Ontology and Its Application in Supply Chain Information Management

Zetian Fu[1], Jun Yue[2,1]* and Zhenbo Li[3]
[1]China Agricultural University
[2]LuDong University
[3]Telecom & Management SudParis
[1,2]China
[3]France

1. Introduction

Since ontology was put forward by Neches and Fikes in 1991, the research on ontology is becoming increasingly matured after more than 10 years development. Although usages on concepts and terms related with ontology do not keep completely identical, the agreement of actual use has emerged. Most researches are concentrated on theoretic in current ontology research, while practical application of ontology is still less.

Ontology takes the role as a philosophical concept originally, which regarded as an explanation or description to an objective existing system from the philosophy category, and concerns the abstract nature of the objective reality. Later, it is given a new definition by the artificial intelligence category with the development of artificial intelligence. Neches and Fikes (1991) define ontology as the "explicit formal specifications of the terms in the domain and relations among them". The terms and relations are abstract description of phenomenon happened in the word. Gruber (1993) gives a most popular definition to ontology:"ontology is the clear specification on a conceptual model". Based on this definition, another new concept of ontology is given by Borst, i.e. (1997) as "ontology is the clear specification on a sharing conceptual model". Studer (1998) thinks that ontology consists of four layers meaning after an in-depth studying on the two above definitions, which are "conceptualization", "explicit", "formal" and "share". Conceptualization refers to models obtained by abstracting some related phenomenon in the objective world, which performs independent of the specific state of the environment. Explicit refers to explicit definitions to used concepts and their restriction. Formal refers to the ontology model can be processed by computer. Share refers to ontology aims at group consensus instead of individual consensus. The ontology goal is to capture the knowledge of relevant domain, provide a common understanding to the knowledge, confirm vocabularies of the domain and define the relationships between the vocabularies clearly.

Some scholars regard ontology as an approach to construct knowledge base. There are different ontology category modes according to different ontology attributes. Gruber (1993) divides ontology into four classes as its level of detail and level of dependence: top level

*Corresponding author

Source: Supply Chain, The Way to Flat Organisation, Book edited by: Yanfang Huo and Fu Jia,
ISBN 978-953-7619-35-0, pp. 404, December 2008, I-Tech, Vienna, Austria

ontology, domain ontology, task ontology and application ontology. Ontology is divided into meta-ontology, general ontology, domain ontology and application ontology as the different applied situations. Mizoguchi etc. (1995) divides ontology into domain ontology, general ontology and task ontology.

Perez etc. (1999) think that ontology can be organized by taxonomy. Ontology consists of five basic modelling primitive, which are “class”, “relations”, “function”, “axioms” and “instance”. In general terms, class is called concept as well. Concept (class) is with very wide meaning, which can be considered as anything. For example, work description, function, action, strategy and reasoning processes etc.. Relationship represents the interacting effect between two concepts in the domain, which is defined as a subset of n-dimensions Cartesian set: $R : C_1 \times C_2 \times \cdots \times C_n$. Function shows a kind of specific relationship, the element *n* can be decided by other *n-1* elements. The formalized definition is as: $F : C_1 \times C_2 \times \cdots \times C_{n-1} \rightarrow C_n$. Axioms represent tautology. Instance refers to elements. Analyzing it form the view of semantic, instance describe objects, while concept mean the set of objects, relations correspond to the set of object element group. The definitions to concept adopt frame structure, which consists of the names of concepts, relations to other concepts and descriptions to concepts in natural language. There are four relations of ontology: “part-of”, “kind-of”, “instance-of” and “attribute-of”. Part-of describes the relationship of a part and the whole. Kind-of describes the inheritance between concepts, similar to the relationship of parent and child of object-oriented. Instance-of describes the instance of concept and concept itself, similar to the relationship of object and class of object-oriented. Attribute-of describes one concept taking a role as attribute of another concept. In actual application, it is unnecessary to apply the meta-language above exactly to construct ontology. And meantime, relationships between concepts are not limited to the four types listed above. The corresponding relationships can be defined according to the status of specific domain to satisfy the requirement of application.

There are five widely applied ontology as below: WordNet(2006), Framenet(2008), GUM (Bateman *et. al.,* 2001), SENSUS(Knight, K. & S. Luk.,1994), Mikrokmos(1996). WordNet is an English dictionary based on psychological language rules, taking synsets as a unit to organize information. Framenet is another English dictionary, adopting description frame called Frame Semantics and providing the semantic analyzing ability. GUM adopts natural-language-oriented processing and supports multi-language processing. SENSUS consisting of more than 70000 concepts adopts natural-language-oriented processing and provides concept-structure to computer understanding. Mikrokmos adopts interlingua TMR to express knowledge, orients natural-language processing and supports multi-language processing.

It is widely recognized that the participation of experts is necessary in domain ontology construction. The process is various proceeding form different ontology projects. Since there is not a standard approach to ontology construction, some standards benefiting to ontology construction are put forward from practice. The most effective is pointed out by Gruber (1995), which consists of five rules: explicit and objective, perfectibility, consistency, expansibility of maximum monotonicity and minimum stability. Explicit and objective refers to that ontology should give out explicit and objective semantic definition using natural language. Perfectibility refers to that the definition should be perfect, and the meaning of a term can be perfectly expressed. Consistency refers to that the deduction from a term should be consistent with the term itself. Expansibility of maximum monotonicity

refers to that it is unnecessary to modify the previous ontology when some new general or specific terms are added to it and minimum stability refers to that modelling object will be given as few as restricts.
With the emergence and application of ontology in various domains, some kinds of ontology construction approaches appeared. The main methods relevant to well-known ontology projects and its modelling processes includes frame methodology (T. R. Gruber, 1993), TOVE ontology and Gruninger and Fox's methodology(M. Gruninger & M. Fox, 1995), KACTUS and Bernaras methodology(A. Th. Schreiber *et. al.* 1995), MHONTOLOGY methodology (Fernández-López. M. *et. al.* 1997, 1999), SENSUS ontology and methodology (Knight, K. & S. Luk, 1994), IDEF5 methodology(Benjamin, P. C. et. al. 1994) and seven steps methodology (Corcho. O. & Gómez-Pérez. A., 2000). Seven steps methodology was put forward by School of Medicine of Stanford University. The seven steps are confirming the domain scope, investigating the possibility to use the previous ontology, listing important terms of ontology, defining classes and their grading system, defining attributes of classes, defining distribution of attributes and establishing instances.

2. Formal representation of ontology models

The formalized ontology language provides a possibility for users to describe concepts of domain model explicitly and formally. Therefore, it should meet the following requirements: a well-defined syntax, a well-defined semantic, efficient reasoning support, sufficient expressive power, convenience of expression.
Till now, there appear some kinds of ontology formalized languages, such as RDF and RDF(S), OIL, DAML, OWL, KIF, SHOE, XOL, OCML, Ontolingua, CycL, Loom. RDF(S) and OWL are wildly used formalized languages.

2.1 RDF(S) language

RDF, RDF(S) (The Resource Description Framework) is a language for representing information about resources in the World Wide Web, which is a recommended standard based on XML by W3C. A simple model is put forward from RDF to express any types of data and the data type consists of marked joint arcs between nodes, which display sources on Web. The arcs display attributes of sources. Therefore, the data model can describe objects and their relationships. RDF data model is an expression of a duality-relationship. As any complex relationships can be decomposed into several simple duality-relationships, so RDF data model can be taken as a basic model for any complex model.
RDF(S) is complementary with XML. First, RDF intends to standardize XML by standardizing and inter-operating modes. XML documents can be cited by RDF in a simple way. Next, since RDF expresses data semantics in a model constructing way, RDF can not be restricted by specific grammar. However, RDF still needs a suitable grammar format to realize its application on Web. Serializing RDF to XML expression can make RDF to obtain a better processing, and make RDF data can be used, transferred and stored as easy as XML. Combination of XML and RDF benefits to data retrieval and discovery of relevant knowledge. It not only realizes the description of data based on semantics, but also fully displays merits of XML and RDF(S).
Similar to tags of XML, property set of RDF(S) have no restricts. In another word, there are thesaurus and polysemy phenomena. RDF(S) can not solve the problems. Although RDF(S) can provide the glossary for it properties and types, data semantic description has semantic

conflicts. In order to clear up the semantic conflicts, a further restrict to semantic description result has been done by citing relevant ontology technology. Fortunately, on the time of providing semantic model understandable to computer, RDF also provides modeling base to ontology language (OIL, OWL) for a certain domain. Thus the application based on RDF(S) can be conveniently combined with the ontology expressed by those ontology languages. The characteristic of RDF(S) makes semantic describing results to have ability to interact with some more domain knowledge, also makes Web data description based on XML and RDF to have a perfect vitality.

In a short, one RDF document includes various source descriptions, while one source description consists of several RDF sentences which are triples consisting of source, property type and property value to express a property of source. The sentences in source description correspond to those sentences of natural, the source corresponds to the subject of natural, the property type corresponds to predicate, and property value corresponds to object. As sentences of natural language can be passivity, so the simple correspondence above is just an analogy of concepts.

2.2 OWL language

OWL (Web Ontology Language) (Grigoris Antoniou & Frank van Harmelen, 2004) is a standard of ontology description language in semantic internet recommended by W3C, which is developed from a combined description language (DAML+OIL) in some research institution in Europe and America. DAML is from an American overture DAML-ONT, while OIL is a kind of ontology description language from Europe. OWL is on the top layer of the ontology language stack put forward by W3C, which is shown in fig.1.

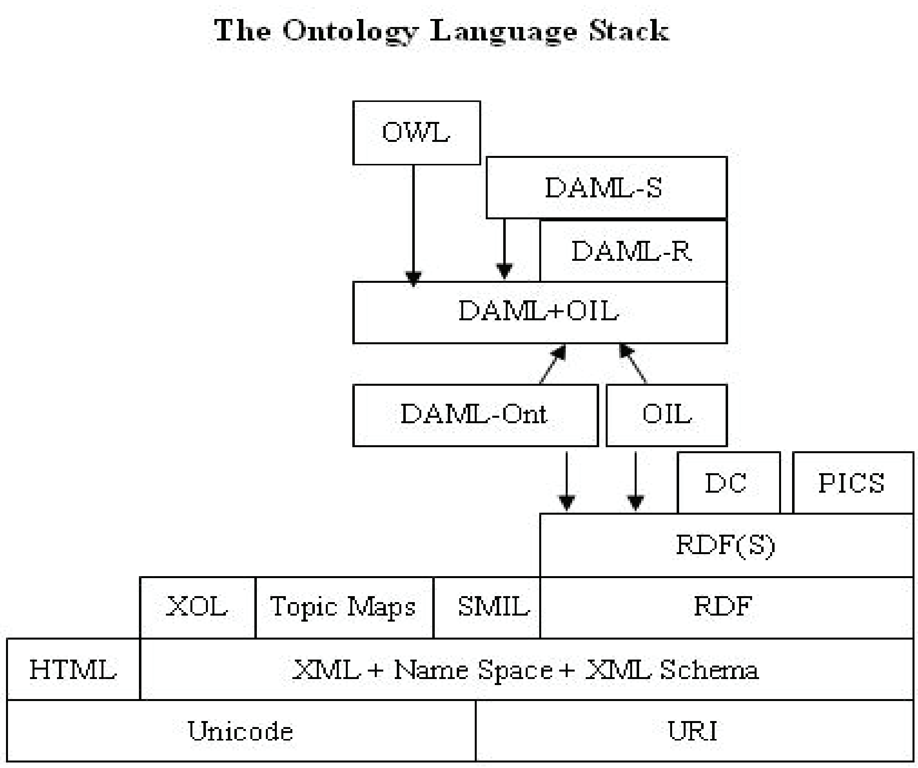


Fig. 1. Ontology language structure

Aiming at various requirements, there are three sublanguages as shown in table 1.

Sublanguage	Description	Instance
OWL Lite	Provided to users who need only one classified layer and simple restrict of property.	Support cardinality and permit it can only be 0 or 1.
OWL DL	Support those who need to express to the maximum extent in the reasoning system, which can ensure the computational completeness and decidability. It contains all restricts of OWL, but it can only be put into certain restricts.	When a class can be a sub-class of multi-classes, it can not be an instance of another class.
OWL Full	Support those who need to express to the maximum extent under free-grammar RDF without calculating guarantee. It permits vocabulary to be added to the pre-defined glossary of an ontology.	A class can be expressed as a set of individuals, and also an individual of a set.

Table 1. Three sublanguages of OWL

The relationships between these three sublanguages are:

- Each suitable OWL Lite is a suitable OWL DL and each suitable OWL DL is a suitable OWL Full.
- Each effective OWL Lite conclusion is an effective OWL DL conclusion.
- Each effective OWL DL conclusion is an effective OWL Full conclusion.

The considerations in choosing which language to use are:

- Choosing OWL Lite or OWL DL mainly depends on the expressiveness degrees of restriction.
- Choosing OWL Lite or OWL Full mainly depends on the requirement degrees of RDF meta-model mechanism.
- While using OWL Full rather than OWL DL, it is unpredictable to support reasoning as there is no complete realization of OWL Full.

The relationships between these three sub-language and RDF(S) are:

- OWL Full can be taken as the expandation of RDF(S).
- Both OWL Lite and OWL Full can be taken as a restricted expandation.
- All OWL documents (Lite, DL, Full) are RDF documents.
- All RDF documents are OWL Full documents.
- Only a part of RDF documents are suitable OWL Lite and OWL DL documents.

3. Design and implementation of supply chain information management system based on ontology

3.1 System architecture

The knowledge management system is to gather relevant knowledge, process the gathered knowledge in semantic level, and provide service.

The system is divided into three parts, Knowledge Gathering, Knowledge Processing and Knowledge Service. Which are shown in fig.2.

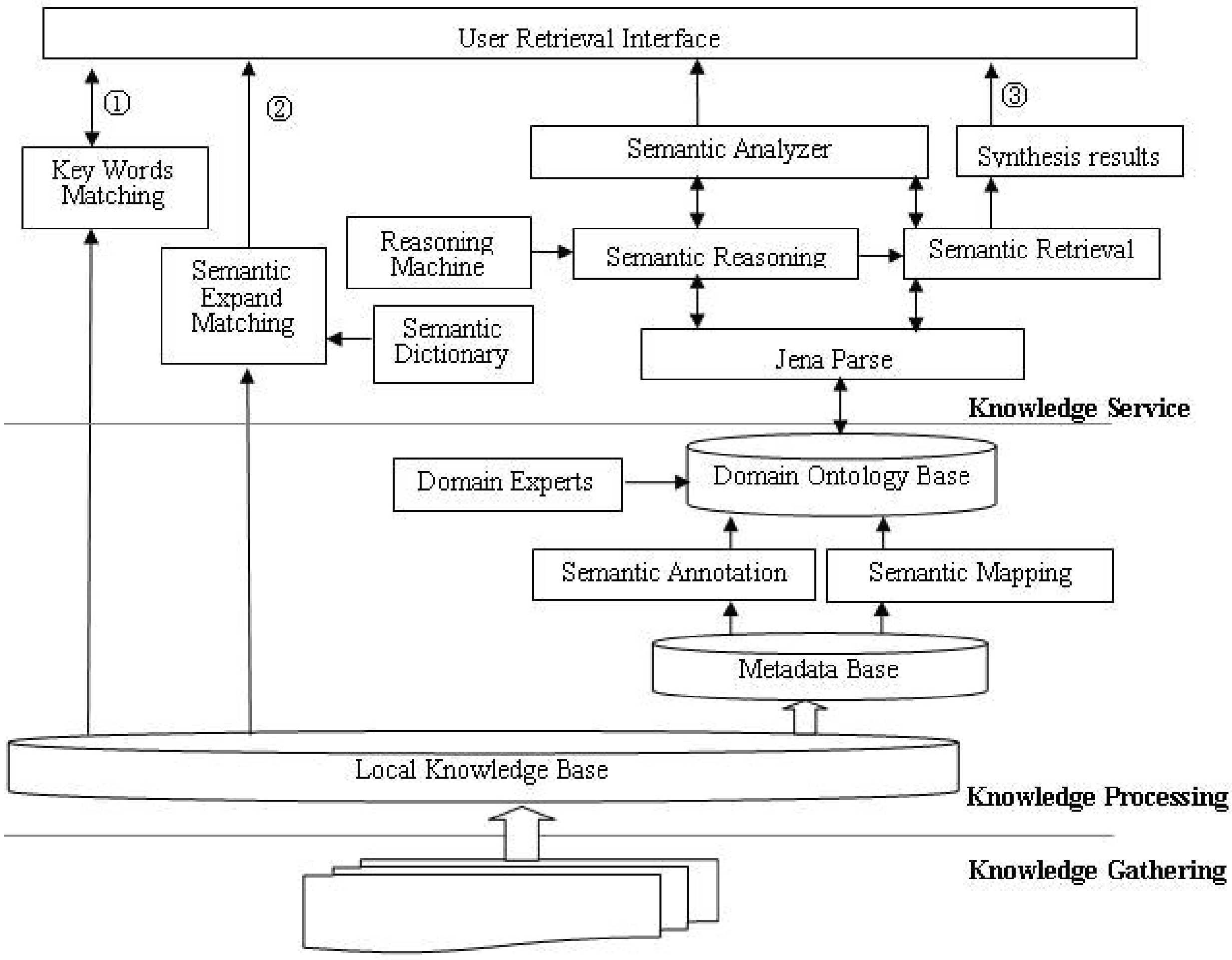


Fig. 2. System architecture

3.2 System module design

The system provides three knowledge acquisition modes which are keywords retrieval, semantic extension retrieval and ontology based retrieval.

3.2.1 Keywords retrieval

Keywords retrieval is a traditional information retrieval mode. At present, many well-known search engines such as Google (www.google.com) and Baidu (www.baidu.com) etc. query information by keywords submitted by users.

Keywords retrieval uses a group of representative keywords (indexing term) to describe each database item. The keywords index can be established in order to improve the efficiency of retrieval generally. Keywords are selected according to the content of database items. Moreover, each keyword can be given a weight to describe its importance.

Keywords retrieval has the same obviously merits and weaknesses. Merits are simple, with faster retrieval speed. The main shortcomings are: It is hard to express retrieval intent. In general terms, the retrieval intent can be expressed by one or several simple keywords hardly, which lead to the retrieval effect not high.

As the polysemy and synonymy phenomena of language, the problem of thesaurus retrieval can not be solved easily. Such as “Apple” can be understood as either apple or the famous

brand of Apple Inc. In addition, as the differences in cultural and educational background etc., different keywords may be chosen for the same information retrieval.
Another problem is “Information Island”. Keywords can only express the description of original data items instead of the real content of data items, which leads to that the relevant information of a concept can not reflect the intrinsically links of concepts. Therefore, the information relevant to a data item can not be obtained only by the data item itself in retrieval. Moreover, in keywords retrieval, the too much pursuit to the retrieval recall leads a large number retrieval results. This makes users hard to analyze and use the results.

3.2.2 Semantic extension retrieval

In order to solve the shortcomings of keywords retrieval, semantic extension retrieval is introduced to the system. Consulting the modus operandi of WordNet and analyzing domain concepts semantically the semantic vocabulary dictionary is established to describe the relationship of domain concepts.
When semantic retrieval is going on, a query condition sets which contains a group of relevant concepts is obtained for users’ initial query conditions by semantic vocabulary dictionary semantic expand, semantic intension, semantic extension and semantic association etc. In the process of semantics explanation, the semantic reasoning can be done according to descriptions-to-relationships between concepts.

3.2.3 Ontology based semantic retrieval

Ontology based supply chain knowledge semantic retrieval is the focus module of systems development. For this, supply chain ontology model has to be established firstly.

3.2.3.1 Construct domain ontology

RDF has been taken as the best choice to express and process semi-structured data, and it has become the W3C recommended standard of both XML and SOAP.
The core of expressing domain ontology by RDF is to construct triple description. In another word, describe complex things as a series of triples. Each statement of RDF contains three parts-main body, predication and object, and the core description of RDF is relationships between things. In RDF model, the definition to relationship is different with it in other system, such as Object-Oriented system. It considers that relationship exists forever in the world and the source object consist of various kinds of complex relationships, while Object-Oriented considers that the world consists of many sources and relationships exist depending on the specific source. Two different points of view make them applied in different environments, and the RDF model shows more powerful description ability. Therefore, RDF model is chosen as the reference in ontology model semantic coding. Another reason for storing ontology model as RDF format is that the domain ontology model can be parsed in Java program by Jena tool kit.

3.2.3.2 Parse domain ontology by Jena

In order to realize the semantic retrieval based on ontology, Jena is adopted to parse and use the constructed ontology, which is the precondition of semantic reasoning based on ontology model.
At semantic retrieval based on ontology, retrieval requires submitted by users are transferred into RDF source objects, by which the more proper ontology model will be obtained.

At the time of semantic processing to ontology model, relevant metadata are processed according to domain ontology and reasoning rules to obtain the connotative information, which services the following operations. Reasoning rules can be reinforced according to the actual requirements, and axiom reasoning and theorem reasoning will be required in this processing. However, axiom reasoning should be used as much as possible and reduce the percentage of theorem reasoning.

4. A case-ontology based vegetable supply chain information system

The vegetable supply chain knowledge management system is to gather vegetable supply chain relevant knowledge, process the gathered knowledge in semantic level, and provide service.

4.1 System ontology model

The system ontology model consists of vegetable supply chain ontology model, vegetable supply chain knowledge ontology model and vegetable supply chain knowledge user ontology model.

4.1.1 Vegetable supply chain knowledge ontology model

There are three sub-sets which are nominal class subset, individual and organization class in vegetable supply chain and verbal class subset. The vegetable supply chain is marked Veg.SCM in the system.

4.1.1.1 Nominal concept subset (Norminal.SC)

Individual and Organization in Vegetable Supply Chain
    Instance: Mr.Zhang (producer), Import&Export Company,…
Vegetable
    Frozen Vegetable
        Instance: frozen mushroom, frozen green soy bean,…
    Fresh Vegetable
        Putrescible Vegetable
            Instance: tomato, cucumber,…
        Disputrescible
            Instance: potato, onion, cabbage,…
Contract
    Exchange Contract
    Transportation Contract
    Process Contract
Time
    Instance: Jan.10th, 2005…
Address
    Instance: Huangshan Road, Shouguang, China…
Person
    Instance: Tongxin Zhang…
Organization
    Instance: China Agricultural University…
Vehicle
    Instance: Huanghe truck…
…….

4.1.1.2 Individual and organization class in vegetable supply chain (Individual-Organization.SC)

The individual and organization class in vegetable supply chain subset is shown in fig.3.

Class	1st 2nd 3rd 4th Sub-class	Instance
Individual / organization	Vegetable producer	
	Non-contract-individual	Mr.Zhang
	Cooperative producer	Mr.Li, some famers…
	Contract producer	Some vegetable produce base…
	Merchant	
	purchase merchant	
	Non-contract	Mr.Wang, one company…
	With-contract	Mr.Qian, one company…
	sale in China	
	Whole sale	Mr.Zhao, one company…
	Retail	
	Individual farmer	Mr.Tian…
	Saler in wet market	Mr.Gao…
	Super market	Wal-mart supermarket…
	Exportant	
	User	
	Restaurant	…
	Family	…
	Others	…
	Process Individual / organization	
	Briefly	…
	Process factory	…
	Transportation	
	Individual	…
	Company	…
	Storage Individual / organization	…

Fig. 3. Individual and organization model

4.1.1.3 Verbal class subset (Verbal.SCM)

Concepts in verbal class subset have the character of verb, but they can be used as noun. They are also called duality concepts. They all have a common property-object, but not are noted very clearly. The values of property are class or instance of individual and organization class in vegetable supply chain. The verbal class subset is as below.

Process
Transportation
Storage
Exchange
…….

4.1.2 Vegetable supply chain knowledge ontology model

Knowledge organization and expression are crucial to the knowledge management system. In order to provide users the convenient and speedy knowledge retrieval, the vegetable supply chain knowledge is organized together as the following mode.

The vegetable supply chain knowledge is divided into four sub-classes: Basic Knowledge, Academic Knowledge, Practical Knowledge and Case Study. Each class has the properties of their own. It is shown in the following figure.

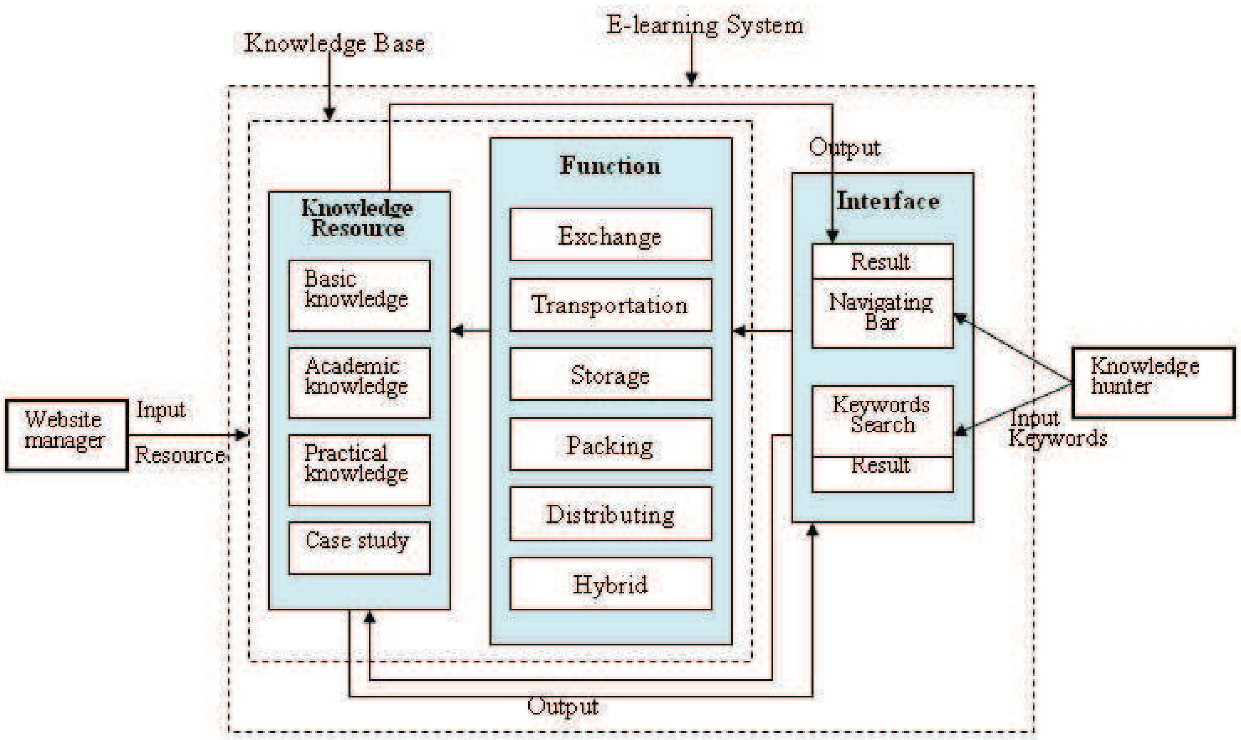


Fig. 4. Framework of Veg. SC knowledge

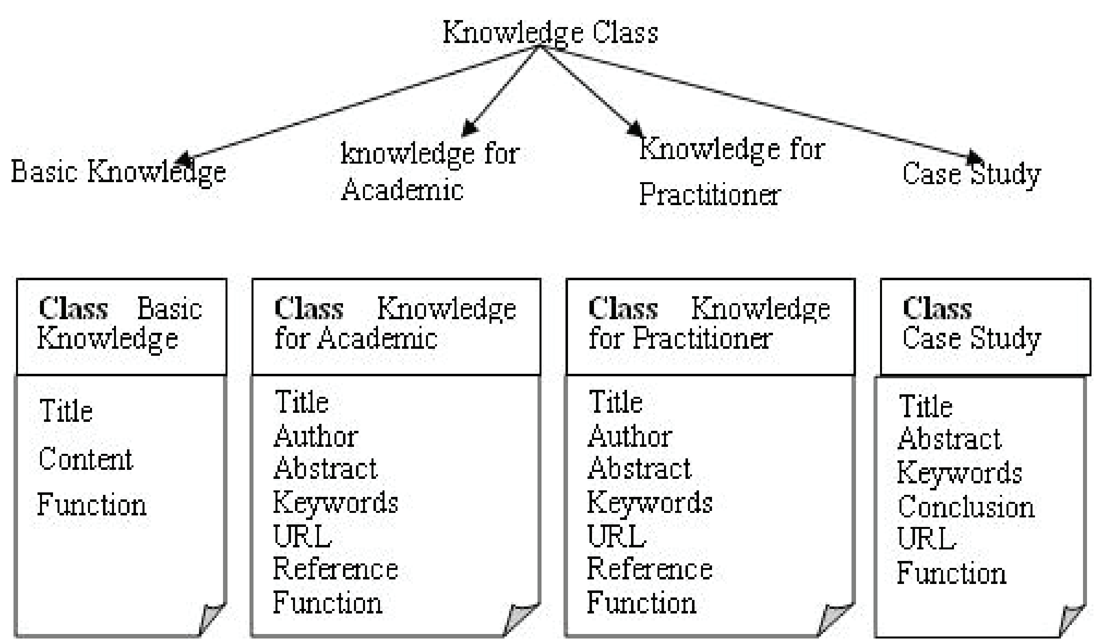


Fig. 5. Knowledge classes and their properties

The vegetable supply chain is divided into five classes considering its functions, exchange, transportation, storage, packing, and hybrid, which are the values or instances of individual and organization class of vegetable supply chain ontology. It is shown in fig.6.
Combining four knowledge classes and five functions, the knowledge retrieval process is shown in fig.7 when the requiring intent is submitted.

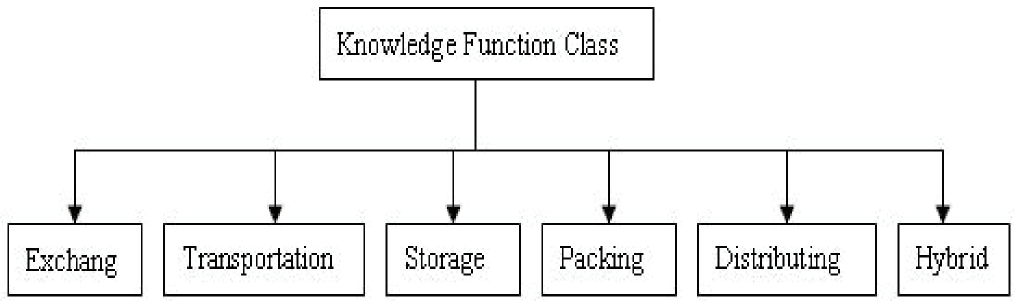


Fig. 6. Function category

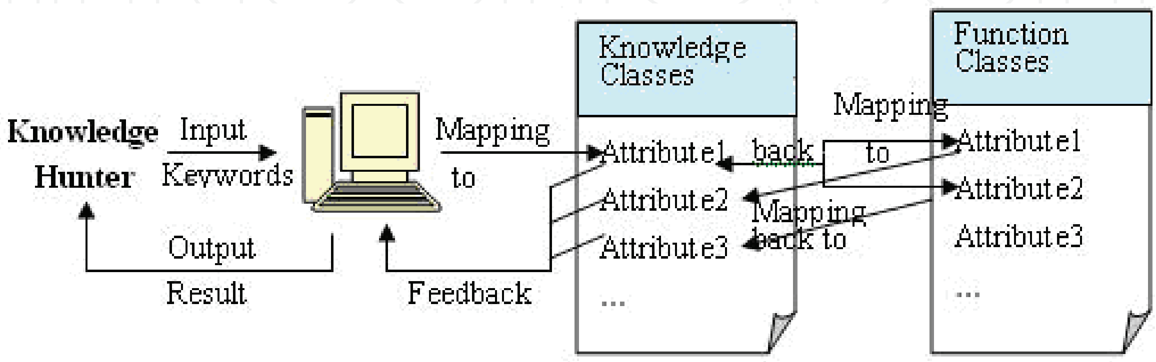


Fig. 7. Retrieval process

4.1.3 Vegetable supply chain knowledge user ontology model

The final user is divided into two classes, academic user and practical user. The academic user pays more attention to theoretical knowledge and case study, while practical user cares more about basic knowledge, application knowledge and case study, which is shown in fig.8.

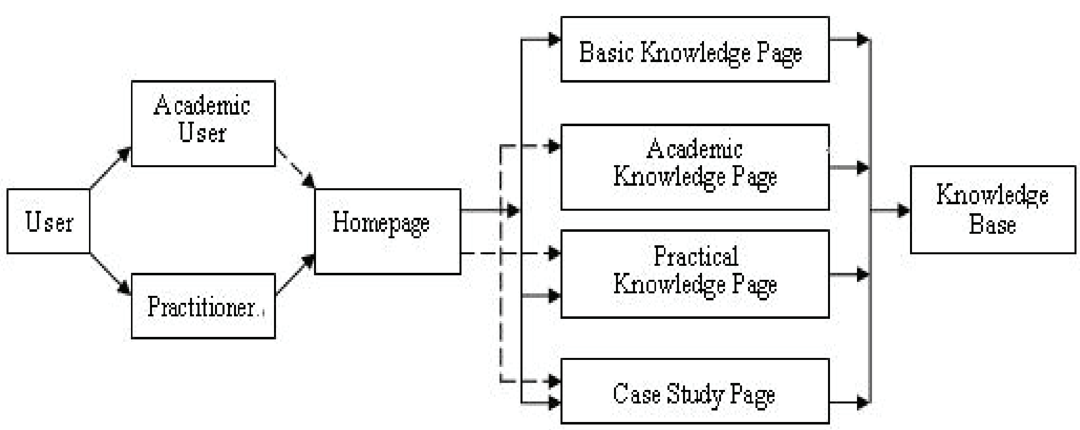


Fig. 8. User classes and their considering knowledge scopes

4.1.4 Integration of ontology models

There are four relationships between two classes which are: “part_of”, “kind_of”, “attribute_of” and “instance_of”. By these four relationships, we integrate all ontology models as a whole which are shown in fig.9.

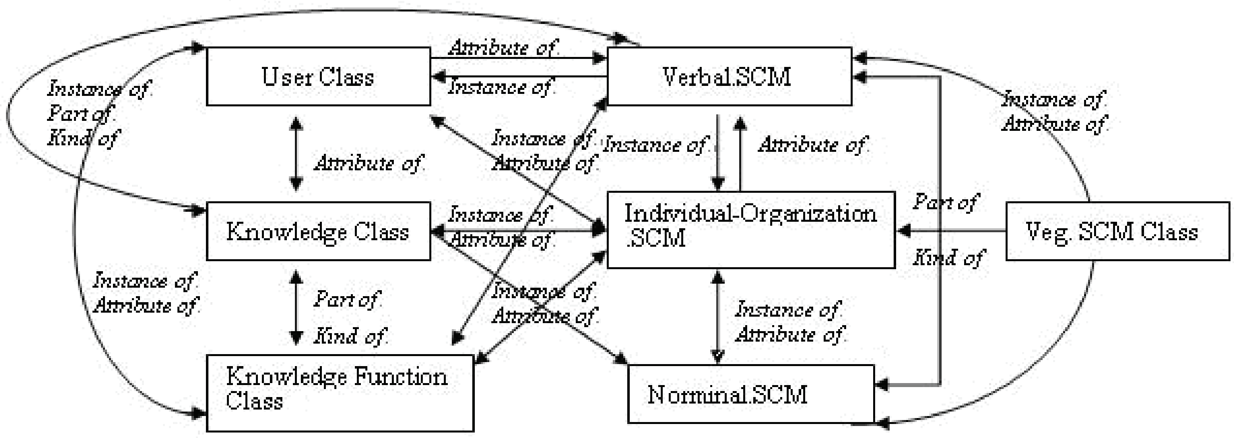


Fig. 9. System ontology model

4.2 Formalization of system ontology

After constructing vegetable supply chain knowledge ontology model, vegetable supply chain knowledge user ontology model and vegetable supply chain ontology model, these ontology models are formalized in order to realize semantic reasoning. RDF(S) and OWL exported by Protégé are adopted here, of which OWL formalization expresses the structure formalized by RDF(S).

4.2.1 RDF(S) formalization

To illustrate the usage of Veg. supply chain knowledge management system, we use our project web site (http://icb.cau.edu.cn/vegnet) as a data-intensive website example. As a website instance, the Veg. supply chain knowledge searching system website contains an index page and a list of resources to present information. Fig.9 shows a fragment of RDF statements describing our website. (The namespace prefix 'vegnet' refers to the namespace of Veg. Supply Chain Knowledge System site ontologies:
xmlns:vegnet="http://icb.cau.edu.cn/vegnet/e-learning/siteontology/").

```
<rdf:Description rdf:about="http://icb.cau.edu.cn/vegnet/e-learning">
<rdf:type rdf:resource="http://icb.cau.edu.cn/vegnet/e-learning/siteontology#Site"/>
<vegnet:IndexResource rdf:resource="http://icb.cau.edu.cn/vegnet"/>
<vegnet:Resource>
<rdf:Bag>
<rdf:li rdf:resource=" http://icb.cau.edu.cn/vegnet/e-learning/bsicknowledge"/>
<rdf:li rdf:resource=" http://icb.cau.edu.cn/vegnet/objective"/academicknowledge>
<rdf:li rdf:resource=" http://icb.cau.edu.cn/vegnet/e-learning"/practicalknowledge>
<rdf:li rdf:resource=" http://icb.cau.edu.cn/vegnet/evens"/casestudy>
...
</rdf:Bag>
...
</vegnet:Resource>
</rdf:Description>
```

Fig. 10. Description of the website

We describe the knowledgebase more detail in fig.10. Knowledge class is divided into six sub-classes: Computer Basic Knowledge, Computer Application Knowledge, Vegetable Supply Chain Basic Knowledge, Vegetable Supply Chain Academic Knowledge, Vegetable Supply Chain Practical Knowledge and Vegetable Supply Chain Case Study. Function is a 2nd sub-class of Basic Knowledge and its value is a sub-class of Knowledge Function Class.

```
<?xml version="1.0"?>
<rdf:RDF
xmlns:rdf=http://www.w3c.org/1999/02/22-rdf-syntax-ns#
xmlns:rdfs="http://www.w3c.org/2000/01/rdf-schema#">

<rdf:Description rdf:ID="KnowledgeClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
</rdf:Description>

<rdf:Description rdf:ID="Computer BasicKnowledge_KnowledgeClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
<rdfs:subClassOf rdf:resource="#KnowledgeClass"/>
</rdf:Description>

<rdf:Description rdf:ID="Computer Applicationknowledge_KnowledgeClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
<rdfs:subClassOf rdf:resource="#KnowledgeClass"/>
</rdf:Description>

<rdf:Description rdf:ID="VegetableSupplyChain BasicKnowledge_KnowledgeClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
<rdfs:subClassOf rdf:resource="#KnowledgeClass"/>
</rdf: Description>

<rdf:Description rdf:ID=" VegetableSupplyChain AcademicKnowledge_ KnowledgeClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
<rdfs:subClassOf rdf:resource="#KnowledgeClass"/>
</rdf:Description>

<rdf:Description rdf:ID=" VegetableSupplyChainPracticalKnowledge_ KnowledgeClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
<rdfs:subClassOf rdf:resource="#KnowledgeClass"/>
</rdf:Description>

<rdf:Description rdf:ID=" VegetableSupplyChain CaseStudy_ KnowledgeClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
<rdfs:subClassOf rdf:resource="#KnowledgeClass"/>
</rdf:Description>

<rdf:Description rdf:ID="KnowledgeFunctionClass">
<rdf:type rdf:resource= "http://www.w3.org/2000/01/rdf-schema#Class"/>
</rdf:Description>

<rdf:Description rdf:ID="Function">
<rdf:type rdf:resource= "http://www.w3c.org/1999/02/22-rdf-syntaxns#
Property"/>
<rdfs:domain rdf:resource= "# BasicKnowledge_ KnowledgeClass"/>
<rdfs:range rdf:resource="# KnowledgeFunctionClass"/>
</rdf:Description>

</rdf:RDF>
```

Fig. 11. Description of the website knowledge

4.2.2 Formalize ontology by protégé and OWL

Protégé software (2008) can be used to construct vegetable supply chain domain ontology. Classes are organized as hierarchy in Protégé, each class has it own sub-class, and the sub-class has it own property. The property in Protégé is described by slot, and the current domain is decided by domain option. Part class structure is defined as fig.12 shown.

Fig. 12. Class structure represented by protégé

Properties of class are described by slot in Protege. The process of constructing slot is similar to that of constructing class. Thereinto, the choice of defaults can be used to setup and inherit the property class and its default value. And the domain option is used to confirm the domain of present slot. Fig.13 shows the property slot of Contract Producer sub-class.

OWL format is chosen as the document storage type when Protégé stores ontology. OWL can be used to express items of glossary and relationship between these items, which is called ontology. When the stored ontology document needs to be cited and understood by a computer, OWL will be introduced.

At the time of storing the constructed ontology in OWL format, an initial standard module of OWL is contained in a series of namespace statements of rdf:RDF tag. These statements are adopted to exactly explain identifiers of the document, by which the other parts of ontology can also be understood. A typical namespace statement is shown as below.

```
<rdf:RDF
  xmlns="http://www.example.org/wine#"
  xmlns:vin ="http://www.example.org/wine#"
  xmlns:food="http://www.example.org/food#"
```

```
   xmlns:owl ="http://www.w3.org/2002/07/owl#"
   xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
   xmlns:xsd ="http://www.w3.org/2000/10/XMLSchema#"
xmlns:dte ="http://www.example.org/wine-dt#" >
```

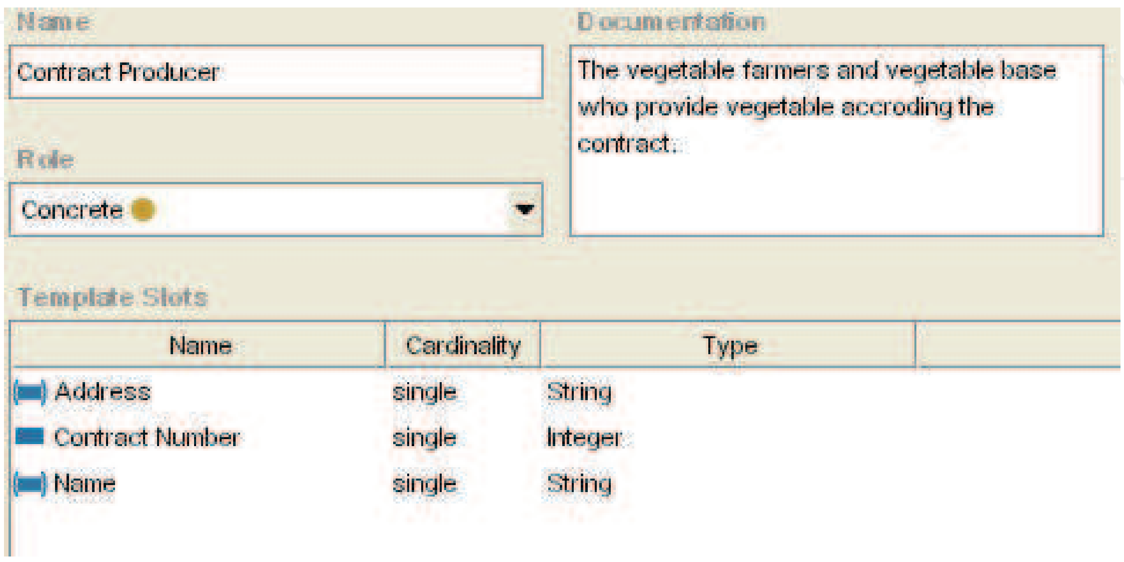


Fig. 13. Property slot of contract producer class

4.3 System development
4.3.1 System development environment and tools
System environment： Windows XP (SP2)
JAVA environment：JDK1.5
Implement tool： Eclipse3.1
Server：Tomcat5.0
Semantic network tools：Jena 2.3, Protégé 3.1

4.3.2 Parse domain ontology by Jena
Jena is adopted to parse vegetable supply chain ontology stored in OWL format in order to realize the semantic retrieval based on ontology. The kits used in parsing process are as below.

```
java.lang.*
java.lang.String.*
java.util.*
java.io.*
com.hp.hpl.jena.rdf.model.*
com.hp.hpl.jena.util.*
com.hp.hpl.jena.rdf.*
com.hp.hpl.jena.ontology.*
com.hp.hpl.jena.reasoner.*
com.hp.hpl.jena.vocabulary.*
com.hp.hpl.jena.reasoner.rulesys.*
```

The first step that Jena parses vegetable supply chain ontology is to read ontology model into memory, before which the createDefaultMode( ) in ModelFactory Class is adopted to create an empty model base on memory storage. Jena also contains other realization modes of Model interface. For example, the Model interface can be created by ModelFactory for modes using relational database.

```
Model model = ModelFactory.createDefaultModel();
```

After the empty model created, the function read of Model interface is adopted to read the domain ontology constructed by Protégé into memory.

```
model.read(new InputStreamReader(vegetable supply chain ontology model document), "");
```

Then a source will be created. The most obvious character of intelligent information retrieval is that source is introduced in the retrieval process. Source can be considered as whatever will be understood, and marked by Uniform Resource Identifier (URI).

```
Resource  myresource=model.createResource();
```

Source holds its property, and each property has its own value. The name of the property is an URI as well.

When vegetable supply chain information retrieval is going on, the retrieval requirements of users will be transferred into RDF source, by which contacts the constructed vegetable supply chain ontology model. Then all the properties and their value of the ontology model are listed by listSubjectsWithProperty method as a source for a given retrieval value, and ResIterator type values will be returned. The final sources can be obtained by hasNext method, which is coded as below.

```
ResIterator  iter=model.listSubjectsWithProperty(searchProperty,searchValue);
while(iter.hasNext() ){
        Resource  r=iter.nextResource();
}
```

For the words and their relations submitted by retrieval users, all the retrieval items will be listed by listObjectsOfProperty method and hasNext method.

```
NodeIterator result=model.listObjectsOfProperty(r,searchProperty);
while(result.hasNext()){
      temp=result.next();
}
```

In the reasoning system, axiom is usually described by standardization terms such as sub-class, sub-property, property definition domain, property value range, base restriction, disjoint etc. The two reasoning rules of the axiom used in the system are as below.

[equating relationship: (*?a* equate to *?c*), (*?b* equate to *?c*),notEqual(*?a*, *?b*)->(*?a* equate to *?b*)]
[similar relationship:(*?a* similar to *?b*),(*?a* similar to *?c*),notEqual(*?b*, *?c*)->(*?b* similar to *?c*)]

The supplement is necessary for reasoning rules.

4.3.3 Vegetable supply chain knowledge acquisition system

The interface of the system consults the design of www.google.com and www.baidu.com etc., which are with concise retrieval engine. The main interface of the system is shown in fig.14.

Supply chain is taken as retrieval item, which is retrieved in keywords based mode. 166 items are returned, which is shown as fig.15.

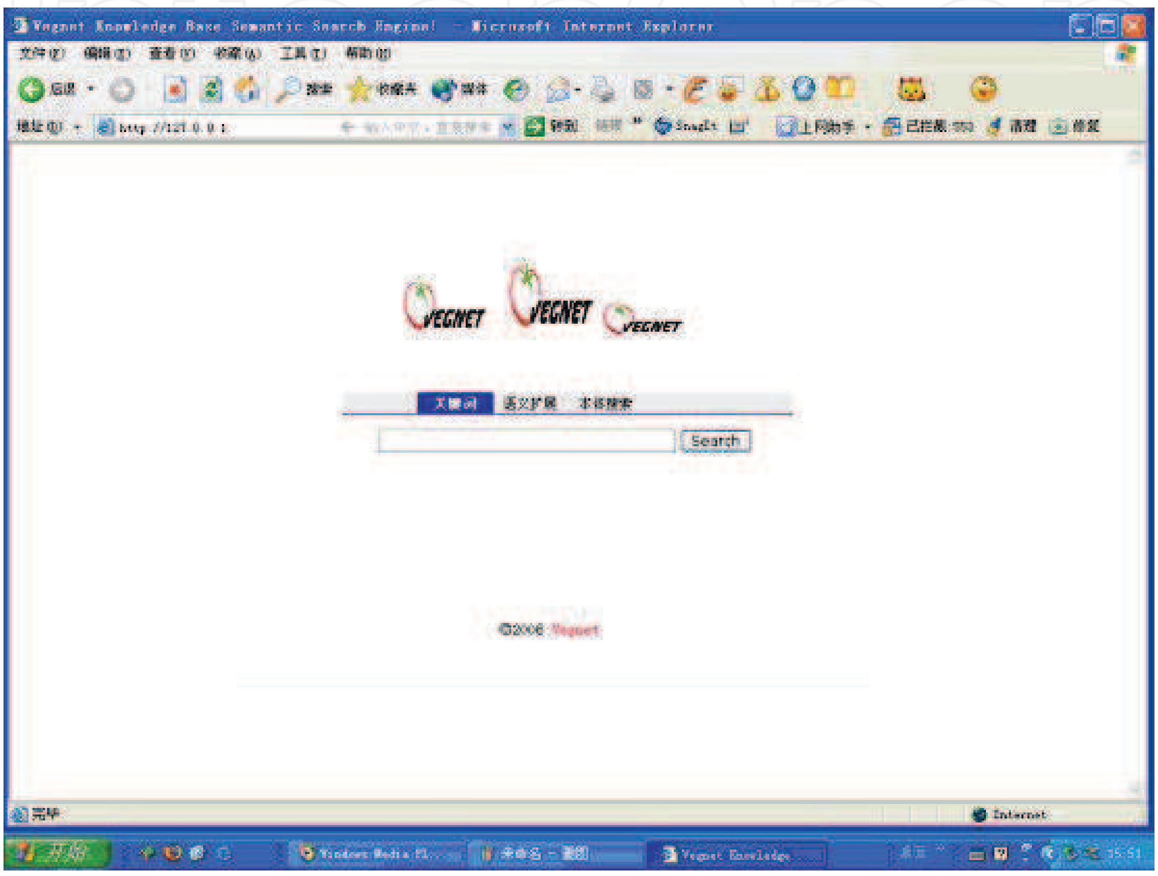


Fig. 14. System interface

Retrieve *supply chain* in semantic extension retrieval module, 239 items are returned. It is shown in fig.16.

The return items which are retrieved in ontology based is shown in fig.17. The first retrieval results list the semantic relationship of concepts according to ontology model. As it is hard for users to describe the retrieval requires properly in the first retrieval, the second retrieval will be done for the reasonable results, which can lead users to obtain the needed literatures.

4.4 Retrieval results analysis

As ontology model and semantic extension module is realized offline, the retrieval time is occupied by read-in ontology model time and reasoning time. The system in response to user retrieval requests can be done on a real-time response for the mount of current vegetable supply chain knowledge.

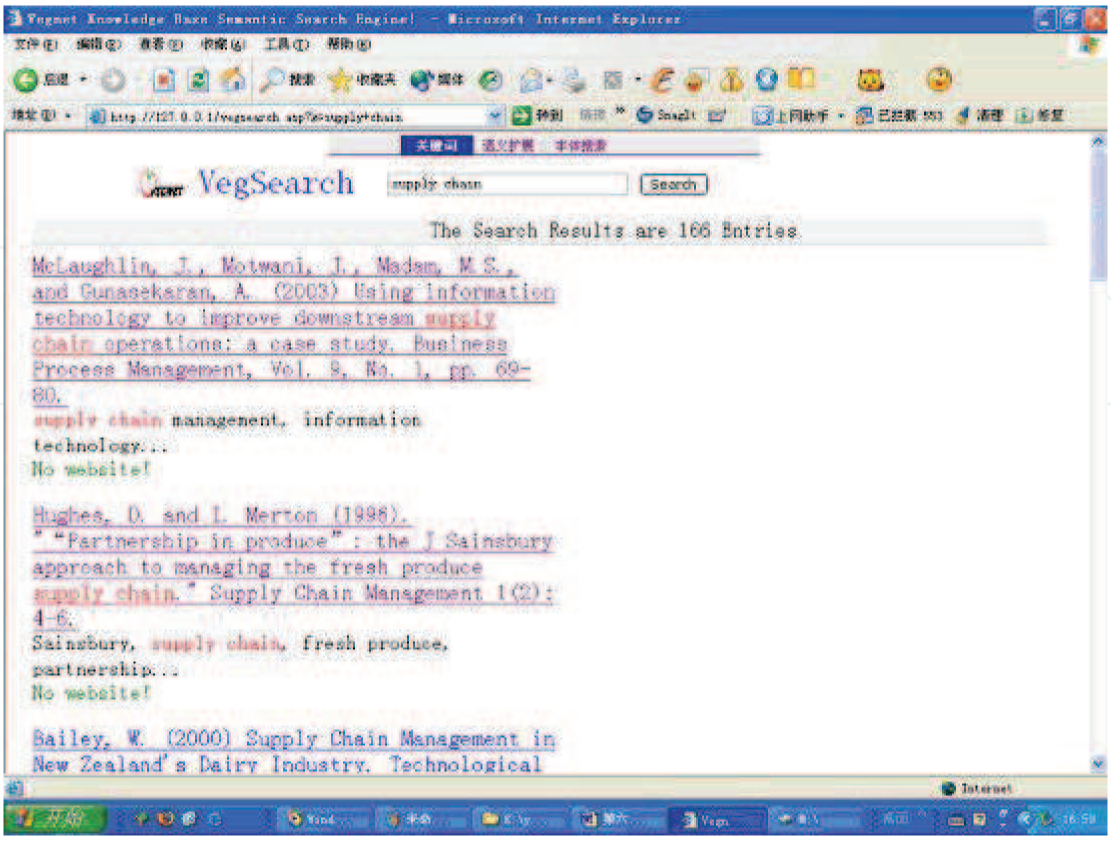


Fig. 15. Keywords based retrieval module

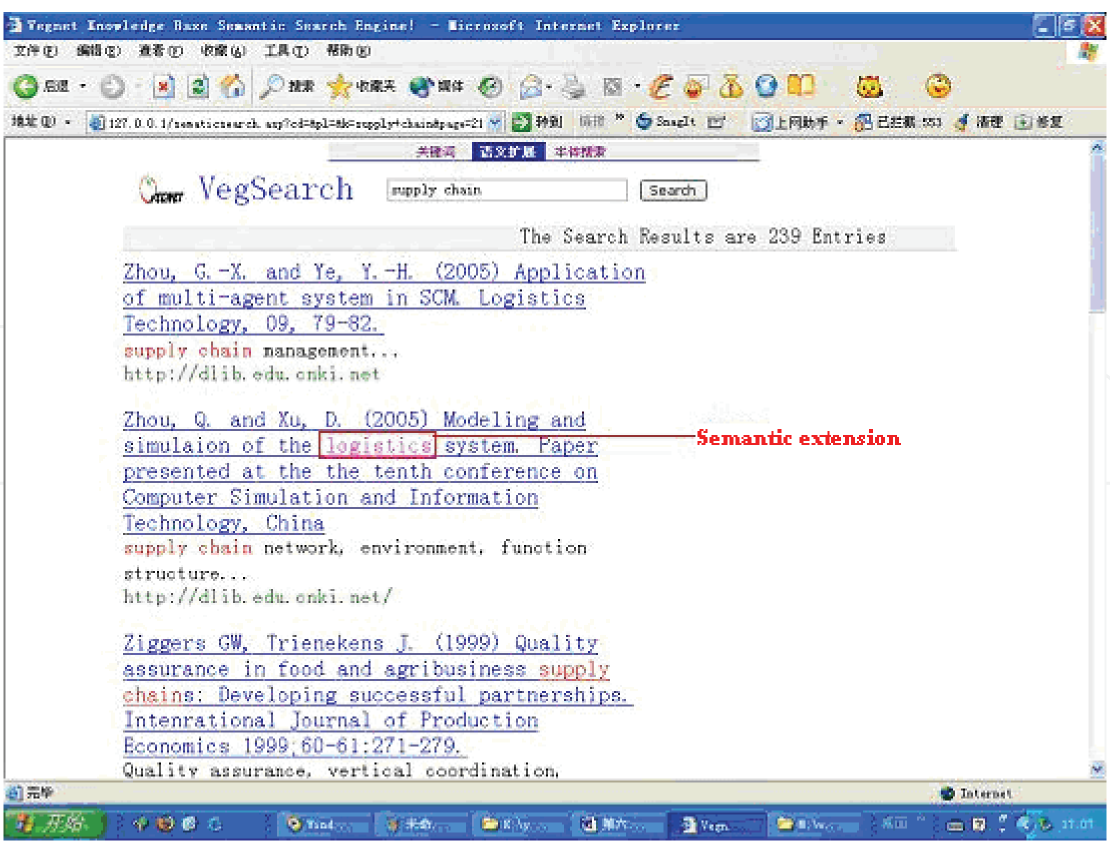


Fig. 16. Semantic extension retrieval module

Fig. 17. Ontology based retrieval module

From the perspective of users, more attention will be paid to function assessment, that is to say that user will pay more attention to whether the retrieval system meet user's retrieval requests. Precision Ratio and Recall Ratio are two basic indicators.

Five concepts (agri_product, fruit, inventory, logistics, transportation) are selected to test the Precision Ratio and Recall Ratio. Due to the system is completed aiming at vegetable supply chain domain. The data is analyzed and processed in the collection processing. Therefore the Precision Ratio is high for each retrieval mode and the Recall Ratio of different retrieval strategy will be inspected. The retrieval results are shown in table 2.

	agri_product	fruit	inventory	logistics	transportation	Average Recall
Keywords	56	16	18	149	48	0.268
Semantic Extension	56	66	18	228	48	0.4412
Ontology Based	91	91	286	350	316	1

Table 2. Retrieval results

Due to the relevant concepts and their relationships in our database are defined in the ontology model, the recall is considered as 1. The average recall of keywords retrieval and semantic expansion retrieval are calculated above this. It can be seen that vegetable supply chain knowledge is semantic tagged in the ontology model. The recall of ontology based retrieval will be the highest recall rate, and the recall of semantic extension retrieval gets the higher recall rate than recall of keywords base retrieval. It is also can be seen that the effect of semantic extension retrieval depends on the definition of dictionary. The average recall of it will be further improved by the expansion of semantic dictionary.

5. Conclusions and future works

5.1 Conclusions

In this chapter, aiming at the problems in traditional knowledge retrieval, ontology is introduced. An approach is put forward to supply chain knowledge management construction, which consists of construction of domain ontology, formalization of ontology model, and development of supply chain knowledge management system based on ontology. Finally, taking vegetable supply chain as a case, complete the vegetable supply chain knowledge management system based on ontology. The better recall and precision shows that the approach is effective. Conclusions are as follows:

- Concepts of supply chain domain and their relationships can be expressed clearly by ontology model. In order to implement an ontology based supply chain knowledge management system, supply chain ontology model, supply chain knowledge ontology model and supply chain knowledge user ontology model are constructed firstly. Each ontology model consists of classes and sub-classes, and there are four kinds of relationships between them, inheritance, part-whole, instance and properties, by which all concepts of supply chain domain are integrated. These ontology models are the base of semantic retrieval;
- Ontology models are formalized in order to get the understanding of computer, RDF(S) is taken to formalize ontology models. And the semantic reasoning is realized by setting reasoning rules;
- The ontology based supply chain knowledge management system can be implemented by Protégé, Java and Jena, by which the developing cost and difficulty will be reduced. Meantime, fasten the developing speedy. And the system can be transferred and used in other operating system convenient.

5.2 Future works

The researches in this chapter will be done further in the followings:

- The expanding of ontology model and the setting of reasoning rules need to be improved. Ontology models and reasoning rules fitting for the present situation have been established, while they need to be expanded and developed in accordance with the changing application situation.
- The storing mode of data and the ordering of retrieval results need to be improved. It will influenced the system capability seriously when the knowledge base and ontology model enlarge to a certain degree.

6. References

A. Th. Schreiber, B. J. Wielinga, and W. H. J. Jansweijer. (1995). The KACTUS view on the 'O' word. *In IJCAI Workshop on Basic Ontological Issues in Knowledge Sharing*.

Benjamin, P. C., Menzel, C. P., Mayer, R. J., Fillion, F., Futrell, M. T., deWitte, P. S., and Lingineni, M. (1994). IDEF5 Method Report. *Knowledge Based Systems*, Inc., September 21, 1994.

Bateman, J. A., Henschel, R. and Rinaldi, F. (2001). The generalized upper model 2.0. *http://www.darmstadt.gmd.de/publish/komet/gen-um/newUM.html*

Borst W N. (1997). Construction of Engineering Ontologies for Knowledge Sharing and Reuse. *PHD thesis,* University of Twente, Enschede.

Corcho, O., Gómez-Pérez, A.. (2000). A Roadmap to Ontology Specification Languages, material for *EKAW00 12th International Conference on Knowledge Engineering and Knowledge Management.* *http://babage.dia.fi.upm.es/ontoweb/wp1/OntoRoadMap/index.html.*

Fernández-López M, Gómez-Pérez A, Juristo N. (1997). METHONTOLOGY: From Ontological Art Towards Ontological Engineering. *Spring Symposium on Ontological Engineering of AAAI*. Stanford University, California, pp 33–40.

Fernández-López M, Gómez-Pérez A, Pazos A, Pazos J. (1999). Building a Chemical Ontology Using Methontology and the Ontology Design Environment. *IEEE Intelligent Systems & their applications* 4(1):37–46.

Framenet. (2008). *Http://www.icsi.berkeley.edu/~framenet/.*

Grigoris Antoniou, Frank van Harmelen. (2004). Web Ontology Language: OWL. *Handbook on Ontologies* .pp: 67-92.

Gruber T R. (1993). A Translation Approach to Portable Ontology Specifications. *Knowledge Acquisition.* pp: 199-220.

Gruber T R. (1995). Towards Principles for the Design of Ontologies Used for Knowledge Sharing. *International Journal of Human-Computer Studies*, 43,pp:907-928.

Knight, K. and S. Luk.. (1994). Building a Large Knowledge Base for Machine Translation". *In Proceedings of the American Association of Artificial Intelligence Conference (AAAI-94)*, July 31, August 3. Seattle, WA. http://www.isi.edu/natural-language/resources/sensus.html#pubs.

M. Gruninger and M. Fox. (1995). Methodology for the design and evaluation of ontologies. *In Proceedings of the Workshop on Basic Ontological Issues in Knowledge Sharing held in conjunction with IJCAI-95*, Montreal, Canada.

Mikrokmos. (1996). *Http://crl.nmsu.edu/Research/Projects/mikro/.*

Mizoguchi, R, M. Ikeda, K. Seta, et al. (1995). Ontology for modeling the world from problem solvingperspectives, *Proc. of IJCAI Workshop on Basic Ontological Issues in Knowledge Sharing, Montreal*.

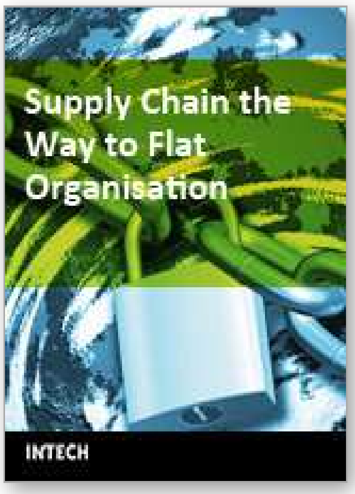
Neches R ,Fikes R E ,Gruber T R ,et al. (1991). Enabling Technology for Knowledge Sharing. *AI Magazine*, 12(3).pp:36-56.

Protégé. (2008). *Http://protege.stanford.edu/.*

RDF. (2008). *Http://www.w3.org/RDF/.*

Studer R, Benjamins V R, Fensel D. (1998). Knowledge Engineering, Principles and Methods. *Data and Knowledge Engineering*, 25(1-2), pp: 161-197.

T. R. Gruber. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition*, 5:199–220.
WordNet. (2006). *Http://www.cogsci.princeton.edu/~wn/*.
W3C. (2008). *Http://www.w3.org/*.



Supply Chain the Way to Flat Organisation
Edited by Julio Ponce and Adem Karahoca

ISBN 978-953-7619-35-0
Hard cover, 436 pages
Publisher InTech
Published online 01, January, 2009
Published in print edition January, 2009

With the ever-increasing levels of volatility in demand and more and more turbulent market conditions, there is a growing acceptance that individual businesses can no longer compete as stand-alone entities but rather as supply chains. Supply chain management (SCM) has been both an emergent field of practice and an academic domain to help firms satisfy customer needs more responsively with improved quality, reduction cost and higher flexibility. This book discusses some of the latest development and findings addressing a number of key areas of aspect of supply chain management, including the application and development ICT and the RFID technique in SCM, SCM modeling and control, and number of emerging trends and issues.

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821