OWL 2 Based Validation and Modeling of Logistic Domain Ontology

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Abstract

Current logistic service system can not meet the diversified requirements of modern logistic business operation due to without available logistic domain ontology. Based on the above problem, the logistic domain ontology and logistic service quality ontology are modeled utilizing OWL 2 according to the process of logistic business operation, and validation results for logistic domain ontology show that the method is effective and feasible.

Keywords: logistics, ontology, logistic domain ontology, validation, OWL 2

1. Introduction

With the development of the industry in China, it is paid more attention to the modern logistics. However, current logistic service system can not meet the requirements for the customers exactly due to without enough available logistic semantic services [1, 2]. Moreover, modeling logistic domain ontology is the only way to achieve logistic semantic service.

The typical three-layer framework on semantic Web was proposed by Tim Berners-Lee in 1998, and semantic Web is used for annotation of WSDL (Web Service Description Language, abbr. WSDL) [3], and the semantics is derived from the corresponding ontology. However, there is no complete and open logistic domain ontology until now, so the method of modeling logistic domain ontology is studied and validated in this paper.

2. Description of Ontology

2.1. OWL 2

OWL (Web Ontology Language, abbr. OWL) 2 is an extension and revision of the OWL Web Ontology Language developed by the W3C Web Ontology Working Group and published in 2004, and OWL 2 is designed to facilitate ontology development and sharing via the Web [4].

The OWL 2 Web Ontology Language is an ontology language for the Semantic Web with formally defined meaning [5]. OWL 2 ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents.
OWL 2 ontologies can be used along with information written in RDF (Resource Description Framework, abbr. RDF), and OWL 2 ontologies themselves are primarily exchanged as RDF documents [6]. The working principle of OWL 2 is to locate the ontology by its name and location, and it can retrieve the new location when redirecting the location of target ontology.

2.2. Ontology Modeling Tools

Currently there are many tools for ontology modeling, such as OILEd, OntoEdit, Ontolingua Server, which are developed by University of Manchester, Karlsruhe University, Stanford University respectively [7], however Protégé, developed by Stanford University for the version of former 3.x, and by University of Manchester for the version of latter 4.x, is a kind of popular tool for ontology modeling, so the latest version Protégé 4.3 [8] is adopted to model logistic domain ontology in this paper, which supports OWL 2 in Protégé OWL files.

3. Domain Ontology Modeling

Ontology modeling is an effective medium to accomplish semantic annotation, semantic searching, service matchmaking, service selection and service composition. Ontology modeling is a complex project because of its time consuming and much data involved, so ontology modeling process includes knowledge classification for special domain, relation confirmation between properties of ontology concepts, and ontology modeling with source sharing and well definition. However, the knowledge data involved in logistics domain is so much, and the relations between knowledge concepts are so complex, that a perfect logistic domain ontology is hard to complete due to different modelers with different knowledge level and different views on the same issue.

Logistic domain ontology includes various ontology class for logistic operation, sub-process and sub-class for logistic activity, relation between super classes, relation and properties between super class and other sub-class. The instances of logistic domain logistic ontology and ontology of quality of service (abbr. QoS) in logistic domain are modeled according to the process of logistic business operation.

3.1. Instance of Logistic Domain Ontology

The instance of logistic domain ontology is modeled according to the concepts of all the sections in logistic business operation, which is shown in Figure 1, and figure (a) and (b) indicate the tree list and class view of logistic domain ontology respectively.

The logistic domain ontology includes the two sub-classes, i.e., logistics_engineering and logistics_management. Logistics_engineering includes its sub-classes, e.g., transportation, storage, package and distribution, furthermore, transportation class consists of mode, location and contact, so every sub-class is composed of further level of subclass. On the other hand, ontology class is the concept with some properties, e.g., distribution is one of the sub-classes from logistics_engineering, which has the property “hasDistribute”, and the corresponding domain is sub-class “goods” from logistics_engineering.

Logistic domain ontology in the form of OWL 2 is shown in Figure 2, and the namespace is in http://www.w3.org/2002/07/owl#. Among that, the classes are defined, e.g., Transportation class is a sub-class of logistics_engineering. At last the Annotation of the ontology is described in the fragment.
Figure 1. Instance of Logistic Domain Ontology

Figure 2. Fragment of Logistic Domain Ontology

3.2. Instance of Logistics Engineering Ontology

The concepts of logistic domain ontology are divided into two sub-classes, i.e., logistics engineering ontology and logistics management ontology, the tree list of the former ontology is shown in Figure 3, which regards all the function modules in the logistic business as sub-class in next level.
3.3. Instance of Logistics Management Ontology

The logistics management ontology refers to mainly logistic category and evaluation for logistics, which is shown in Figure 4. The sub-classes in the former part are defined according to logistic function type, and the sub-classes in the latter part are used to evaluate the quality of logistic activities.

3.4. Instance of QoS Ontology in Logistic Domain

QoS is named to describe the quality of Web service, thus logistic services are evaluated with QoS in logistic domain, which is abbreviated with QoSL. QoSL is composed of quality of logistic business service (abbr. QoB) and QoS.

Among that, the indexes of QoB consists of time character, quantity character, damage character and price, on the other hand, the indexes of QoS is composed of performance, security, configuration management and cost.

Time character indexes of QoB represents punctuality of logistics, referring to lading rate, punctual arrival rate, bill transfer rate. Quantity character and damage character indexes of QoB represents the intact degree of goods, referring to breakage rate, shortage rate, substitute container rate. Price of QoB depends on the type of goods and transport distance.

Figure 3. Instance of Logistics Engineering Ontology
Performance indexes of QoS include reliability, availability, throughout put, concurrency, compatibility, standardization, capability, scalability, response time and execution time. Security indexes of QoS include authorization, authentication, confidentiality, data encryption, non-repudiation, accountability, auditability and security level. Configuration management indexes of QoS include completeness, stability and regulatory. Finally, cost indexes include price and fine.

The QoSL is modeled according to the above indexes and the corresponding category, which is shown in Figure 5.
4. Validation for Logistic Domain Ontology

The ontology modeled should be validated in order to verify the validity of ontology format and syntax, so a validation method [9] is proposed in Figure 6.

After the logistic domain ontology modeled above is converted into RDF format, it is validated with RDF Validator developed by W3C (World Wide Web Consortium, abbr. W3C), and the results of validation is shown in Figure 7.

Validation Results

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Logistic domain ontology modeling is an effective way to achieve logistic semantic service, but there is no open logistic domain ontology available now, so a logistic domain ontology is modeled and validated in order to solve the problem, and the methods of ontology modeling and validation are as follows.

Firstly, a logistic domain ontology is modeled with Protégé 4.3 and displayed in the form of visual graphics based on the process of the logistic business operation. The logic concepts of the ontology are divided into two sub-classes, i.e., logistics engineering and logistics management. OWL 2 is adopted to describe the concepts of the logistic domain ontology and their attributes, which supports the storage for Semantic Web documents.

Furthermore, a validator is utilized to validate the logistic domain ontology, and the results show that the RDF document resulting from the ontology is validated successfully. Meanwhile, the predicate and object based on the ontology are listed in the table, which indicates that the method of logistics domain ontology modeling is correct and effective.

Finally, the ontology modeled in this paper is not perfect yet due to the rapid development of logistics and higher requirements from the clients, so an improved ontology applied in logistic domain will be modeled in future on the basis of our current research foundation. Furthermore, dynamic matchmaking for logistic Web services will be studied based on the improved logistic ontology, in order to meet the various requests of the clients.

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References


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