Combining Web Services Toward Innovative Design of Agile Virtual Enterprise Supported by Web 3.0

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Abstract: - With the Internet dominating the business world, the need to have an effective web3.0 service has increased among Agile Virtual Enterprise（AVE）emerging out of the context of globalization manufacturing, Innovative design is seen as the core competitiveness of AVE which need the knowledge engineering method urgently. However, the current human readable web can not meet the demands of complexity, flexibility and Real-time for innovation design. Until the emergence of the web 3.0, it is possible for intelligent software agent based on machine accessible SOA services which can be combined to higher level of enterprise web services. We give a new innovative design platform by combining enterprising Web Services based on Web 3.0. This paper gives ontology for innovative design which including design, process, skill, application domain and organization sub ontology and the OWL description of environmental production domain. Then we complete the innovative design service model by Protégé tools, setup the design service web platform based on J2EE with Protégé-OWL API, and give a practical case in the domain of environmental protection device manufacturing. In the end, we points the performance of knowledge database is important in the future.

Key-Words: - knowledge, innovative design, Agile Virtual Enterprise, semantic, ontology, web services
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1 Introduction

As Web services grow in popularity, enterprising Web and application developers create new and innovative applications with their data. In addition to single-service applications, developers are creating mash-ups, applications that combine data from multiple services to create something new which is suitable for AVE.

AVE is a highly dynamic, reconfigurable agile network of independent enterprises sharing all resources, including knowledge, market, and customers; using specific organizational architectures that connect all partners into a concurrent value chain [1], which is seen as a new and most advanced organizational paradigm, and is expected to serve as a vehicle towards a seamless perfect alignment of the enterprise within the market. The sponsor is called Core Enterprise (CE), the other partners is called Partner Enterprise (PE). PE has deeply infiltrated into the value chain of CE that makes most decision of CE depending on the participation of PE. Every PE has its core competitiveness, such as advanced device, unique manufacturing process and rich industry experience etc. which can be presented as individual knowledge in common. Since AVE is regard as the mainstream operation mode of enterprise in the current century, it is necessary to integrate and optimize the business process across AVE to achieve the maximum profit by knowledge management.

Innovative design is the key problem of product in the current changing world, which is seen as the core competitiveness of AVE. The features, structure, quality, cost, as well as manufacturing, maintenance and environmental protection are basically determined by the product design stage. Innovation design has become the primary factor for AVE to succeed in the global competition. It is the inevitable to change from "made in China" to "China to create" for the China's enterprises. Environmental protection equipments manufacturing (EPEM) has become a booming industry of great importance in China. However, due to the different environmental conditions both home and abroad, some local conditions get even worse. Therefore, it is very urgent to combine the China's local conditions and the abroad best applied design for independent innovation.

AVE emerges and develops in the context of globalization manufacturing, which stresses the cooperation of core competencies of PE in innovative design. From the perspective of information science, the core competitiveness, such as technology, skill, process and other things, can be published and provided in the form of web service on the Internet with digital and networked knowledge. AVE is the outcome of the Internet times; however, non-structured and semi-structured knowledge on the current Internet can not meet the demands of complexity, flexibility and Real-time for innovation design. Until the emergence of the Web 3.0, it is possible for AVE innovative design based on semantics web services.

Web 3.0 has the characters as follow: (1) Transformation. Web 3.0 has been described as the "executable web". In the analogy to file system permissions, Web 1.0 was "read-only", Web 2.0 is "read-write", and Web 3.0 will be "read-write-execute". With the still exponential growth of computer power, it is not inconceivable that the next generation of sites will be equipped with the resources to run user-contributed code on them. The "executable web" can morph online applications into Omni Functional Platforms that deliver a single interface rather than multiple nodes of functionality. (2) Network computing. Related to the artificial intelligence direction, Web 3.0 could be the realization and extension of the Semantic web concept. Academic research is being conducted to develop software for reasoning, based on description logic and intelligent agents, for example, the World Wide Mind project. Such applications can perform logical reasoning operations using sets of rules that express logical relationships between concepts and data on the Web. Sramana Mitra differs on the viewpoint that Semantic Web would be the essence of the next generation of the Internet and proposes a formula to encapsulate Web 3.0. Web 3.0 has also been linked to a possible convergence of Service-oriented architecture and the Semantic web. Web 3.0 is also called the "Internet of Services", i.e. besides the human readable part of the web there will be machine accessible SOA services which can be combined to higher level of services. (3) Distributed databases. The first step towards a "Web 3.0" is the emergence of "The Data Web" as structured data records are published to the Web in reusable and remotely query-able formats, such as XML, RDF, Website Parse Template and microformats. This is also known as the bottom-up approach. The recent growth of SPARQL technology provides a standardized query language and API for searching across distributed RDF databases on the Web. The Data Web enables a new level of data integration and application interoperability, making data as openly accessible and linkable as Web pages. The Data Web is the first step on the path towards the full Semantic Web. In the Data Web phase, the focus is principally on making structured data available using RDF. The full Semantic Web stage will widen the scope such that both structured data and even what is traditionally thought of as unstructured or semi-structured content (such as Web pages, documents, etc.) will be widely available in RDF and OWL semantic formats. Website parse templates will be used by Web 3.0 crawlers to get more precise information about web sites' structured content. (4) Intelligent applications. Web 3.0 has also been used to describe an evolutionary path for the Web that leads to artificial intelligence that can reason about the Web in a quasi-human fashion. Some skeptics regard this as an unobtainable vision. However, companies such as IBM and Google are implementing new technologies that are yielding surprising information such as making predictions of hit songs from mining information on college music Web sites. There is also debate over whether the driving force behind Web 3.0 will be intelligent systems, or whether intelligence will emerge in a more organic fashion, from systems of intelligent people, such as via collaborative filtering services like del.icio.us, Flickr and Digg that extract meaning and order from the existing Web and how people interact with it. [5]

2 Web3.0 Services of AVE

Actors of AVE are business companies or other organizations that wish to electronically execute selected process with their partners with the purpose of exchanging messages. In innovative design scenario most of the discussion relates to communication between two partners. The communication is established through a message exchange. Although usually only two parties are involved in execution of innovative design (the execution is based on an agreement that was settled before the design), there are some situations when a third party (or even more parties) is getting involved when innovative design is already underway in the AVE. For example in the big plane innovative design scenario many parties communicate one with each other, but CE is invited, too, to supervise and to conclude the transaction. From a Semantic Web Services' perspective, the CE could join and interpret the agreement and all the steps, which should be undertaken, based on a semantic description provided by two other companies, to supervise and to conclude the transaction.

There are three well-known business protocols standards, namely RosettaNet, EDI and ebXML that are solving to some extent system integration problems among distributed business systems (inter-enterprise integration). When applying one or more protocol standards, PE becomes isolated and does not need to know the infrastructure of their business partners to communicate with them. The business protocols isolate the internal information infrastructure from the external communication infrastructure. Independently of infrastructure seclusion, we discovered the requirements for Semantic Web Services in area of process definition and execution, and object (message) definition. Semantic Web Services can enrich B2B protocol standards by supplementing complementary machine interpretable description for processes and objects (messages) which enhancing the cooperating efficiency and reducing the complication of AVE, especially of innovative design [2].

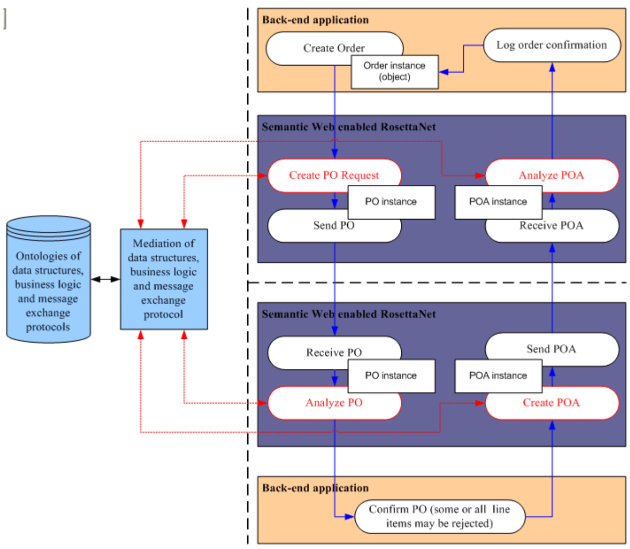

Fig.1 Semantic Web Services Architecture

Business Protocol Standards have been long established and used among AVE. They are using plain text documents as messages (text or XML or other formal formats) that have no state attached to them as for example PO for its whole "life" remains only PO document (message) without the possibility to refer to it as draft PO, sent PO, accepted PO, etc. (regardless of the system where the PO remains at the particular period of time, it only remains PO and nothing more). Having PO message, there is no mechanism to figure out if the order is scheduled for sending or if it has been already accepted. For example, there is no action attached to flat RosettaNet XML documents. We would require ontology for RosettaNet objects. The ontology would describe the message semantics, (object semantics) so when new information are introduced or new version of message is created, the change or addition could be more easily incorporated into an existing environment (Fig. 1).

Ontology is an explicit specification of a simplified, abstract, view of some domain that we want to describe, discuss, and study. It is specification of a conceptualization of a knowledge domain. Ontology is a controlled vocabulary that describes objects and the relations between them in a formal way, and has a grammar for using the vocabulary terms to express something meaningful within a specified domain of interest. The vocabulary is used to make queries and assertions. Ontological commitments are agreements to use the vocabulary in a consistent way for knowledge sharing. [7] Ontology can include glossaries, taxonomies and thesauri, but normally have greater expressivity and stricter rules than these tools. A formal ontology is a controlled vocabulary expressed in an ontology representation language. The primary goal of ontology here is to represent core competitiveness of each partner in AVE, it is typically the result of a combination effort where one gathers various authoritative sources on the domain and creates a consensus. There are different types of ontology [3]; we use domain ontology to describe the domain of innovation design of AVE. Domain ontology should contain a description of the domain and their properties, relationships, and constraints. Often, ontology may serve various purposes:

Reference on a domain: Explicit design knowledge serves as a reference to which PE looking for detailed information on the product design.

Classification framework: The concepts explicated in ontology are a good way to categorize information on the innovation design. Indication of synonyms in the ontology helps avoiding duplicate classification. Other relations among the concepts of the ontology help PE browsing it and finding information PE is looking for.

Interlingua: Tools and/or experts wishing to share knowledge on the innovation design domain modeled, may use the ontology as a common base to resolve differing terminologies. Ontology can also be transformed to Semantic Web Services which helps the knowledge share and discovery to PE among AVE by using all kinds of business application of IT system.

Web3.0 Services of AVE is an application that takes data -- usually Web service data of PE, and usually from more than one source -- and uses it to create application suitable for AVE that displays information for an arbitrary number of Web services and displays it on a Web page. The application is built to be as generic as possible to achieve flexibility and maintainability. You can define the services in their own class, with an array of services to display. To add to or remove services from the final output, you can manipulate the contents of the array, and an XML template that specifies the ultimate display accompanies each service definition. The end result is that you can control the services used, the appearance of their data on the final Web page, and even sub services linked to the main service by simply manipulating what amounts to input instructions.

On the Web3.0, an AVE intelligent agent can process the business transaction only if the information published on the semantic Web is identified in a machine readable and understandable way by means of Web Ontology Language (OWL). OWL is a family of knowledge representation languages for authoring ontologies, and is endorsed by the World Wide Web Consortium. This family of languages is based on two (largely, but not entirely, compatible) semantics: OWL DL and OWL Lite semantics are based on Description Logics, which have attractive and well-understood computational properties, while OWL Full uses a novel semantic model intended to provide compatibility with RDF (Resource Description Framework) Schema. OWL ontologies are most commonly serialized using RDF/XML syntax. OWL is considered one of the fundamental technologies underpinning the Semantic Web, and has attracted both academic and commercial interest [6]. If we label the Web services of PE available to the CE and their data in this way, with more information, AVE can enable the application to make intelligent choices. For example, the application is able to understand which services represent manufacturing information, and which represent online exhibition, or even further, online E-commerce. It would know which information from those services represent the title, description, price, cost, time, and capability and so on.

3 Ontology for Innovative Design

We defined ontology of the knowledge used in innovative design to serve as a structuring framework for our research. We will not enter in a detailed description here, and only present the main concepts of the ontology and how they relate so as to better illustrate afterward how it helped us in the rest of the work.

The ontology is divided into five subontologies: the product subontology, the design skills subontology, the design process subontology, the organizational structure subontology, and the application domain subontology. In the following, we present each of these subontologies, their concepts and relations. The following conventions are used: ontology concepts are written in CAPITALS and associations are underlined. Fig. 2 illustrates how the subontologies combine together. [4]

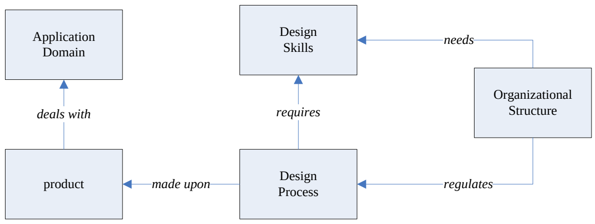

Fig.2 Ontology for Innovative Design

3.1 Design Ontology

A DESIGN system <u>interacts</u> with USERS and possibly other DESIGNS. It is <u>installed on</u> some PE and <u>implements</u> environmental protection design TASKS (of the application domain). It is <u>composed of</u> ARTIFACTS that can generally be decomposed in DOCUMENTATION and PRODUCTS. Three kinds of documentation are considered: (i) PRODUCT RELATED, describing the product itself; (ii) PROCESS RELATED, used to conduct environmental protection projects; and (iii) SUPPORT RELATED, helping to operate the system.

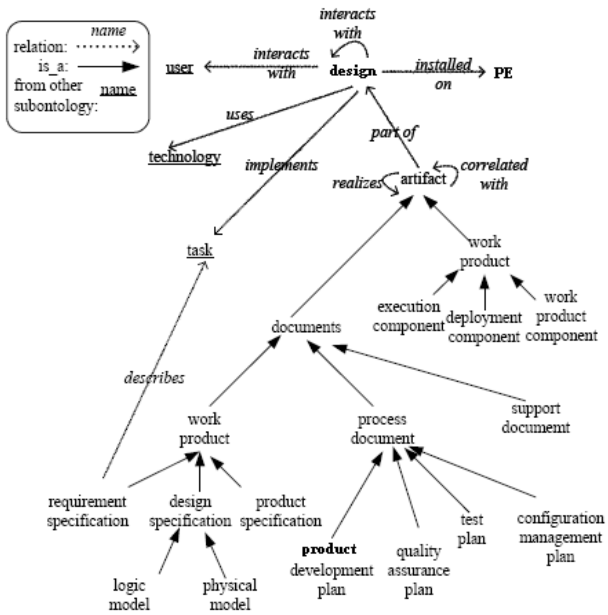

Fig.3 Design Ontology

PRODUCTS represent all the designed artifacts that compose the design system itself. They are classified them in: (i) EXECUTION COMPONENTS, generated for the design system execution; (ii) DEPLOYMENT COMPONENTS, composing the executable design; and (iii) WORK PRODUCT COMPONENTS, that are the blueprint, the prescription, and anything from which the deployment components are generated.

All those ARTIFACTS are, in some way, related one to the other. For example, a requirement is related to design specifications which are related to deployment components. There are also relations among requirements which are shown as Fig 3.

3.2 Skills Ontology

The second subontology describes the skills needed in environmental protection to development. The DESIGNER must know the DEVELOPMENT ACTIVITY that must be performed, the FACTORIES the system runs on, and various ENVIRONMENTAL PROTECTION TECHNOLOGIES. Apart from that, the DESIGNER must also understand the CONCEPTS of the application domain and the TASKS performed in it. There are four ENVIRONMENTAL TECHNOLOGIES of interest: possible PROCEDURES to be followed, MODELING LANGUAGE used, CASE TOOLS used, and finally, the SYSTEM'S ENVIRONMENT used in the system (Fig 4).

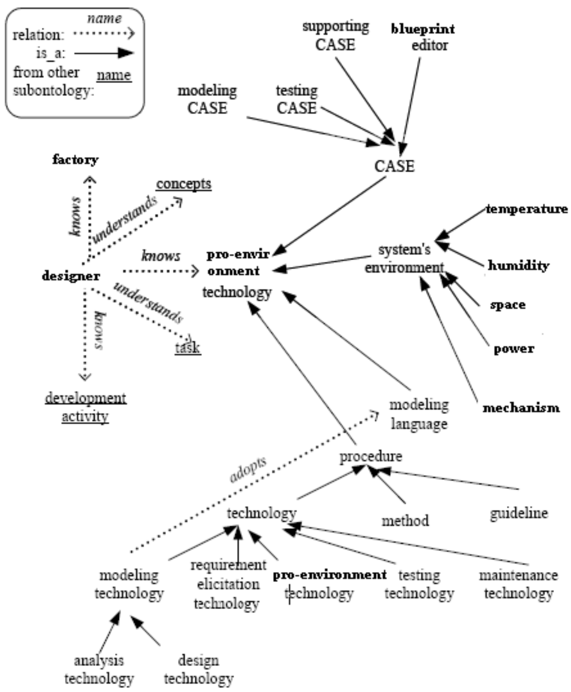

Fig.4 Skills Ontology

3.3 Process Ontology

A DEVELOPMENT PROJECT originates in a DEVELOPMENT REQUEST submitted by a CE. These REQUESTS are classified either as DEVELOPMENT REPORT or ENHANCEMENT REPORT. DEVELOPMENT REQUEST is divided into PERFORMANCE REQUIREMENT, INFORMATION REQUIREMENT, ECONOMY REQUIREMENT, CONTROL REQUIREMENT and EFFICIENCY REQUIREMENT, etc. One or more DEVELOPMENT REQUESTS generate a DEVELOPMENT PROJECT that will define the different product DEVELOPMENT ACTIVITIES to execute.

We classified the DEVELOPMENT ACTIVITIES in the following types: REQUIREMENT DETERMINATION, ANALYSIS, DESIGN, and IMPLEMENTATION.

Finally, different types of person (HUMAN RESOURCES) may participate in these ACTIVITIES (such as ENGINEERS, MANAGERS, and PE HUMAN RESOURCES).

3.4 Application Domain Ontology

The fourth subontology organizes the concepts of the Application Domain as shown in Figure 2. We represent it at a very high level that could be instantiated for any possible environmental production domain. We actually defined a meta-ontology specifying that a domain is composed of domain CLASS, related to each other and having SLOT which can be assigned values and FACET that defines constraints for the SLOT is meta-ontology would best be instantiated for each application domain with domain ontology. We also considered that the CLASS in an application domain is associated with the TASKS performed in that domain and those TASKS are regulated by some FACET (Fig 5).

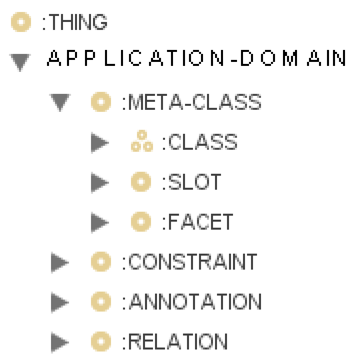

Fig.5 Application domain subontology

To environmental production domain, we setup the embodied subontology model partly shown in Fig 6. It includes the environment pollution classes, slots, facets and pollution approaches and so on which can be transformed as OWL shown as follow.

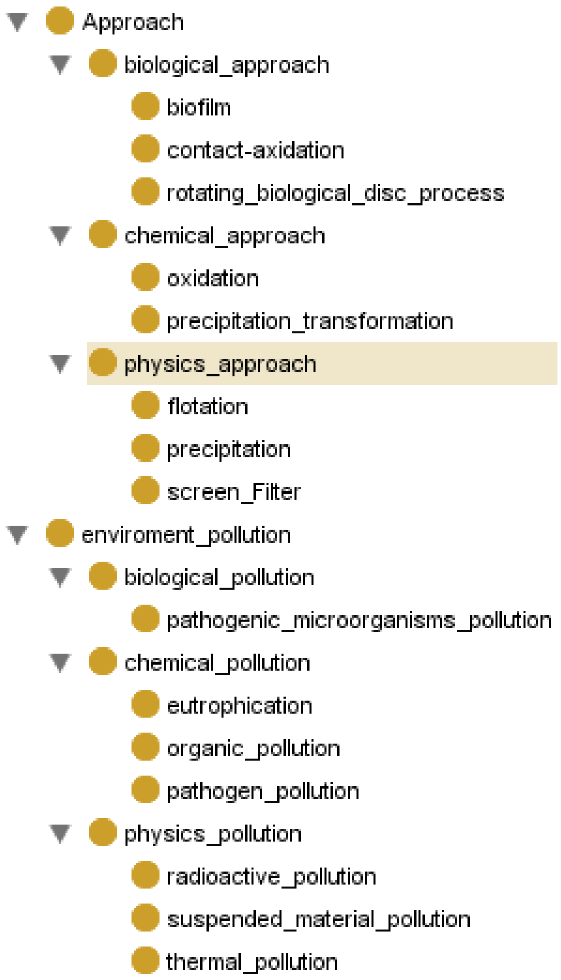

Fig.6 Environmental production domain subontology


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xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema
#"
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3.5 Organization Ontology

Organizational structure is AVE composed of PE where HUMAN RESOURCES fill different POSITIONS. We also included the fact that an organization defines GUIDELINES to be adopted in the execution of the tasks. Our goal here was not to define all possible aspects of an organization, but only to define that the development is an activity performed by people in some PE that compose the whole AVE with its own rules.

4 Development and Case Study

With analyzing the latest norms of SEM-GRD, the GGF semantic grid research group, and the successful experience of famous e_Science reference project, we proposes the innovative design method (SEM-PDM) based on semantic grid by combining knowledge engineering, and select the domain of environmental protection device manufacturing as the application field.

SEM-PDM domain models in any of these languages can be uploaded and linked into the Web just like you would publish an HTML page. Once an RDF or OWL file is online, other Web resources or applications can link to it. For example, a HTML page showing a specific product could encode metadata to link back to the corresponding entity in an OWL model so that all applications that understand what a "product" is can make sense out of the HTML page. Or, providers of specific products can instantiate the RDF Schema classes to announce their portfolio to SEM-PDM agents in an unambiguous exchange format. A typical scenario for such a Semantic Web application is shown in Fig. 7.

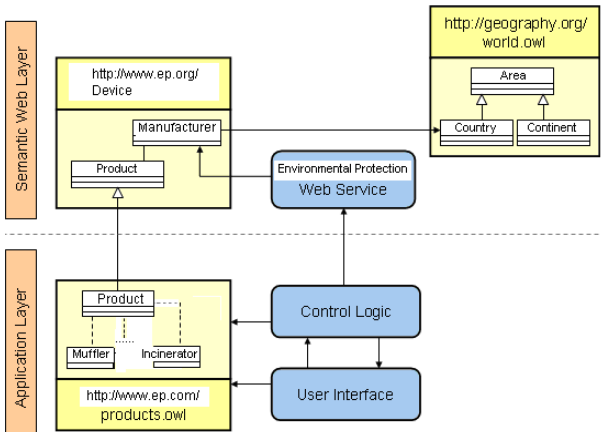

Fig.7. SEM-PDM logical view using Semantic Web

We deploy the E-exhibition business service by Servlet of J2EE which is shown as follow code. Everyone on line can access the E-exhibition by the Internet Explore just like the ordinary style, but the Semantic Web Service has been deploy on the server which provide the inference engine and knowledge database.

SEM-PDM adopts the J2EE framework based on open-source software with MySQL database server, JBOSS4.0 application server, as shown in Fig 8. The role is divided into user groups, the administrator group and the domain experts group. By using Protégé, the development tool developed by Stanford University, the domain expert describe design capacity of the rules, restrictions, formulas, processes, and instances based on OWL setting up design domain ontology database, service information description database and capacity database respectively. In way of special XML sequence and in accordance with the Triples (Subject-Predicate-Object) format, it stores the data into RDBMS through JDBC by mapping ontology to object. The related semantic analysis, discursion engines and capacity search is available depending on Protégé-OWL API. AVE work flow is available by combining the Flow4J component and ontology description.

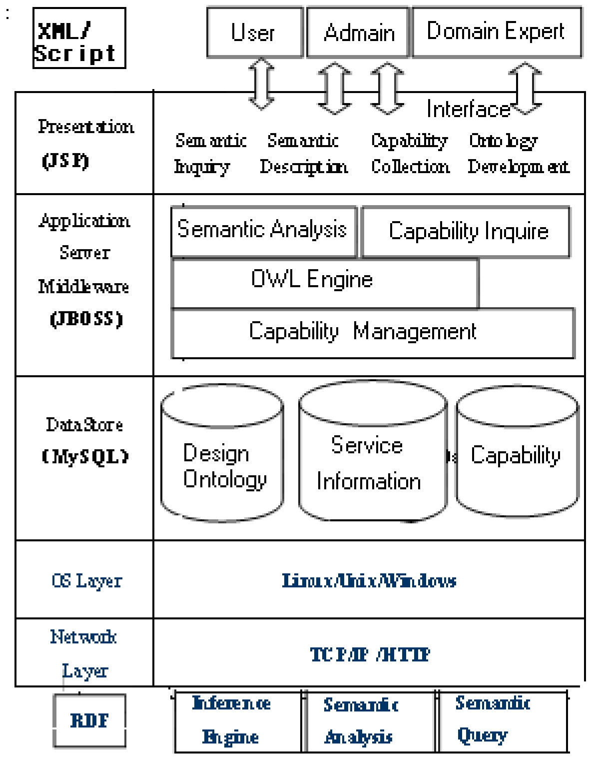

Fig.8 SEM-PDM Model

It is important that how the CE find the core design capability and how the PE cooperate design with each other, which can be solved by web service. All the design knowledge mapping to ontology is saved in RDBMS, and web service components is developed to encapsulating Protégé-OWL API which executing ontology search and inference engine function by accessing the ontology in RDBMS. The interface of web service components is published on Internet for the interaction of PE among AVE. There are three well-known business protocols standards, namely RosettaNet, EDI and ebXML that are solving to some extent system integration problems among distributed business systems (inter-enterprise integration). To show the effectiveness and benefits

of SEM-PDM, we implement a simulator of the environmental protection expert search of AVE. In this section, we first introduce the evaluating scenario, and then the important results are given.
Suppose a factory wants to a special device processing gas of C3H3N. He needs to access SEM-PDM and publish the requirements; CE gets the requirements and set up AVE according to individual core competitiveness which has been stored in the knowledge database as ontology shown as figure 4. When AVE urgently search an environmental protection expert with advanced qualification to deal with the problem that export gas thickness less than 150000 mg/m3, it is convenient to submit the query to SEM-PDM, the results is shown as Fig 7.

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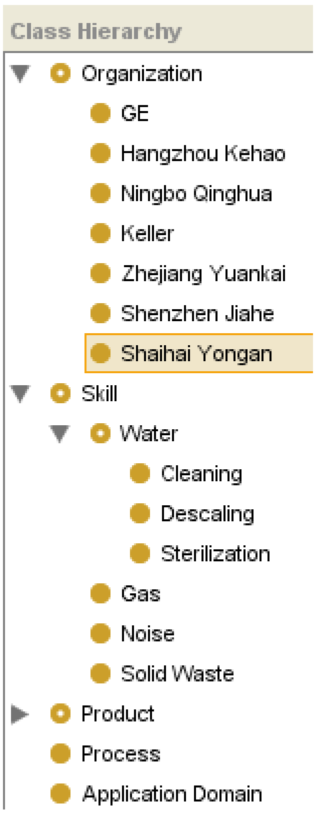

Fig.9 SEM-PDM Ontology Hierarchy

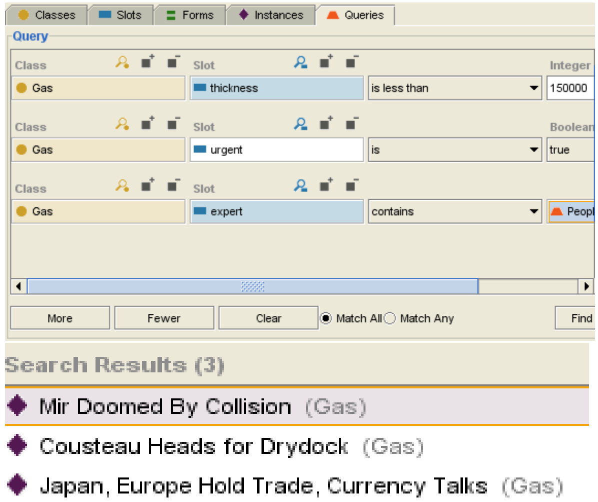

Fig.10 SEM-PDM Query

Suppose a factory wants to a special device processing gas of C3H3N. He needs to access SEM-PDM and publish the requirements; CE gets the requirements and set up AVE according to individual core competitiveness which has been stored in the knowledge database as ontology shown as figure 9. When AVE urgently search an environmental protection expert with advanced qualification to deal with the problem that export gas thickness less than 150000 mg/m3, it is convenient to submit the query to SEM-PDM, the results is shown as figure 10.

Protégé is a powerful Ontology modeling tools providing the Protégé Programming Development Kit (PDK) which is a set of documentation and examples that describes and illustrates how to develop and install plug-in extensions for Protégé, and how to work directly with the Protégé APIs. Protégé has a core API, which is used to access basic Protégé functionalities and frame-based knowledge bases (such as those created with Protégé-Frames). Protégé also has an OWL API that extends the core API to provide access to OWL ontologies (such as those created with Protégé-OWL). The Protégé API can be used directly by external applications to access Protégé knowledge bases and make use of Protégé forms without running the Protégé application. By Protégé-OWL API, we have transformed the AVE Ontology model into OWL object and mapped the object-oriented schema to an RDBMS schema. [8]

4 Conclusion

This paper details the creation of an innovative design web service platform supported by web 3.0 that gives control over the data displayed back to the PE of AVE. It represents information of PE core capability in RDF; create an ontology using the XML-based Web Ontology Language, which will enable CE to automatically choose between services and parts of services of PE. The purpose of this paper is to create a web 3.0 application so smart that AVE can literally add and remove services of PE at innovative design according to the dynamic confederacy model.

Innovative design is a knowledge intensive activity. Designers need knowledge of the application domain, the requirements for the development, and the platform of the cooperation, how it interacts with its environment, etc. All this knowledge may come from diverse sources: experience of the developers, knowledge of users, document and etc. How to elicit and record them is of key importance. In this paper, we submit that this lack of knowledge is one of the prominent problems in innovative design, and we look for some solutions to help solve it. We designed ontology of the knowledge useful to innovative design as a framework to support other knowledge management solutions. The ontology of the knowledge useful to innovative design may be seen as a reference, listing all the concepts we need to worry about. [4]

In terms of future work, there is a need to solve some of performance problem of knowledge database using ontology, or vocabularies that define concepts and their relationships of AVE by to build an XML cache, which saves the results of previous requests and also enables AVE to retrieve specific design information.

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