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제3자 물류 환경에서 도메인 온톨로지 구축

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A Study on Construction of Domain Ontology in Third-party Logistics

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요 약

대다수 산업과 무역유통 기업은 물류 자원을 통합한다. 기업들은 제품 운송부분을 원가를 절약하기 위해서 전문적인 물류회사에 맡긴다. 여기서 전문적인 물류회사를 제 3자 물류라 한다. 컴퓨터와 인터넷의 발전에 따라 발주와 화주 그리고 제 3자 물류회사 간에 인터넷을 통해 연결된다. 여러 회사에서 사용하는 관리 프로그램이 각각 다르기 때문에 이질적인 데이터는 제 3자 물류정보시스템에 큰 문제가 되었다. 본 논문에서는 지식 공학 방법론을 이용하고, protégé를 개발도구로 이용하여 도메인 온톨로지를 구축하였다. 그리고 물류 온톨로지에 규칙 베이스를 만들어서 그들이 완전하게 개념간의 관계를 표현할 수 있다. 또한 물류 온톨로지와 룰 베이스의 기초에 제 3자 물류회사의 배송센터에 지능 정보시스템을 설계하고 정보 시스템의 작업 프로세스를 시각적으로 보여주도록 실례를 제시하였다.

▸ 키워드 : 온톨로지, 규칙기반, 제3자 물류기업

Abstract

A large number of industry and trade circulation enterprises integrate logistics resource. They give links of product transport to some professional logistics enterprises in order to reduce costs. We call these professional logistics enterprises as the Third-party Logistics. As the development of the computer and internet, the suppliers, buyers and the Third-party Enterprises connect each other with internet. And different company use different management software, so heterogeneous data become a big problem of the information system for Third-party Enterprises. We built the logistics ontology with protégé, and translate it in OWL. We also built the rules for Logistics Ontology to improve the limitations of the OWL. Then we design the intelligent system for 3PL Enterprises Distribution Center based on Logistics Ontology and Logistics Rules. At final, we give an example to show the workflow visually.

▸ Keyword : Ontology, Rule base, Third-party Logistic Enterprises

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Ⅰ. Introduction

A large number of industry and trade circulation enterprises integrate logistics resource. They give links of product transport to some professional logistics enterprises in order to reduce costs.

Usually we call these professional logistics enterprises as The Third party Logistics Enterprises. They typically specialize in integrated operation, warehousing and transportation services that can be scaled and customized to customer's needs based on market conditions and the demands and delivery service requirements for their products and materials [1]. Because of the management with computers, they have to exchange many information of the cargo every day. Usually, different company use different management software, and different data base designers and managers use different concept interpretations when create the data model, so a concept sometimes have many different interpretations in different systems. It leads to the semantic heterogeneous in the information system for Third party Enterprises.

Yan Jian yuan realized the data sharing and exchanging by XML, and then introduced this method in logistics information exchange platform [2]. She provided a heterogeneous data exchange model based on the attributes of the XML (open, self descriptive and expandability), and then used this model to implement enterprises' Internal and external data share. But XML cannot present the relationship between the data since it is a descriptive method for structured data.

Although there are some researches on heterogeneous data, the semantic heterogeneous in the information communication and exchange still is the problem of logistics information platforms and systems, it is presented as the following:

1) Different system use different concept and non standard term to describe the domain knowledge.

2) Although XML can present the relationships between the concepts, but it cannot present the connotative relationships of them.

Ontology is an explicit and formal specification description of shared concept model. So we use ontology to solve semantic heterogeneous problems, we design logistics domain ontology to normalize the logistics concepts for the Third party Logistics Enterprises and then set the logistics rules to present the relationship between the concepts, finally, provide application of the Logistics Domain Ontology and the Logistics rules in the Distribution Center of the Third party Logistic Enterprises.

II. Related work

2.1 Ontology

Ontology is a metaphysics concept. As the development of the artificial intelligent, people introduce ontology into computer science. In recent years, Ontologies are widely used in artificial intelligence, the Semantic Web, systems engineering, software engineering, biomedical informatics, library science, enterprise bookmarking, and information architecture. They are used for knowledge representation, sharing, integration, reuse and management.

In computer science and information science, many definitions of ontologies have been given, in our opinion, the essence of an ontology is based on the related definitions made by T. Gruber, he defined it as 'formal, explicit specification of a shared conceptualization'. [3] Studer explained ontology detailed as following [4]:

1) Conceptualization: refers to an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon.

2) Explicit means that the type of concepts used, and the constraints on their use are explicitly defined.

3) Formal refers to the fact that the ontology should be machine readable, which excludes natural language.

4) Shared reflects the notion that an ontology captures consensual knowledge, that is, it is not private to some individual, but accepted by a group.

2.2 Ontology Language

There are many ontology representation languages; the OWL is generally used since it is the basic of the Semantic

Web. It adds more vocabulary for describing properties and classes, for instance, relations between classes, cardinality, equality, richer typing of properties, characteristics of properties, and enumerated classes. It has more facilities for expressing meaning and semantics than XML, RDF, and RDF-S as well [5].

2.3 Ontology Methodology

Knowledge Engineering Methodology is an ontology development methodology which is based on Protégé. Includes seven steps as following [6]:

1) Determine the domain and scope of the ontology.
2) Consider reusing existing ontologies
3) Enumerate important terms in the ontology
4) Define the classes and the class hierarchy
5) Define the properties of classes
6) Define the facts of the class
7) Create instances

III. Construction of Domain Ontology in Third party Logistics

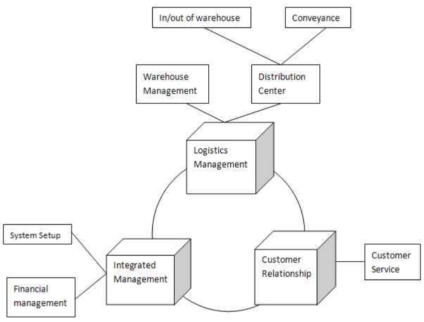

Fig.1 3PL Enterprises Information System Structure

Fig.1 shows the three main parts of the 3PL Enterprises information system: Integrated Management Center, Customer Service Center and Logistics Management Center. The Logistics Management Center is the most important department; it includes the Warehouse Management Center and Distribution Center. The information system of Warehouse Management Center is used for managing the inventory level. The information system of Distribution Center controls the transport information, such as the location information of cargo in the warehouse, the load information of the cargo and the location information of the conveyance. So we begin our study from the Distribution Center.

3.1 Building the ontology for 3PL Enterprises

3.1.1 Determine the scope and purpose of the ontology

The basic operation of the logistics service is transport and warehouse. So people always pay attention on the transport operation and the warehouse operation. We provide the following questions to ensure the requirement and to test the characteristics of the ontology:

- What is will be transported?
- What are the properties of the cargo and considerations during the transport?
- How to develop a rational transport plan?
- What should be transported by specific conveyance?
- Whether the warehouse could accommodate the cargo or not?

3.1.2 Enumerate important terms in the ontology

Domain information dictionary is used for define useful and potential domain concepts, properties and instances. We can prevent inconsistencies between the concepts of the domain ontology with it. Since the information dictionary can ensure the each concept is complete, concise, and without redundancy.

Table1. Information Dictionary

vocabulary	C/P	Definition	Category
LogisticsDomain	Class	father class of the logistics concepts	Thing
CargoDomain	Class	father class of the cargo	LogisticsDomain
WarehouesDomain	Class	father class of the ware house	LogisticsDomain
ConveyanceDomain	Class	father class of the conveyance	LogisticsDomain
cantTransportWith	property	the cargo cannot transport with	ObjectProperty
transport	property	the property of transport	ObjectProperty
isDangerours	property	dangerours cargo or not	DatatypeProperty
......	......	......	......

3.1.3 Define the classes and the class hierarchy

Because our study is based on the transport operation and warehouse operation, we need a classification method which includes the information about transport operation and warehouse operation. As the figure 5 shows, we class the goods as following: dangerous cargo, explosive cargo, flammable cargo, and fragile cargo, gasify cargo, hygroscopic cargo, liquid cargo, mordant cargo and so on.

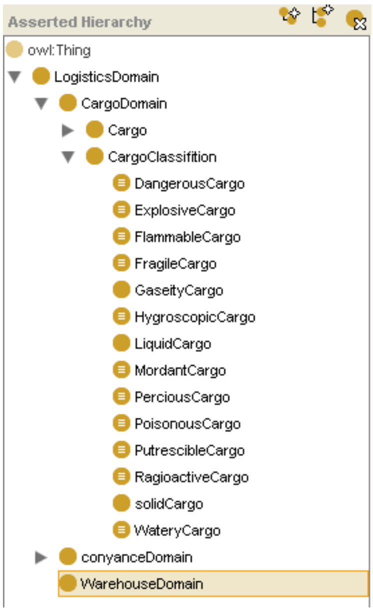

Fig.2 Class and Class Hierarchy in Protégé Interface

Cargo should be transported, different cargo correspond different conveyances. We class the conveyance as: plane, train, ship, and vehicle. And vehicle includes: van, tank wagon, special Vehicle, refrigerator car, and flat car.

Fig.3 Conveyance of the Cargo in Protégé Interface

3.1.4 Define the properties of classes

After defining the classes and the class hierarchy, we define the properties of classes. All of the propery is defied by ourselves, and all the property has domain and range. There are two kind attributions in the ontology:

ObjectProperty presents the relationship of the class, so the domain and range of it is class.

DatatypeProperty presents the information of the class, so the domain of it is class, but the range is data type.

So the range is different. For example, the property 'isTransprtBy' is a object property, the domain is ' Cargo', the range is 'conveyance', it means cargo is transport by conyance. And 'isDangerous' is a datatype property, the domain is 'cargo' and the range is 'bool'. It means the cargo is dangerous or not. We list the property of the classes in the table 2.

Table 2. Attribution of the Cargo

Property	Domain	Range	Mean
isTransportedBy	Cargo	Conveyance	is transported by
cannotTransportWith	Cargo	Cargo	can not transport with
isDangerous	Cargo	Bool	dangerous cargo or not
isExplosive	Cargo	Bool	explosive cargo or not
isWartery	Cargo	Bool	is waterery cargo or not
isFragile	Cargo	Bool	is fragile cargo or not
isMordant	Cargo	Bool	is mordant cargo or not
isHygroscopic	Cargo	Bool	is hygroscopic cargo or not
isFlammable	Cargo	Bool	is flammable cargo or not
isPoisonous	Cargo	Bool	is poisonous cargo or not
isPutrescible	Cargo	Bool	is putrescible cargo or not
hasState	Cargo	State	cargo state
highestTemprature	Cargo	Int	highest temprature
lowestTemprature	Cargo	Int	lowest temprature

And we realize them in the protégé.

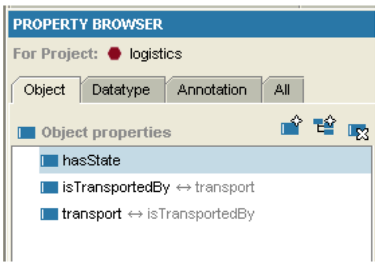

Fig.4 ObjectProperty of Cargo in protégé interface

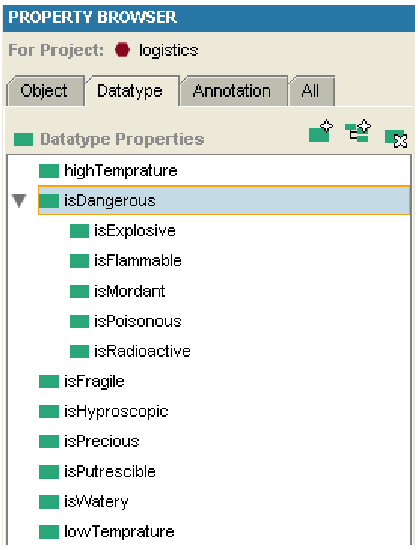

Fig.5 DatatypeProperty of Cargo in protégé interface

3.1.5 Define the facts of the class

The attributes are used for establish the constraints, in other word, the attributes are used to restrict the individual belongs a certain class or not.

Table3. List of Define the facts of the class

Class	Necessary and Sufficient Condition	Meaning
DangerousCargo	⊆ Cargo and isDangerous has true	Dangerous Cargo
ExplosiveCargo	⊆ Cargo and isExplosive has true	Explosive Cargo
FlammableCargo	⊆ Cargo and isFlammable has true	Flammable Cargo
FragileCargo	⊆ Cargo and isFragile has true	Fragile Cargo
HygroscopicCargo	⊆ Cargo and isHygroscopic has true	Hygroscopic Cargo
ModantCargo	⊆ Cargo and isMordant has true	Modant Cargo
PoisonousCargo	⊆ Cargo and isPoisonous has true	Poisonous Cargo
RadioactiveCargo	⊆ Cargo and isRadioactive has true	Radioactive Cargo
WateryCargo	⊆ Cargo and isWatery has true	Watery Cargo
LiquidCargo	⊆ Cargo and hasState has liquidState	Liquid Cargo
GaseityCargo	⊆ Cargo and hasState has gaseity	Gaseity Cargo

3.2 Building the rules

After building the ontology with protégé, it can translate the internal representation into OWL.

OWL can present the semantic of class concept in the domain ontology with constraint and Boolean combinations; it also can present the relationship between concepts with the attributions. But the description of the OWL comes from the inference of relevance based on the classification. Sometimes OWL cannot present the logical rules, such as 'if … then …'. In the domain ontology for 3PL Enterprises, we need 'if … then …' to present the logistics rules.

The basic rules of the logistics are following:

1) The rules on distribution: The poisonous, radioactive cargo should be transport separately; the watery cargo cannot be transported with hygroscopic cargo; the explosive cargo cannot be transported with flammable cargo.

2) The rules on choosing the convey: Liquid cargo must be transported by tank wagon; putrescible cargo must be transported by refrigerator car; dangerous cargo must be transported by special vehicle.

Because the important application of ontology is reasoning (inference), in our study we want to use ontology to realize the intelligent information system by reasoning. Except for the rules, we need inference engine to realize the reasoning. So we choose Jena. It is a Java framework for building Semantic Web applications; provides a programmatic environment for RDF, RDFS and OWL, SPARQL and includes a rule based inference engine [5]. To introduce the rules into intelligent system, we should build the rules in Jena formal rule language.

```
[poisonousRule: (?x rdf:type LO:PoisonousCargo)(?y isPoisonous?
        (?b rdf:type LO:False)
        ->(?x LO:cannotTransportWith?y)]
[hygroscopicRule: (?x rdf:type LO:HygroscopicCargo)
        (?y rdf:type LO:WarteryCargo)
        ->(?x LO:cannotTransportWith?y)]
[explosiveRule: (?x rdf:type LO:ExplosiveCargo)
        (?y rdf:type LO:FlammableCargo)
        ->(?x LO:cannotTransportWith?y)]
```

3.3 Intelligent System of the 3PL Enterprises

As Fig.6 shows, we design an intelligent information system for the 3PL Enterprises Distribution Center, the system gets the information about the cargo from users and Jena read the 3PL Ontology OWL document, then 3PL Ontology Individual will be produced with Jena API. Then the Inference Engine do the reasoning based on the 3PL

Rule Base and 3PL Ontology Individual. At final, the intelligent system put out the result of reasoning to users.

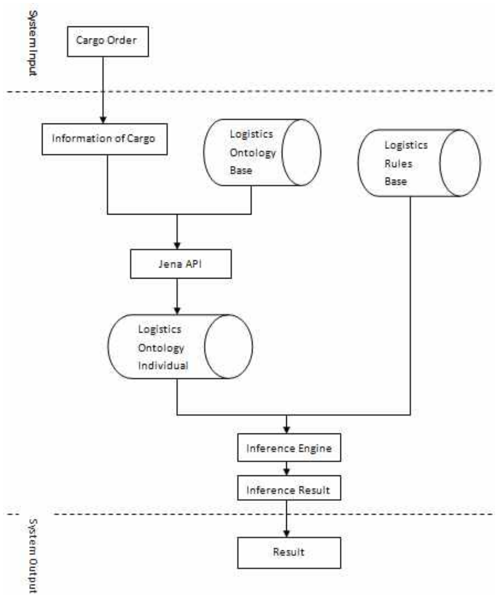

Fig.6 Workflow of the Distribution Center

I give assume an example to show how the intelligent information for the 3PL Enterprises works.

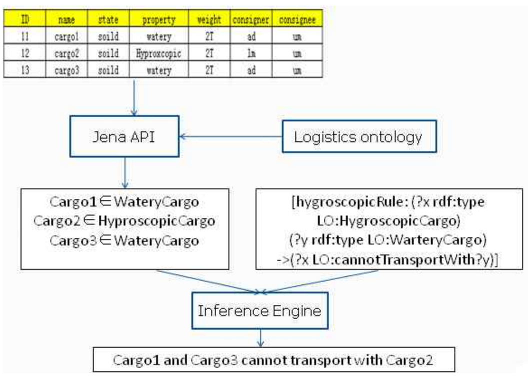

Fig.7 Example of the Distribution Center Workflow

As Fig.7 shows, we assume that we get a Cargo Order

ID	name	state	property	weight	consigner	consignee
11	cargo1	soild	watery	2T	ad	ua
12	cargo2	soild	Hyproxcopic	2T	la	ua
13	cargo3	soild	watery	2T	ad	ua

We can get the Logistics ontology individual

Cargo1∈WarteryCargo
Cargo2∈HygroscopicCargo
Cargo3∈WarteryCargo

According to

[hygroscopicRule: (?x rdf:type LO:HygroscopicCargo)
(?y rdf:type LO:WarteryCargo)
->(?x LO:cannotTransportWith?y)]

We get the result

Cargo1 and Cargo3 cannot transport with Cargo2

IV. Conclusion

We have built domain ontology for Third party logistics in our study. Then we presented them in OWL (an ontology Language).

We also built the rules for Logistics Ontology to improve the limitations of the OWL. Then we design an intelligent system based on logistics ontology, logistics rules and inference engine in the distribution centers of the 3PL Enterprises.

Ontology is an explicit and formal specification description of shared concept model. The Logistics Domain Ontology supports unified concept interpretations for designers and managers to create the data model. In that case interact and share of the data can be implemented in an integrated environment. It will give a big help to realize seamless integration and connection with most systems of the Logistics.

The Logistics Ontology and Logistics Rules base realize the information system reasoning automatically; make the information system Intelligent.

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