http://ansinet.com/itj

ITJ

ISSN 1812-5638

# INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (17): 3939-3945, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.3939.3945


# An Ontology-based Support System for Collaborative Product Design in Manufacturing Supply Chain

Xu Heng
School of Management, Henan University of Technology,
Business Intelligence and Knowledge Engineering Lab,
Henan University of Technology, Zhengzhou, 450001, China

**Abstract:** Based on ontology this paper putted forward the process model of Collaborative Product Design (CPD) on knowledge management which could realize the information communication and sharing among the design group's activities under the environment of distributed design. Further, the storage strategy for ontology knowledge base which is based on RDF language and relational database was proposed and the instance of ontology knowledge base was created for knowledge of universal bicycle parts. This provides the applicable method to storage ontology model in relational database. At last, the prototype system was build by using object-oriented technology, web technology and ontology modeling. This research realizes the design data management and the design process management in the domain of product design based on the semantic model and proposes a solution for CPD knowledge management. It has the theoretical significance and application value for connecting the different types of knowledge and providing the support system of design knowledge for designer.

**Key words:** Collaborative product design, knowledge management system, ontology, RDF, knowledge base

## INTRODUCTION

Product design is a process of group cooperation and the different stylist and all kinds of technical personnel and suppliers and customers participate in each stage of the design which needs each participant's full potential and ingenuity (Reglil and Cicirello, 2000). All kinds of personnel information, the communication of the design idea and the discussion of unknown problems is needed to achieve clear and best results in the design process (Liu, 2007). To solve these problems arising in the course of design work and make that all kinds of personnel could work at the same design goal, not only need effective organization management and what more need effective techniques. Using modern and networking information communication technology could change the communication occasions, geographic location or environment, etc and also can shorten the time of effective communicate and improve the efficiency of the communication (Xie, 1996).

With the development and application of the CPD theory, research on how to use computer technology and network technology, to connect the different types of knowledge and to provide product knowledge network platform for collaborative design personnel has important theoretical significance and application value.

## PROCESS MODEL OF CPD BASED ON KNOWLEDGE MANAGEMENT

Although the tools of CPD management, such as Product Data Management (PDM), Product Information Management (PIM), Technical Document Management (TDM) and Technical Information Management (TIM) (McIntosh, 1995) provide the functions of storage, integration, management and control of data and information in the process of product design effectively through the structured way, it has limited ability to the management of design knowledge because it can't support the activities of CPD in the environment of knowledge management. It is an efficient path with designing application platform that faces the environment of collaborative and distributed design and support CPD for solving the problems of the acquisition, storage and retrieval of experience and design knowledge, etc.

Based on the above analysis, this paper puts forward the process model of CPD based on knowledge management and ontology as shown in Fig. 1. Its aim is to support task and process of CPD based on the PDM and CAD in the aspect of knowledge management. It could realize information communication and sharing of design group activities in the environment of distributed design and the dynamic monitoring and adjustment of design project management in a certain extent and support

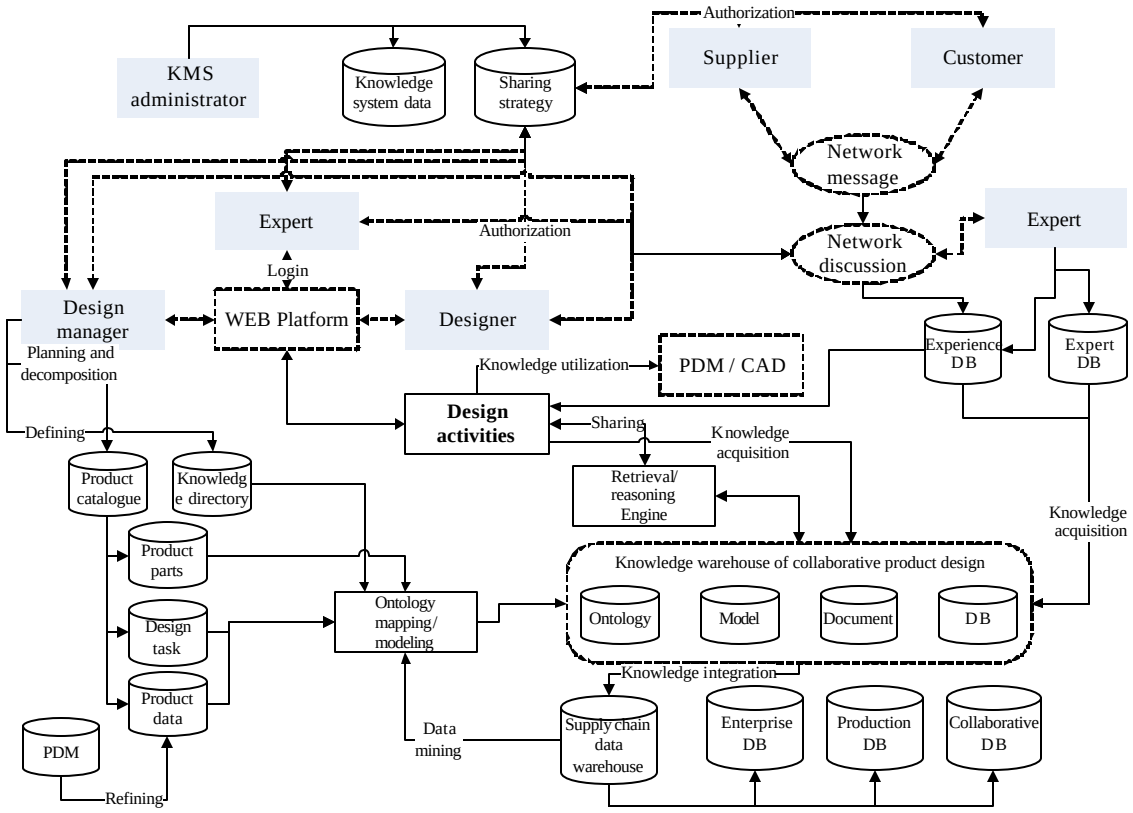


Fig. 1: Process model of CPD based on knowledge management and ontology

collaborative work of the designers and teamwork with different knowledge background and integrate and unify the existing information system or design tool of design departments based on network through expanding and improving itself. And it could effectively acquire and store the large number of knowledge and experience which the design staff has produced in the working process and realizes the description and retrieval standardization of knowledge resource through the ontology model (Xu, 2010).

## STORAGE PATTERN OF ONTOLOGY KNOWLEDGE BASE BASED ON RELATIONAL DATABASE

The original goal of ontology is to achieve the integration and reuse and sharing of knowledge. Meanwhile, the ontology provides the concept and terminology with rigorous definition and group consensus for the systematic knowledge; this laid a foundation in order to realize the knowledge sharing and interoperability at the semantic level. In the field of product design, the design activity is a kind of knowledge organization process, good understanding and realization the of final design results need to index and reference to a large number of knowledge related to the design, knowledge storage is the technology foundation to build a knowledge system, so research of storage and structure of knowledge base based on ontology is particularly important.

Firstly, ontology is sets of protocol in standard language for the purpose of the knowledge integration, reuse and sharing. For example: The Protégé-Frames should comply with the Open Knowledge Base Connectivity protocol (OKBC), The Protégé-OWL should comply with the Web Ontology Language (OWL) of W3C. Secondly, ontology is machine (computer) oriented theory, technology and method with formal expression and reasoning of knowledge based on formal and clear statement on the concept of certain areas. At last, ontology is software applications and development framework associated with ontology modeling.

**Storage strategy of ontology knowledge base:** Now research of Resource Description Framework (RDF) storage based on relational database is relatively mature: According to characteristics of RDF data, relationship of the RDF data could be decomposed and

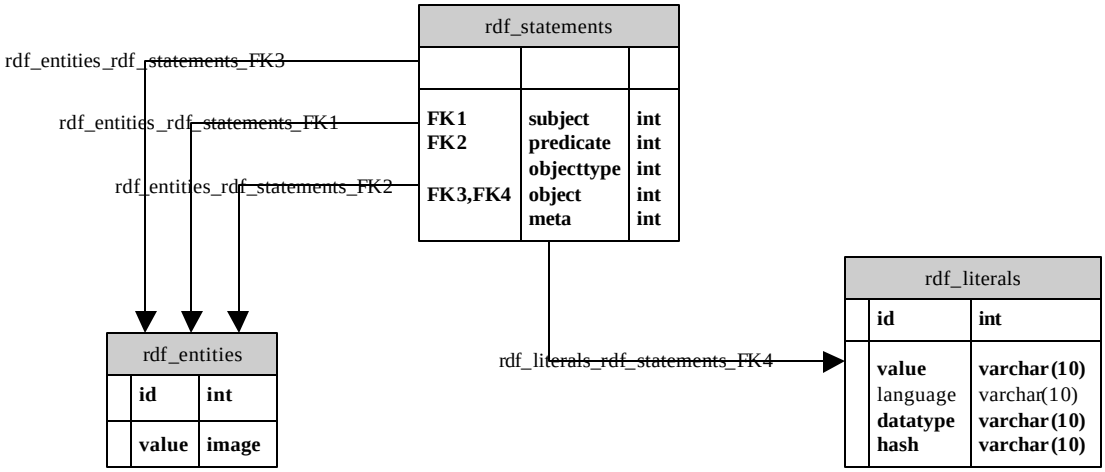


Fig. 2: RDF storage structure of ontology knowledge base

stored in different relational tables, so Yi *et al.* (2007) proposed a kind of RDF data storage based on relational database model; Wu and Zhang (2007) put forward a method that using the format of vertical scheme to construct the storage table of RDF data, then the RDF data would be mapped into records in the storage table of RDF data through schema mapping, so as to it could effectively use the existing relational database resources to manage the RDF data; Chen and Lan (2008) proposed a way to store RDF data based on relational database and through the Jena to parsing an instance of RDF data, so as to realize the RDF data stored in relational database.

At present there are three common RDF storage strategies: XML/RDF file, the special XML/RDF database and traditional relational database. The storage strategy based on file has faster speed and is easy to implement, but for large-scale RDF data it is limited by memory size. The management tools for special XML/RDF database has not yet been relatively mature, such as the OMM. The relational database technology is mature and widely used, the efficiency is higher than object-oriented database and its transaction system can ensure the correct operation; At the same time, the database is suitable for the application of knowledge query based on ontology, directly query on the relational database triple is faster. So, the use of relational database to store the RDF data is feasible.

Due to the OWL is essentially a special kind of RDF and Protégé 3.4 beta already have the function with transforming OWL ontology model into the RDF format. Therefore, this paper proposes a storage strategy of ontology knowledge base for relational database based on RDF language. Its purpose is ontology model established by Protégé 3.4 beta could be converted into storage structure which could use mature management technology of relational database, in order to avoid the knowledge stored in different types (TXT, XML, RDF, OWL, HTML, etc.) files that are hard to operation and maintenance.

**RDF storage structure of ontology knowledge base:** Existing RDF storage strategies based on relational database mainly include horizontal mode, vertical mode, decomposition mode and hybrid mode (Wang *et al.*, 2006; Yi *et al.*, 2007). Considering the basic principle of storage strategy of ontology knowledge base, based on the vertical mode and expansion, the RDF storage structure of ontology knowledge base based on relation model could be built. This RDF storage structure is composited with entity table (rdf_entities), literals table (rdf_literals) and statement table (rdf_statements). Entity table stores all of entity, including the subject, the predicate and the object with URI; literals table stores all the literal values; Statement table is auxiliary table with each value of the subject, the predicate and the object pointing to the other two tables' ID; the "objecttype" shows it is URI resource or literal.

In order to facilitate the transformation and input of ontology knowledge base, in the physical structure of system database, there are no primary key and constraint relation between the above three tables and the constraint checking and data validation could be tested by Protégé 3.4 beta. The logical relationship between the three data tables is shown in Fig. 2.

**Instance analysis:** According to the RDF storage structure of ontology knowledge base, the universal bicycle parts would be instanced for building the ontology knowledge base. As shown in Table 1-3, it is the fragment instance about entity table, literals table and statement table of ontology knowledge in relational database.

For instance, the semantic relationships composed with the records which the value of "id" is "30", "31" and "15" in Table of "rdf_entities" and the records which the value of "subject" is "30" in Table of "rdf_statements" is an RDF triples: "抱式后闸" is subclass of "后闸"; the semantic relationships composed with the records which the value of "id" is "44" and "56" in Table of "rdf_entities" and the records which the value of "subject" is "56" in Table of "rdf_statements" and the records which the value of "id" is "483" in Table of "rdf_literals" is an RDF triples: "consist_of" means "由...组成".

Table 1: Data segment of "rdf_statements" table

| Subject | Predicate | Objecttype | Object | Meta |
|---|---|---|---|---|
| 28 | 15 | 0 | 29 | 1 |
| 30 | 15 | 0 | 31 | 1 |
| 31 | 15 | 0 | 29 | 1 |
| 56 | 44 | 1 | 483 | 1 |

Table 2: Data segment of "rdf_entities" table

| Id | value |
|---|---|
| 4 | http://www.w3.org/1999/02/22-rdf-syntax-ns#type |
| 15 | http://www.w3.org/2000/01/rdf-schema#subClassOf |
| 28 | http://www.owl-ontologies.com/Ontology1214716234.owl# 鞍座 |
| 29 | http://www.owl-ontologies.com/Ontology1214716234.owl# 本体部件 |
| 30 | http://www.owl-ontologies.com/Ontology1214716234.owl#抱式后闸 |
| 31 | http://www.owl-ontologies.com/Ontology1214716234.owl# 后闸 |
| 32 | http://www.owl-ontologies.com/Ontology1214716234.owl# 悬臂前闸 |
| 44 | http://www.owl-ontologies.com/Ontology1214716234.owl#Text |
| 56 | http://www.owl-ontologies.com/Ontology1214716234.owl#consist_of |

Table 3: Data segment of "rdf_literals" table

| Id | Value | Language | Datatype | Hash |
|---|---|---|---|---|
| 483 | 由...组成 | | *#string | mdXOnXpgg2FG+/yiBb69937EumI= |
| 496 | 一个类型 | | *#string | uVVxUhk1jgVOq+CYpg9FGVEKhwI= |
| 497 | 单位 | | *#string | hTWBt4RHBN7Bw7jb8xlnz5nL0xM= |

*:http://www.w3.org/2001/XMLSchema

## CONSTRUCTION AND REALIZATION OF THE PROTOTYPE SYSTEM

Based on the design principle and development process of knowledge systems engineering and the quality control system of knowledge management, the prototype of CPD support system was gradually build.

The main function of the CPD support system is management of knowledge data, designer, resources and process which should be related to the CPD in the distributed environment. It is the set of knowledge sharing and data management and team organization and would rely on open resources, optimization flow and accurate knowledge control to improve the quality of product development and shorten the cycle of product design.

**Application structure of CPD support system:** The CPD support system adopts Browse/Server structure and the application structure of CPD support system is shown in Fig. 3.

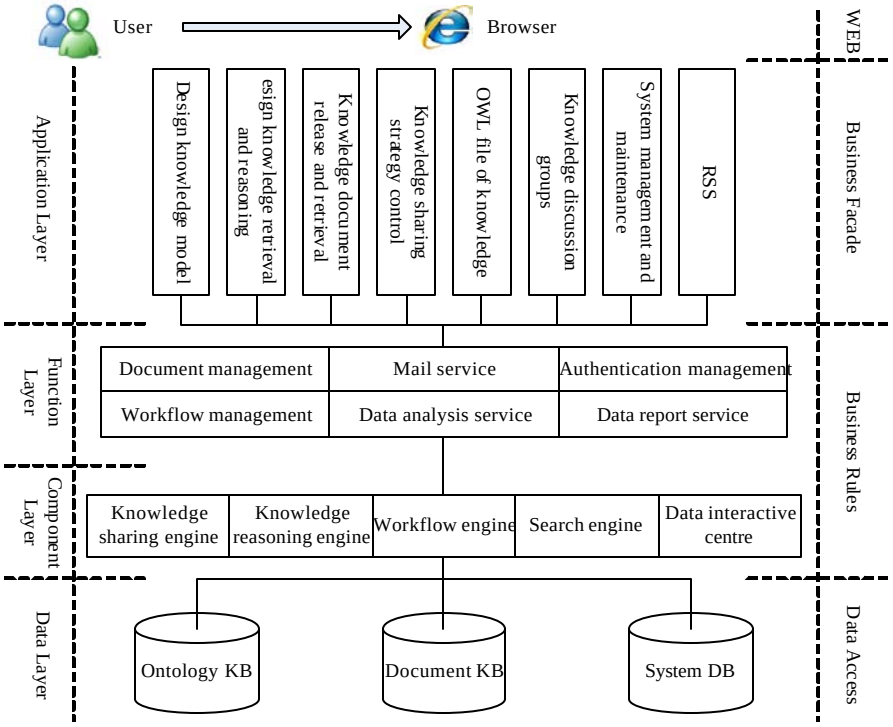


Fig. 3: Application structure of CPD support system

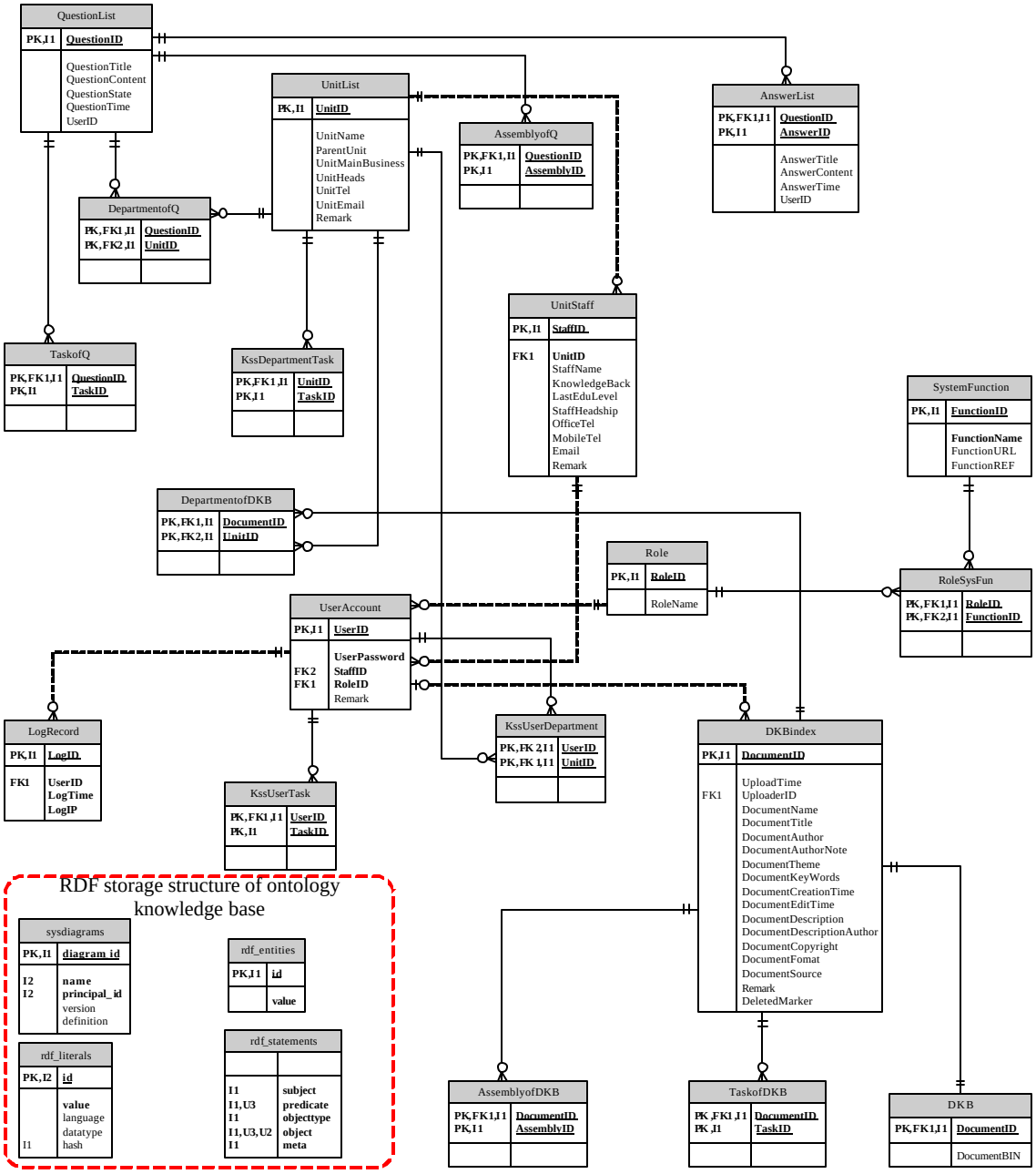


Fig. 4: The data structure of CPD support system

In this application structure, data layer has three entity objects, its meaning were as follows:

- **Ontology knowledge base:** It is responsible for the OWL files established by Protégé stored in SQL Server 2005 with persistent form. In addition, the access for the ontology model also needs the support of the interface of the ontology knowledge base
- **Document knowledge base:** It is responsible for the text files, graphics, images, audio and video that these carriers could represent all sorts of knowledge to store in relational database by binary data
- **System database:** The contents of discussion group, knowledge sharing strategy, access control strategy and basic information of system management related the CPD could be stored in the system database

**Data structure of CPD support system:** The data structure of CPD support system based ontology knowledge base is shown in Fig. 4.

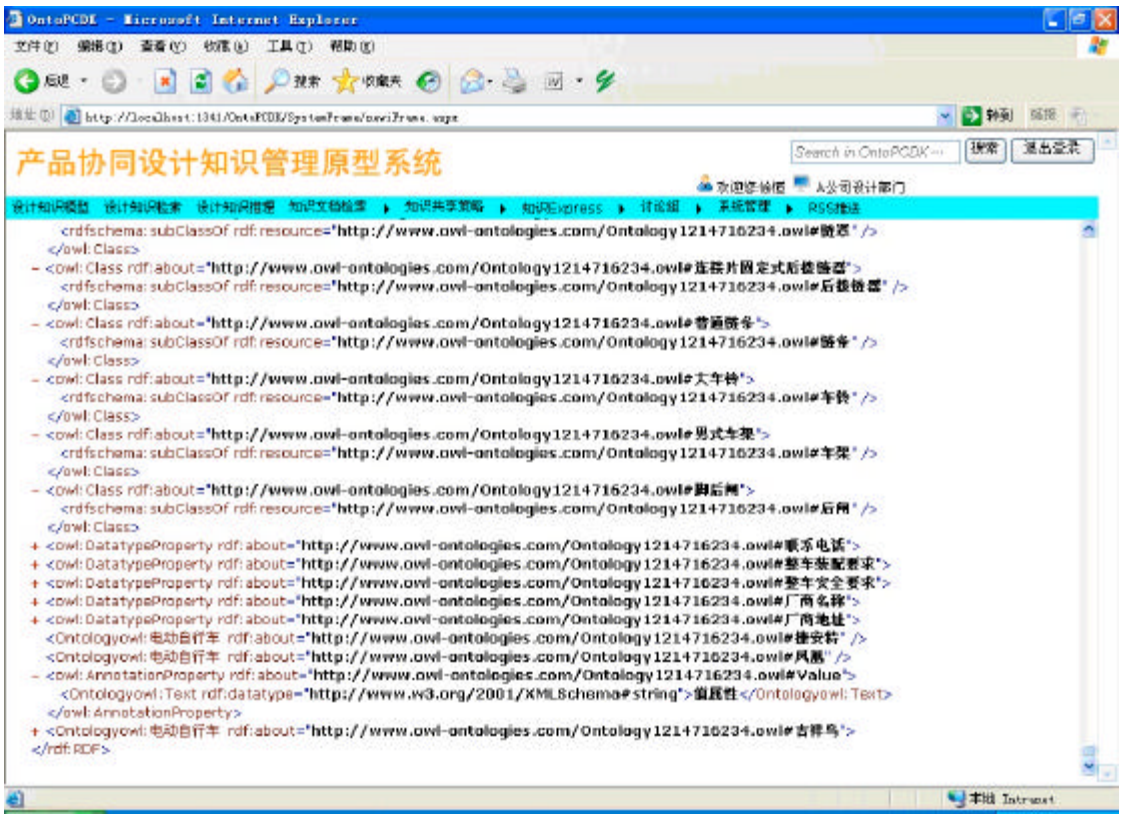


Fig. 5: A web page of design knowledge of prototype system

**Realization of CPD support system:** Based on the above analysis of CPD under the manufacturing supply chain environment, the prototype system is build by using object-oriented technology, web technology and ontology modeling. The development environment is Microsoft.net Framework 2.0. The main development tool is Microsoft Visual Studio 2005 with asp.net 2.0 and C# 2.0. The tool of knowledge ontology modeling is protégé 3.4 beta. ERwin DataModeler V7.2 is used for modeling the data structure of prototype system and SQL Server 2005 is selected as storage and management tools for system data and knowledge base. A web page of design knowledge of prototype system is shown in Fig. 5.

## CONCLUSION

With the continuous development of manufacture information engineering, it is an inevitable trend that realizes the design data management and the design process management in the domain of product design based on the semantic model.

Through the comparative analysis of ontology and knowledge base, the RDF storage structure of ontology knowledge base is put forward and the example analysis shows it is effective. This provides the applicable method to storage ontology model in relational database. Based on the analysis of theory and technology about ontology, as the research object of CPD in manufacturing supply chain, a complete set of technology solutions was established for supporting the knowledge modeling of CPD and the application of support system based on web. Therefore, it has the important theoretical and practical value that establishes the knowledge application platform for supporting the CPD; also it is the important way that could train the competitive advantage of the whole manufacturing supply chain.

## ACKNOWLEDGMENT

This study was supported by the National Nature Science Foundation of China (71001034 and 71102087 and 70971121) and the Grants Program of Youth Backbone Teachers of Colleges and Universities in Henan Province (2012GGJS-090) and the Doctorial Foundation of Henan University of Technology (2009BS017) and the Grants Program of Science and Technology Innovative Talents of Henan University of Technology (2011CXRC21) and

the Science Research Project of Education Department in Henan Province of China (2010B630008). The author is grateful to the anonymous referee for a careful checking of the details and for helpful comments that improved this study.

## REFERENCES

Chen, G.Y. and L. Lan, 2008. Research and implement of RDF storage strategy. Mod. Comput., 4: 112-113.

Liu, G.Y., 2007. Design Management. Shanghai Jiaotong University Press, Shanghai.

McIntosh, K., 1995. Engineering Data Management: A Guide to Successful Implementation. McGraw- Hill, New Yor, ISBN:13-9780077076214, Pages: 279.

Reglil, W.C. and V.A. Cicirello, 2000. Managing digital libraries for computer-aided design. Comput. Aided Des., 32: 119-132.

Wang, W., X.Q. Yan, W.F. Li and D.F. Chen, 2006. An approach to store OWL object in relational database. Microcomput. Inform., 22: 156-158.

Wu, Q.X. and Z.H. Zhang, 2007. Storing and manage RDF data in semantic web. Microcomput. Inform., 23: 144-145.

Xie, Y.B., 1996. Modern design and knowledge acquisition. China Mechn. Eng., 7: 36-41.

Xu, H., 2010. A process model of collaborative product design based on design chain and knowledge management. Proceedings of the International Conference on Logistics Systems and Intelligent Management, Volume 1. January 9-10, 2010, Harbin, China, pp: 425-429.

Yi, Y.X., Z.L. Song and K.Y. Yin, 2007. Research and implementation on storage schema of RDF data. Inform. Sci., 25: 1218-1222.