Journal of Southeast University (English Edition) Vol. 23, No. 3, pp. 333 – 337 Sept. 2007 ISSN 1003—7985

Semantic web-based networked manufacturing knowledge retrieval system

Jing Hao Zhang Jing Li Junhuai

(School of Computer Science and Engineering, Xi' an University of Technology, Xi' an 710048, China)

Abstract: To deal with a lack of semantic interoperability of traditional knowledge retrieval approaches, a semantic-based networked manufacturing (NM) knowledge retrieval architecture is proposed, which offers a series of tools for supporting the sharing of knowledge and promoting NM collaboration. A 5-tuple based semantic information retrieval model is proposed, which includes the interoperation on the semantic layer, and a test process is given for this model. The recall ratio and the precision ratio of manufacturing knowledge retrieval are proved to be greatly improved by evaluation. Thus, a practical and reliable approach based on the semantic web is provided for solving the correlated concrete problems in regional networked manufacturing.

Key words: knowledge retrieval; semantic web; ontology; networked manufacturing

It is common knowledge that the cooperation among enterprises is a process involving the allocation and combination of the advantageous knowledge resources of each individual enterprise, which involves a series of activities, such as discovering knowledge, acquiring knowledge, sharing knowledge, and combining knowledge, etc[1–4]. How to manage these activities in a reasonable and effective way and how to ensure maximum knowledge sharing have become the central tasks in knowledge management in the networked manufacturing environment.

As the web technology of the coming generation, the advent and development of the semantic web have become an important impetus in the development of knowledge management technology[5–6]. In addition, with the deepening of research and the wide application of semantic web technology, the criteria and technology needed by the semantic web are being perfected, and in particular, the standardization of SPARQL, which will be completed in the near future[7]. At the 15th W3C International Conference held in Edinburgh in May, 2006, Berners-Lee announced that the time had come to apply the large amount of existing data to the semantic web.

It is known that web services aim at service and that the semantic web aims at intelligibility and manageability. If a semantic service description and reasoning research is to be carried out by combining the advantages of web services and the semantic web with SOA as guidance, a semantics-based service retrieval mechanism can be built, which can provide enterprise users better and richer services and at the same time improve the degree of automation of manufacturing knowledge integration.

1 Framework of Semantic Web-Based Manufacturing Knowledge Retrieval System

Based on the characteristics of semantic web development and the analysis of the above mentioned knowledge retrieval system and by considering the requirements of manufacturing knowledge management under the networked manufacture model, this paper presents a framework for the semantic web-based manufacturing knowledge retrieval system, including a series of facilities to support knowledge sharing to improve networked manufacturing. The framework is shown in Fig. 1.

This resources retrieval system provides the administrators a flow model of information resources management including information collection, verification, marking, and storage, etc. It also serves as a custom-built platform for the users to search and transfer information. With this system, users can add semantic descriptive information according to the contents of the proper resources and by using the knowledge ontology developed by domain experts, and the users can find the information relevant to the semantics in a more convenient way. Logically, the framework of the system is divided into seven layers. From top to bottom, they are the user layer, the access layer, the interface

Received 2007-05-18.

Foundation items: The National High Technology Research and Development Program of China (863 Program) (No. 2003AA1Z2560, 2002AA414060), the Key Science and Technology Program of Shaanxi Province (No. 2006K04-G10).

Biographies: Jing Hao(1972—), male, doctor, jinghao@xaut.edu.cn; Zhang Jing (corresponding author), male, doctor, professor, zhangjing@xaut.edu.cn.

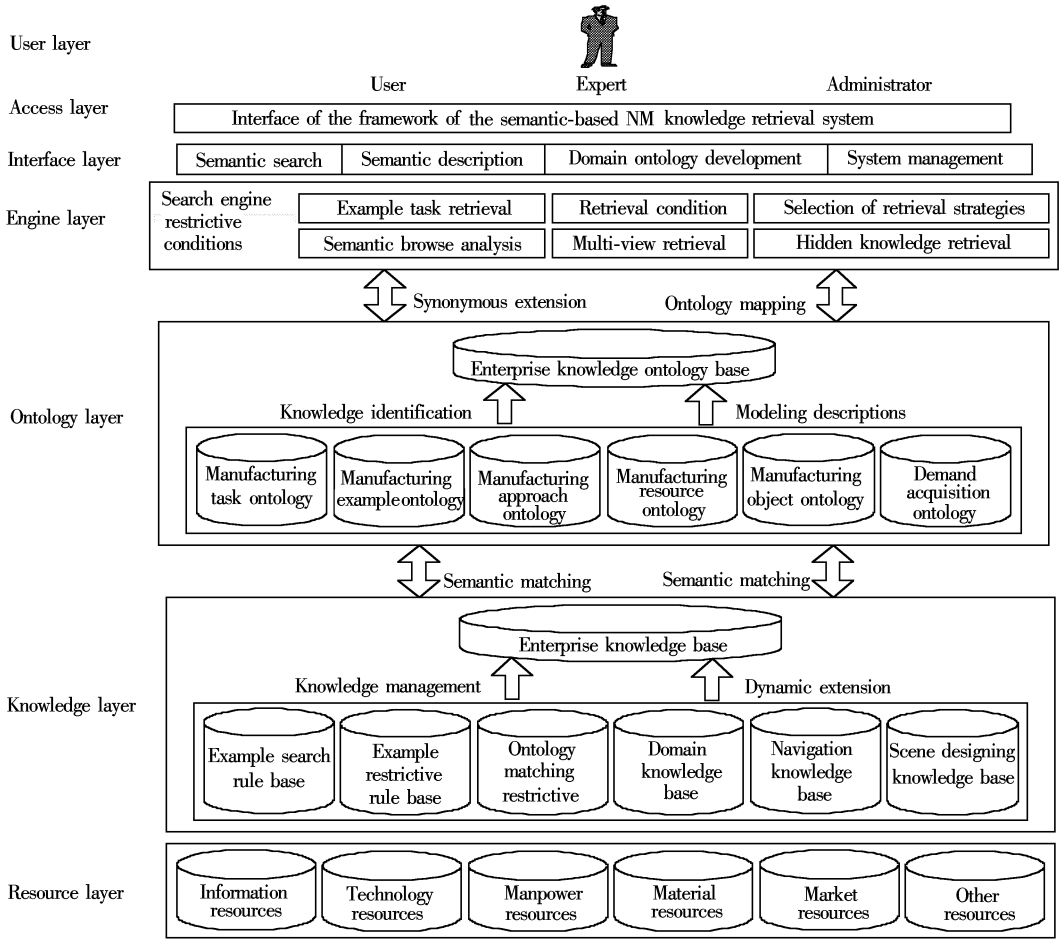

Fig. 1 Framework of the semantic NM knowledge retrieval system

layer, the search engine layer, the ontology layer, the knowledge layer, and the resources layer.

The basic work principle of the knowledge management system is as follows.

When the user puts in search conditions after having gained access to the access layer, the system receives the search request from the user and carries out corresponding semantic processing and intelligent search; then through ontology mapping, it carries out synonymous extension and association to the key words; afterwards it feeds the results back to the user, letting the user make selections and determine the search range; the normative search key words are given to the ontology mapping module via the search engine to conduct searches in ontology base; the ontology mapping carries out matching of the matched ontology model (the concepts and semantic relations) in the knowledge base; in the end, the matched results are fed back to the user interface via the search engine.

2 Improved Model of Semantic Web-Based Information Retrieval

With the development of information search technology, the development of the multi-element-array information search model has aroused great interest among researchers and the development of ontology, web mining and fuzziness correlation has accelerated the development of web information search. Most of the conventional information search models are based on a four-element array, which can only be interoperated on the data layer and the grammar layer and lacks interoperation on the semantic layer. Since semantic interoperation of information can be realized by ontology and web mining technology, in this thesis an improved semantic-based web information search model is proposed. The framework is shown in Fig. 2.

The work principle of this information retrieval improved model is as follows.

First, original document bases are preprocessed by document classification, feature abstraction and metadata semantics annotation. Accordingly, the respective document model, the domain model and user model are formed. Among them, the document model is expressed as $D = \langle D_c, D_f \rangle$, where D_c is the document subject, D_f is non-subject property and the dynamic adjusting node, the domain model is the formal expression of a series of concepts or terms used for the search of normal and extensive users. The uncertainty of the deduc-

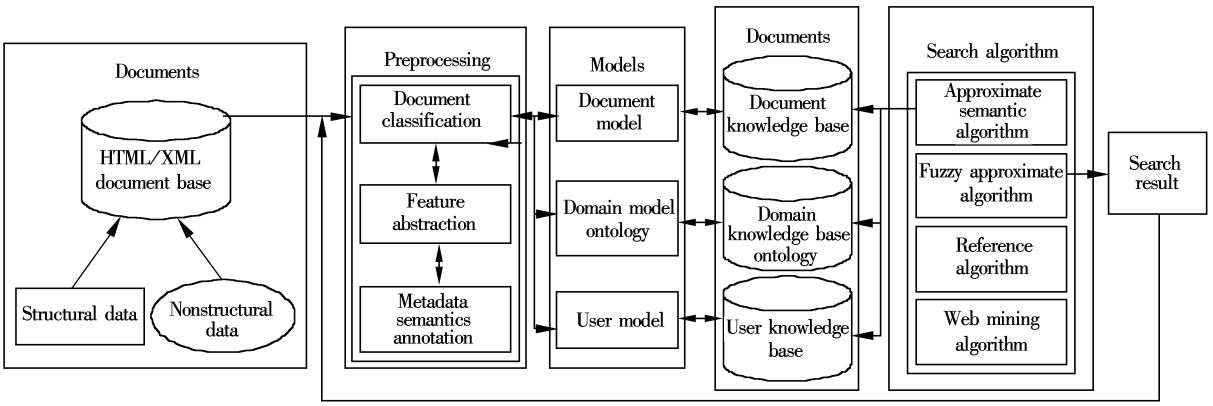

Fig. 2 Framework of semantic-based web information retrieval model

tion users can be expressed as $O = \langle C, R \rangle$, where C is the concept; R is the relationship between the concepts; the user model used to express the information demand of the users is expressed as $U = \langle U_c, U_f \rangle$, where U_c is the expression of the user concept; U_f is the expression of the users' other attributes and also the dynamic adjusting node of the users' information intentions. And then, corresponding document knowledge base, domain knowledge base and user knowledge base can be created. Finally, the search results will be provided for users through several search algorithms (such as the approximate semantic algorithm, the fuzzy approximate algorithm, the reference algorithm and the web mining algorithm).

The realization of this semantic web-based information retrieval improved model involves dynamic modeling among users, domains, and documents, and it is also the basis of the reference search algorithm selection and realization.

3 Test Methods of Semantic Web-Based Manufacturing Knowledge Retrieval

With semantic technology becoming increasingly mature, research on semantic-based ontology knowledge has interested many researchers. However, since there are not completely mature methods and tools for semantic information query searches and systematic descriptions of the methods adopted in the available literature, researchers find no methods and tools for reference. In addition, due to its complexity and its distribution, the results of knowledge searches in networked manufacturing knowledge are difficult to test. Therefore, the authors propose a set of test methods based on the idea of semantic web-based network manufacturing knowledge retrieval, including sample selection, primitive data acquisition, data abstraction and organization, and the test results of some of the sample data obtained. The test methods designed are proved to be correct and advanced; they can also be used for reference in testing other search models.

The following are the procedures of the test methods:

1) Selection of sample data

To ensure that this process is objective and scientific, it is absolutely necessary to use the theory of probability and the principles of statistics in the course of collecting data and sorting out data and analyzing data so as to discover the rule.

2) Determination of research target

To test that the test method can be used for general purposes, some influential gateway websites are adopted in this paper.

3) The acquisition of primitive sample data

In this research, 44% of the resources of the gateway sites listed are chosen as samples by random sampling generated by computer. The random sampling tool used is written in the form of JavaScript. The Chinese industry control website, the Chinese mechanics website, the Chinese manufacture information gateway, and the Chinese machine tool website are selected as information sources.

After comparing several downloading tools, an offline explorer is chosen to download data from the websites. When each parameter of the tool is set, it can be used to download data according to the user's intentions.

4) Preprocessing and document logical processing

After downloading the primitive data, the link must be extracted from the page layout and some operations must be performed for further analysis, such as removing overlapped URIs, building inverted searches, calculating the appropriate number and saving the data in the base. The logical processing is mainly applied to subject identification, prediction and relevant calculations.

5) Knowledge base building

The reason why the semantic retrieval can provide more intelligent search service than full text search lies in the fact that the semantic search has richer knowledge. Therefore, the top priority of realizing the semantic search is to build a user oriented knowledge base.

In building domain models, some existing object-orientated tools can be used, such as Rational Rose. Another method is the direct application of modeling tools, such as OIL editor and Protégé. The modeling in this paper is based on the Java-based ontology development tool, namely, Protégé3. 1.

6) The test and test flow chart of the five-element-array modeling

The test and test flow chart of the semantic web-based manufacture knowledge search system is shown in Fig. 3.

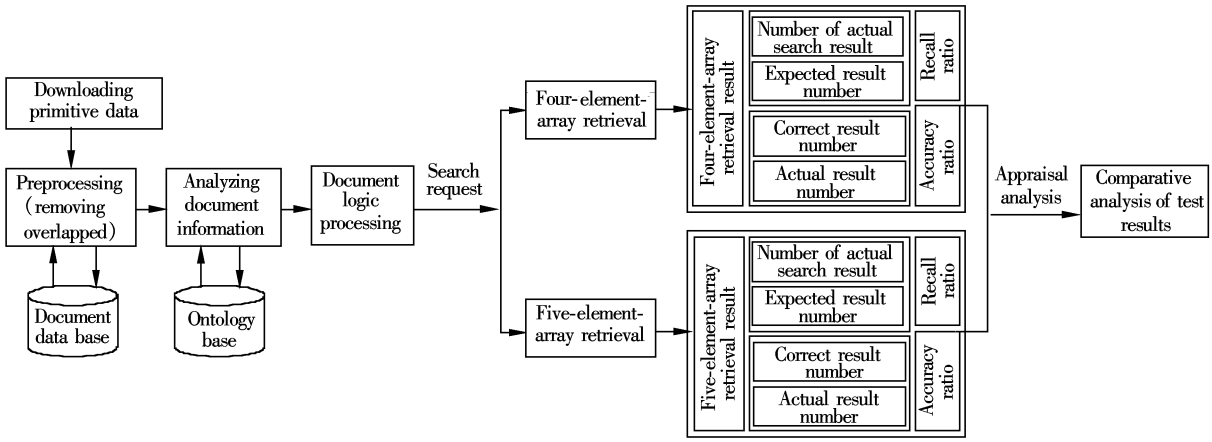

Fig. 3 Five-element-array retrieval model test process

7) Programming and test environment

- Programming environment

The program is written in the integrated environment of JBuilder 10 by using Java language.

- Database realization

To the database involving the conventional information database and the ontology database, SQL Server 2000 can be used to save the information and the ontology base can also be saved by putting it in the SQL server in the form of tables.

8) Test results

In this paper, several Chinese web pages meeting eight search requirements are used to carry out the test. Tab. 1 shows the test results.

Tab. 1 The contrast test results between four-element-array and five-element-array model %

Number	Link address	Conventional four-element-array model		Conventional five-element-array model	
		Accuracy ratio	Recall ratio	Accuracy ratio	Recall ratio
1	http://www.gongkong.com/	61.2	70.3	63.1	71.6
2	http://www.gongkong.com/agent/	68.3	71.4	66.5	70.5
3	http://www.gongkong.com/news/	69.1	78.5	70.8	79.8
4	http://www.e-works.net.cn	61.8	69.8	64.1	72.3
5	http://www.jichuangwang.com	67.5	72.6	68.6	73.4
6	http://www.jx.cn	60.7	68.1	61.5	69.1
7	http://www.jx.cn/xwzx/xwzx.asp	59.8	67.2	60.7	68.7
8	http://www.jx.cn/v33/cpdq/cpdq.asp	62.6	72.8	64.3	73.2

From the above comparison, it is obvious that the modeling based on the five-element-array is superior to the one based on the four-element-array. Still, there are slight differences on certain subjects, which need further study and improvement.

4 Conclusion

The premise and key of networked manufacturing knowledge management lie in the building of an effective information retrieval mechanism. The semantic web provides a fine semantic platform for manufacturing knowledge management, enabling the manufacturing knowledge management system to understand the deep level knowledge and realize automatic management. This paper focuses on knowledge sharing and repeated applications, meeting all the essential requirements of the knowledge management and proposes a semantic-based NM knowledge retrieval method. Its recall ratio and accuracy ratio have been verified by examples.

References

[1] Montreuil B, Frayret J M. A strategic framework for networked manufacturing [J]. *Computers in Industry*, 2000, **42** (2/3): 299 − 317.

[2] Dan B, Li L, Zhang X, et al. Network-integrated manufacturing system [J]. *International Journal of Production Research*, 2005, **43**(12): 2631 − 2647.

[3] Cloutier L, Frayret J M, D' Amours S, et al. A commitment-oriented framework for networked manufacturing coordination [J]. *International Journal of Computer Integrated Manufacturing*, 2001, **14**(6): 522 − 534.

[4] Tan K H, Platts K. A connectance-based approach for managing manufacturing knowledge[J]. *Industrial Management and Data Systems*, 2004, **104**(2): 158 − 168.

[5] Medjahed B, Bouguettaya A. A multilevel composability model for semantic web services[J]. *IEEE Transactions on Knowledge and Data Engineering*, 2005, **17**(7): 954 − 968.

[6] Pulido J R G, Ruiz M A G, Herrera R, et al. Ontology languages for the semantic web: a never completely updated review[J]. *Knowledge-Based Systems*, 2006, **19**(7): 489 − 497.

[7] Rapoza J. SPARQL will make web shine [J]. *EWeek*, 2006, **23**(18): 50.

基于语义 web 的网络化制造知识检索系统

井 浩 张 璟 李军怀

(西安理工大学计算机科学与工程学院,西安 710048)

摘要:针对传统知识检索方法缺少语义层次互操作的技术缺陷,建立了一个基于语义 web 的制造知识检索系统的体系结构. 该结构包括一系列支持知识共享以促进网络化制造协同的机制. 提出了一种基于五元组的语义信息检索模型,建立了一套语义网络化制造知识检索测试方法. 最后,经过实例验证该系统能显著提高网络化制造模式下制造知识信息检索的准确率和查全率,为解决区域性网络化制造中的相关知识检索问题提供了一条切实可行的途径.

关键词:知识检索;语义 web;本体;网络化制造

中图分类号:TP391