paper presents the semantic service interoperability architecture of edge cloud collaboration as shown in the figure below. Firstly, the data of the underlying power equipment is collected through the edge software at the edge end, and the data of these devices are structured and encapsulated, that is, the semantic unified description. After encapsulation, multiple virtual model device objects are exposed to the upper application, and the application interfaces of these device model objects are re encapsulated to abstract five unified device microservices, namely microservice capabilities. The post cloud application and the edge end work together to complete multiple cloud applications, namely the edge cloud collaboration capability.
The automatic expansion capability of the model is still not considered in this architecture. We will discuss it in detail in section 3.5 and the three basic capabilities of the architecture in Sections 3.1 to 3.3.

3.2 Semantic Expression Ability
In the figure 2, ATTR on the left side represents the abstraction of semantic attributes of interconnected production metadata, providing support for the subsequent efficient use of semantic data, and the right side SENSOR_STANDARD part realizes the detailed description of interconnected production data, in which the data item realizes the semantic description of data, status realizes the identification of data status, context realizes the description of data context and association, and reporting supports data report.

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3.3 Microservice Capability

The on-site power equipment can provide a variety of functional services, which can be divided into equipment connection service, equipment observation service, equipment configuration service, equipment alarm service and equipment planning service. These five services ensure the diversity of power process oriented service methods, and provide unified service invocation interface for upper application. These five kinds of services are the secondary encapsulation of edge resources. In the process of secondary encapsulation, the function expansion of edge resources reading and writing operation and the combination of basic services are included. After the secondary encapsulation, the system can provide users with more abundant and practical call interfaces, which are more convenient for Internet developers to redevelop. The five interface services are described below.

A Power Internet Observation Service

Power internet observation service (PIOS) is the basic service in the power Internet service. It provides a standard way to achieve the information acquisition of all sensor systems, such as remote sensing, field monitoring, fixed or mobile. It is located between the user and the industrial instrument perception data warehouse or real-time sensing data, providing convenience for users to access data information. PIOS is the bridge between application layer and data. The application layer sends a request to the PIOS service, which queries the data source and returns the real-time or historical observation data to the application layer.

B Power Internet Configuration Service

Power internet configuration service (PICFS) is the basic service of power Internet. It provides a standard configuration method to write information of all sensor systems, such as remote sensing, field monitoring, fixed or mobile. The application layer sends a request to the EICS service, which queries and requests the write permission of the device resource. If the permission is allowed, the application calls this service to configure the instrument.

C Power Internet Warning Service

Power internet warning service (PIWS) is used to publish and subscribe industrial Internet alarms. It is a service that clients can register and receive industrial instrument alarm information. PIWS provides pre-defined and customized alarm services. When the mode is defined in advance, PIWS sends a subscription request to the registered user, and the user confirms whether or not to subscribe to the alarm; when the mode is customized by the user, the alarm service determines whether the observation data constitutes an alarm according to the preset alarm conditions of the user. If the alarm condition is met, the alarm is started and the alarm notice is sent to the subscriber. PIWS service mainly includes alarm announcement, reservation and notification process.

D Power Internet Connection Service

Power internet connection service (PICS) is the user needs to establish the corresponding use relationship between the user application and the power equipment before using the power Internet, that is, the connection service, which is the basis of the other four services.

E Power Internet Planning Service

Power internet planning service (PIPS) aims to provide a unified complex task submission mode for power Internet with certain information processing capabilities. In some specific application environments, the power Internet needs to complete a series of complex operations independently or cooperatively. These operations are the collection of simple read-write services. The power Internet needs to complete these pre-designed complex operation sets, which are called planning services. Therefore, a set of application models of planning services are defined.

3.4 Cloud Edge Collaboration Capability
According to the different division of labor between the edge and the cloud, there should be the following scenarios of collaborative processing problems between the edge and the cloud, which are explained separately below.

Resource collaboration: edge nodes provide infrastructure resources such as computing, storage, network, virtualization, etc., and have local resource scheduling and management capabilities. At the same time, they can cooperate with the cloud to accept and implement cloud resource scheduling management strategies, including device management, resource management and network connection management of edge nodes.

Data collaboration: the edge node is mainly responsible for the collection of field / terminal data, preliminary processing and analysis of data according to rules or data model, and uploading the processing results and relevant data to the cloud; the cloud provides storage, analysis and value mining of massive data. The data collaboration between the edge and the cloud supports the controllable and orderly flow of data between the edge and the cloud, forming a complete data flow path, and carrying out life cycle management and value mining of data with high efficiency and low cost.

Intelligent collaboration: the edge nodes perform reasoning according to AI model to realize distributed intelligence; the cloud carries out centralized model training of AI and distributes the model to edge nodes.

Application management collaboration: the edge node provides application deployment and running environment, and manages and schedules the life cycle of multiple applications in this node; the cloud mainly provides supply.

3.5 Service Expansion Capability

The expansion capability of service interoperability system refers to that in the edge cloud collaborative environment, the edge end is responsible for building the device models covered by the edge end. These models are automatically classified and extended to the corresponding model branches by the cloud after they are uploaded to the cloud. If there is no model branch, the new branch will be created. Through this mode, the model library in the cloud can constantly update and expand, so as to cover the whole system Industry model.

Whether in the cloud or at the edge, the model is managed by multi branch tree structure. For example, a cloud platform defines a multi branch tree memory structure as shown in the figure below, which is used to describe the equipment model of the power plant. The root node in the figure contains two power plants, powerplant1 and powerplant2. The power plant1 contains the measuring point values M1 to Mn of workshop1, workshop1 and several sensors, workshop1 contains large equipment boiler and generator set generator, and the boiler and generator set have several sensor measuring point values M1 to Mn.

![Fig 3. Example of memory structure of multi branch tree](image)

Tree structure is widely used in computer science to represent the relationship between things, with a very strong universality. In opcua, the tree structure is used to divide and classify all services and attributes; in owl, the tree structure is used to classify all object classes; in thingworx and other large
Internet of things platforms, the tree structure is used to classify and manage the constructed instances. In this paper, the tree structure is also used to manage the model.

The automatic model building process of service interoperability system is given below. First of all, each edge is responsible for the model collection on its branch, and upload the model to the cloud. If multiple edge ends upload multiple models to the cloud, the cloud will form a model library. In the above example, the edge end 1 covers all the edge measuring point information in the boiler, then the model in the edge end 1 can be defined as:

Edge end 1: root / powerplant1 / workshop 1 / boiler / (M1-Mn)

Similarly, the models in edge end 2 and edge end 3 can be defined as:

Edge end 2: root / powerplant1 / workshop 1 / generator / (M1-Mn)

Edge end 3: root / powerplant1 / (M1-Mn)

According to the above definition of edge model, firstly, edge terminal 1 uploads the model, and then the cloud is in the initial state, and the model library as shown in figure (1) is directly constructed; secondly, edge end 2 uploads the model, and the cloud starts to traverse from the root node, powerplant1 = powerplant1 (“=” means both are the same node, and the specific judgment method is defined by different systems), workshop1 = workshop 1, boiler! = generator! (“!” Indicates that the two nodes are different nodes, and the specific judgment method is defined by different systems). Then it can be concluded that the boiler and generator nodes have the same parent node. Therefore, after edge 2 uploads the model, the tree structure in the cloud is shown in figure (2); finally, the model of edge terminal 3 is added, and the final tree structure of cloud is shown in figure (3).

According to the automatic model building process, the edge model collector can be deployed randomly in the power field, then the model of the whole power industry can be automatically constructed from bottom to top.

4. Experiment
In this part, we evaluate the method of automatic service extension through experiments on simulated data sets. The data set we selected contains about 500000 sensor point attributes, covering the power industry, power generation, transmission, transformation, and use, saving 50390 equipment models.

The experimental environment is windows 10 operating system, the programming language is java1.8, the processor is Intel i7-8565u 1.8GHz 8-core, memory is 8GB.
Fig 5. Service automatic expansion experiment data trend chart

As shown on the left side of the above figure, the insertion time does not fluctuate greatly with the increase of the number of sensor points, and it is maintained at about 60 ms. This shows that the method has strong robustness for processing large data volume models, in which the classic edit distance method is used to calculate whether the nodes are the same or not. As shown on the right side of the above figure, the accuracy rate of model classification does not change with the increase of the number of sensor points, which basically maintains above 95%, which can meet the application standard.

5. Conclusion
Firstly, this paper summarizes the research status of existing service interoperability systems at home and abroad, and concludes that the data architecture of universal service interoperability system should have the ability of semantic expression, micro service and edge cloud collaboration. Then, it continues to analyze that the existing architecture does not support the automatic expansion ability of service interoperability model, so that it is based on the pervasive ability. Finally, the method is verified by a large number of experimental data, and it is concluded that the method has high practicability in terms of timeliness and accuracy.

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