Modelling of Resources and Activity of the Scrap Iron and Steel Reverse Supply Chain Service Based on Ontology

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Abstract: Scrap steel reverse supply chain service system is a typical complex system. The realization of the service activities involves a large number of service resources. And there are multiple relationships between atomic service activities and service resources. To realize the search matching between complex service resources and service activity demand in scrap steel reverse supply chain service, the modelling method of service resource information in scrap steel reverse supply chain based on ontology is proposed. After analysing the classification method of service resource, the ontology information model of service resources and service activities is constructed. Then the search matching between service demander and service resource provider is transformed into the mapping between service resource ontology and service activity ontology to solve. Finally, the ontology model of specific instance is established, and the Semantic Web ontology language OWL is used. The model is proved to be correct and feasible by describing the instance service resource ontology and service activity ontology.

1. Introduction

Scrap reverse supply chain service is a typical complex system, which involves many kinds of service activities such as recovery service, detection and classification service, inventory transportation service, matching decision-making service and waste disposal. How to model the service resource that completes the service activity, and map the service resource to the service activity is a problem worthy of further discussion.

At present, a large number of scholars have discussed service discovery or service matching. Omid fatahi valilai regards everything in the cloud computing environment as a service, and a service-oriented method is used to build the cooperation and integration platform of distributed manufacturing service agent [1]. A matching method is designed based on reasoning and semantic similarity calculation with service behavior constraints, and the accurate matching degree of the service to be matched is obtained through this method [2]. For the process of service composition, local semantic matching based on abstract service and global semantic matching based on QoS awareness are proposed [3]. For mass customization environment, this paper proposes an ontology-based configuration method of service product / service package is proposed by Dong, and a configuration model is established [4]. Aiming at the efficient matching of equipment resources and processing tasks in cloud manufacturing environment, a matching method of equipment resources and processing tasks in cloud manufacturing environment is proposed [5]. The above researches mainly focus on the organization and management of service
resources and devices, and few consider the modeling of service activities and the mapping with service resources from the perspective of ontology.

In view of the above problems, a unified modeling method of service resources activities of scrap steel reverse supply chain based on ontology is proposed, and a mapping model between ontologies based on service resources and service activities is designed. Taking the service requirements of a scrap steel processing enterprise and the service resources provided by relevant service enterprises as examples, the corresponding ontology model is established in OWL, so as to achieve the purpose of simulating the real enterprise service requirements, and the correctness and feasibility of the proposed method is verified.

2. Scrap iron and steel reverse supply chain Service and ontology representation
According to the customer demand in the scrap iron and steel reverse supply chain, the scrap steel reverse supply chain service integration platform provides the service demander with the optimal service solution and service according to a certain service mechanism. A large number of scattered scrap iron and steel recycling and processing enterprises’ information is integrated in the service integration platform. And the service activities such as recycling service, transportation service, processing service, distribution service and decision-making service which are completed by service providers are managed in the platform, and also the service resources. The completion of atomic service activities which are inseparable involves a lot of service resources. Service resources are the material basis for the realization of related service activities, and the realization of the function of service activities depends on the collaborative operation of related service resources. The relationship between the service activities and the service resources is extremely complex. How to clearly express the relationship between the service activities and the service resources is one of the key points for the successful operation of the service system.

In order to express the relationship between the service activities and the service resources clearly, it is necessary to build the mapping model of service activities and resources in the service integration platform, and establish the agent model for the customer service requirements and service provider to track and match. In the platform, the ontology semantic network representation can be adopted. As one of the cores of semantic web, ontology is a kind of conceptual model which can describe resources at semantic and knowledge levels, so as to realize the systematic information processing of service resource semantics.

3. Modelling of service resources and service activities based on ontology

3.1 Classification of service resources in scrap reverse supply chain
The purpose of service resource classification is to make the modeling and management of service resources standardized and consistent. The service resources can be easily integrated, shared, dynamically organized and managed in the service platform of scrap reverse supply chain.

The service resources in the reverse supply chain of scrap steel can be divided into narrow sense and broad sense. Narrow sense of service resources only refers to the services provided, such as logistics services, training services. In a broad sense, service resources refer to the sum of all logistics information and technical elements needed to complete the service requirements of service customers, from service scheme design, service implementation to service evaluation. The service resources of scrap steel reverse supply chain can be regarded as the service personnel, service technology, equipment, information, energy, capital, site and other resources which are involved in the process of scrap steel recycling.

3.2 Service resource ontology model
The service resources needed in the service process of scrap steel reverse supply chain are obtained by analyzing all the service activities which compose the service process. According to the function of service activities and the classification characteristics of service resources, the service resources needed
by service activities can be encapsulated, and then the key service resource set representing service activities can be extracted. These service resource sets must be unique and can uniquely represent a service activity. Therefore, it is necessary to establish appropriate service resource information model and service activity information model to facilitate the service integration platform to search and match the service resource demander and service resource provider.

An ontology-based construction method of service resource information model of scrap steel reverse supply chain is proposed, and the service resource ontology model is established, as shown in Figure 1.

![Figure 1. service resource ontology model of scrap steel reverse supply chain](image)

The service resource ontology of scrap steel reverse supply chain mainly includes: service resource information (ServiceResourceInfo), service basic information (ServiceBasicInfo), service domain information (ServiceDomainInfo), service state information (ServiceStateInfo) and service function information (ServiceFunctionInfo).

Definition 1: service resource ontology. $\text{ServiceResource} = \{\text{ServiceResourceInfo}, \text{ServiceBasicInfo}, \text{ServiceDomainInfo}, \text{ServiceStateInfo}, \text{ServiceFunctionInfo}\}$.

Service resource information mainly refers to the key service resource package name, key service resource package number, price range, service time and service quality, etc.

Definition 2: $\text{ServiceResourceInfo} = \{\text{KeyServiceResourcePackageName}, \text{KeyServiceResourcePackageNumber}, \text{PriceRange}, \text{ServiceTime}, \text{ServiceQuality}\}$.

Service domain information mainly refers to the information that service resources belong to scrap steel processing services, decision services, logistics services and recycling services.

Definition 3: $\text{ServiceDomainInfo} = \{\text{Processing Services}, \text{Decision Service}, \text{Logistics Services}, \text{Recycle Service}\}$.

Service Basic information mainly refers to the key service resource name, resource provider, etc.

Definition 4: $\text{ServiceBasicInfo} = \{\text{KeyServiceResourceName}, \text{ServiceResourceProvider}, \text{ContactionInfo}\}$.

Service state information mainly refers to the information of service resources in service, service idle, underloaded, service interruption, invalid service, etc.

Definition 5: $\text{ServiceStateInfo} = \{\text{InService}, \text{Service idle}, \text{Underloaded}, \text{Service interruption}, \text{Invalid service}\}$.

Service function information mainly describes the function information of service resources.
Definition 6: Service Function Info = \{Types of detectable services, the processing scrap steel type, the processing size, Transportable service size\}.

3.3 Service activity ontology model

The reverse supply chain service activity of scrap steel is the key service function activity included in the service process of scrap steel recycling and reprocessing. According to the different service needs, the recycling service process is different, and the corresponding service function activities are also different. The service activity ontology mainly include: service resource information (ServiceResourceInfo), service basic information (ServiceBasicInfo), service domain information (ServiceDomainInfo), service state information (ServiceStateInfo) and service function requirement information (ServiceFunctionRequirementInfo). The service activity ontology model can be constructed, as shown in Figure 2.

**Figure 2. service activity ontology model of scrap steel reverse supply chain**

Definition 7: service activity ontology. ServiceActivity = \{ServiceActivityInfo, ServiceBasicInfo, ServiceDomainInfo, ServiceStateInfo, ServiceFunctionRequirementInfo\}.

(1) Service activity information mainly refers to service activity name, products quantity, price range, service time, service quality and other information needed by service demanders.
Definition 8: ServiceActivityInfo = \{ServiceActivityName, ProductsQuantity, PriceRange, ServiceTime, ServiceQuality\}.

(2) ServiceDomainInfo refers to the domain of service activities.
Definition 9: ServiceDomainInfo = \{Processing Services, Decision Service, Logistics Services\}.

(3) ServiceBasicInfo refers to the basic information of service activities.
Definition 10: ServiceBasicInfo = \{ServiceProvider, ContactInformation\}.

(4) StateInformation refers to the state information of service activities.
Definition 11: StateInfo = \{NotStarted, Underway, Completed\}.

(5) ServiceFunctionRequirementInfo refers to the function requirement information.
Definition 12: ServiceFunctionRequirementInfo = \{Types of detectable services, the processing weight, the processing scrap steel type, the processing size, Transportable service size\}. 
4. Service resource and service activity matching model based on Ontology

After the unified service resource ontology model and service activity ontology model are established, the owner and demander can dynamically add service resource supply and demand information to the model in system integration platform. When the agent of service platform receives the requirements, which will be transformed into atomic service activities, and the information of service activities is mapped and matched. Through the semantic similarity algorithm, the semantic similarity $S_1, S_2, S_3, S_4$ and $S_5$ between service resources and service activity ontology elements are calculated in turn, and the service resource set that meets the requirements is obtained. The matching and optimal configuration are completed. The matching model of service resource ontology and service activity ontology is shown in Figure 3.

![Matching model of service resource ontology and service activity ontology](image)

5. Cases

X metal resources company needs to establish scrap reverse supply chain service integration platform in its region. X metal resources company needs to recover 200 tons of scrap iron and steel from the superior recycling center. The service activities involved include recycling service, transportation service and testing service. The enterprises or centers providing service resources mainly include: social regional recycling center, scrap steel transportation company, scrap steel storage and transportation company, etc. In order to make the service resources and activities clearly expressed, and correctly build the service integration platform. OWL language is used to express and store the service resources and activities information of scrap steel reverse supply chain. The ontology model of service resources and service activities is established by using the above ontology modeling method and ontology construction software protégé, and some owl fragments are given, taking processing service as an example.

| Attribute Class | Attribute Name | Attribute Value |
|-----------------|----------------|-----------------|
| Service activity information | Key service resource name | Processing equipment |
|                   | Products Quantity | 200000          |
|                   | Price Range      | 560000-600000   |

Figure 3. matching model of service resource ontology and service activity ontology
| Service domain information | Service Time | 90 |
|----------------------------|--------------|----|
|                           | Service Quality | High quality scrap |
| Processing service         | No           |
| Logistic service           | Yes          |

Processing service resource owl program fragment:

```xml
<......>
<KeyServiceResource ackageName rdf:about="SC_201908097_Class56"/>
<KeyServiceResourcePackageName rdf:datatype="http://www.scrapsteelservice.org/2001/XMLSchema#string">
  <Crusher-Vibrating Conveyor-Magnetic separator/>
  <KeyServiceResourcePackageName/>
  <KeyServiceResourcePackageNumber rdf:about="SC_201908097_Class57"/>
  <KeyServiceResourcePackageNumber rdf:datatype="http://www.scrapsteelservice.org/2001/XMLSchema#string">
    3-5-3
  </KeyServiceResourcePackageNumber>
  <Typesofdetectableservice rdf:about="SC_201908097_Class65"/>
  <Typesofdetectableservice rdf:datatype="http://www.scrapsteelservice.org/2001/XMLSchema#string">
    Radioactivity detector
  </Typesofdetectableservice>
  <......>
</KeyServiceResourcePackageName>
</KeyServiceResource ackageName>
</KeyServiceResourcePackageNumber>
</Typesofdetectableservice>
<......>
</ServiceResourcePackageNumber>
</ServiceResourcePackageName>
</ServiceResourcePackage>
</SerivceresourceProvider>

Through the above application example, the correctness and feasibility of the proposed modeling method of service resources and service activities are verified.

6. Conclusions

The successful operation of reverse supply chain service of scrap iron and steel is one of the effective operation management modes to realize sustainable development of iron and steel industry. In order to realize the successful operation of the reverse supply chain service system of scrap steel, it is necessary to clarify the complex relationship between service activities and service resources. After analyzing the classification of service resources, the service resources ontology model and service activities ontology model are proposed, the matching model of service resources are designed. The search matching between service requirements and service provision is transformed into the mapping matching between service resource ontology and activity ontology. Finally, the feasibility and effectiveness of this method is verified through a specific example application.
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