An Ontology-Driven Knowledge Management System Used in the Patent Library

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Abstract: The introduction of the ontology-driven mechanism brings new opportunities for the knowledge management. In this paper, we describe the results of our continuing work, by researching on the structure design of the ontology-driven knowledge management system, and propose three stages in the system model, i.e., the knowledge acquisition, the knowledge organization and knowledge application. Based on the proposed model, we choose the technology novelty consulting system in our patent library as the platform to perform the patent knowledge management and the experiment results validate the feasibility and validation of our system model.

1 INTRODUCTION

The principle of "clear and precise description specification of the domain conceptual model for revealing the nature of the object" is referred to the ontology (Razmerita, 2003). The introduction of the ontology-driven mechanism and semantic web has a significant impact on the knowledge management, and the ontology based models are becoming a straightforward choice of the future knowledge management system. Online patent information and document inspection services would become a suitable application for such system.

The ontology-driven mechanism provides the theoretical principle and technical support for the knowledge organization, and the semantic web draws a feasible blueprint for knowledge web applications (Davies, 2007). The relevant researches are growing fast recently, e.g., (Zhou, 2009; Yu, 2009; Bian, 2004) for building ontology-driven models, (Xia, 2014; Dieng-Kuntz, 2006; Chau, 2007; Cheng, 2009; Dong, 2006) for developing application systems, and (Sureephong, 2007) for introducing a case study used in the industry domain. Based on these researches, three categories can be drawn for describing the ontology-driven knowledge management model: ① It is based on the knowledge flow to build the components of the system model. Such method focuses on the knowledge acquisition, knowledge storage and knowledge re-utilization (Huang, 2005), where the ontology is the core technique to link all the nodes along the knowledge flow (Chen, 2003). Examples of this kind include (Jiang, 2009; Zhan, 2010). ② It is based on the knowledge composition to describe the layers of the system structure. Such ontology-driven knowledge management system contains an application layer, a core integration layer, a resource layer, etc. One may utilize the domain ontology on the integration layer, the notated documents on the application layer, and the processed knowledge in the document system or the database on the resource layer (Benjamins, 1998). An extended example of this kind can be find in (Chau, 2008), where the integration layer is divided into the description layer and the object layer, such that the ontology is recognized to be either the concept library or the object library on the description layer, while users utilize the specific knowledge on the object layer. ③ It is from the angle of the system development that the functional components of the system model are described. Users utilize the knowledge resource through the intermediate procedures such as semantic analysis and ontology inference (Sun, 2009). A realistic example is witnessed in (Maedche, 2003), where the components, including user interfaces, knowledge management, knowledge model, workflow management and intelligent application system, are developed while the ontology is stored in the knowledge model.

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The common drawback of the aforementioned literature is that their main focus is put on the function of the ontology in the system; however no clear and complete model for the knowledge management system is concluded. Besides, there are barely few studies for utilize the ontology-driven knowledge management on the patent information. In this paper, we propose a ontology-driven and semantic-web-oriented structure to build the knowledge management system model, and then describe the detailed components and its workflow. Such model is applied to the knowledge management in our patent database and a case study indicates the feasibility and validation of our system model.

2 ONTOLOGY-DRIVEN KNOWLEDGE MANAGEMENT SYSTEM MODEL

In this section, we give a systematic view of the proposed knowledge management system as depicted in Fig.1. The whole model is divided into three parts, i.e., the knowledge acquisition, the knowledge organization and knowledge application, similar as in (Antezana, 2009). At the stage of the knowledge acquisition, the information from different sources is first pre-processed, then the specific objective knowledge (including the instant objects, object relationship and logic rules) is attained through the machine learning or manual extraction, and afterwards they are generalized to form the abstract knowledge (including concepts, concept relationship, axioms and inference rules). At the stage of the knowledge organization, the acquired knowledge is described in an object-oriented form (e.g., XML) to construct the domain knowledge ontology library which is used to guide the semantic annotations for attaining new object libraries as the extension of the original knowledge ontology. In such a way, a knowledge map can be built based on the effective organization of the domain knowledge. At the stage of the knowledge application, services such as the knowledge topology depiction, the knowledge search and the knowledge innovation are available for users, wherein the knowledge innovation also gives a feedback to extend the knowledge ontology. Meanwhile, the semantic web shall be utilized to build a network platform to offer all the services.

2.1 Knowledge Acquisition

The so-called domain-knowledge mainly comes from four sources. ① The domain information. Literature is the main form to store the domain information, which is increasingly expressed as texts in the network service of a patent information library. ② Experts. Domain knowledge also exists in the memories of the experts in this domain, some of which may not be recorded as texts yet. ③ Existing knowledge. Many researchers have contributed to build domain knowledge libraries or the domain ontology, e.g., in (Dong, 2006; Yan, 2007). ④ External information. It means the other sources relevant to the studied domain. One example is like that, for the knowledge "Method and means for creating anti-gravity illusion are patented", its relationship with the song "Smooth Criminal" is not included in this knowledge. However, it is good to know that this song helps people to wildly remember such anti-gravity illusion performed by the patent inventor Michael Jackson. Information from

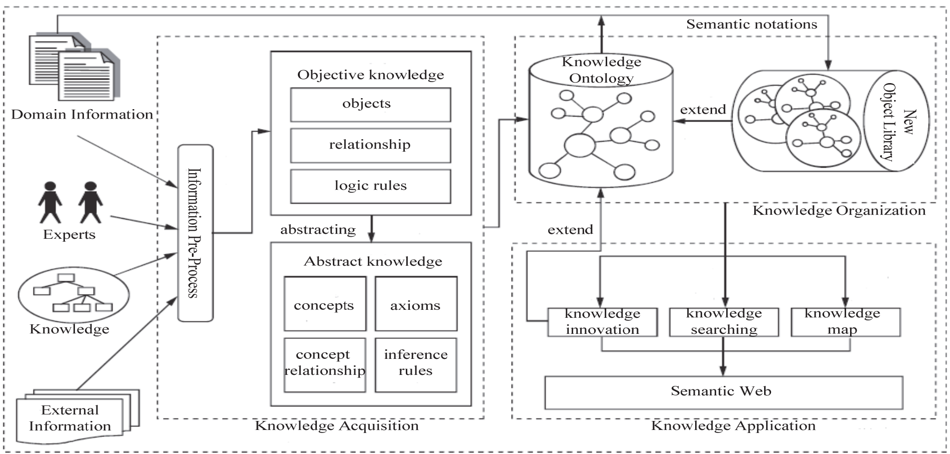

Figure 1: Ontology-driven knowledge management system structure.

different sources is needed to be processed first into a unified form and then transformed into the domain knowledge. More specifically, the domain knowledge is categorized into two forms. ①Abstract knowledge. It indicates those summarized descriptions based on objective facts by abstracting the common characteristics, which is mainly reflected as concepts, principles, rules, etc. For example, “a person applies a patent” summarizes a certain kind of behaviors, and it is also usefully to guide semantic annotations of objective facts of all patent applications. ② Objective knowledge. It indicates those detailed descriptions of objective facts. For example, “Method and means for creating anti-gravity illusion is patented by Michael Jackson” is an objective knowledge. The “Michael Jackson” is the objective description of the inventor, and the patent itself is detailed by “Method and means for creating anti-gravity illusion”, while “patented” shows their relationship. The objective knowledge is the sole resource to attain the abstract knowledge, which can be obtained by machine learning or manual extraction aided by experts.

2.2 Knowledge Organization

It is significant to organize the acquired knowledge into a domain knowledge library for further utilization or knowledge accumulation. Typical methods such as the thesaurus (Dong, 2006; Yan, 2007) are widely adopted for knowledge organization. However, the complicated semantic relationship between knowledge is beyond the capabilities of these methods. Along the development of the ontology-driven mechanism in the knowledge engineering, the object-oriented manner is more suitable for organizing knowledge, where the object properties are used to describe the knowledge relationship. Fig.2 depicts an example of such detailed description in the form of XML, wherein the “Person” and “Patent” is the concept while “Apply” and “Applied” is their properties, respectively.

The synthesized domain knowledge can be further used to guide for semantic annotations (Uren, 2006; Zhang, 2002), which mainly have two methods.①manual annotating. Experts may label the domain knowledge based on the ontology definition, which is usually time-consuming. ② automatic annotating. It is typical to adopt a language processing technology to automatically perform the semantic analysis and complete the annotation. No matter manual annotating or automatic annotating, many computer tools can be found (Zou, 2004) to accelerate the efficiency and accuracy.

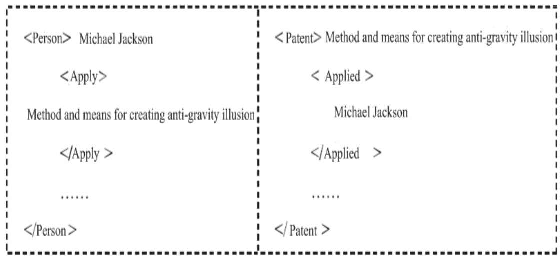

Figure 2: Example of knowledge organization description.

2.3 Knowledge Application

Based on the researches on existing literature, we can summarize that there are three areas in the knowledge applications, i.e., the knowledge map, the knowledge searching and the knowledge innovation. The semantic web, as the future network platform, is considered as an effective tool for the knowledge management and its service.

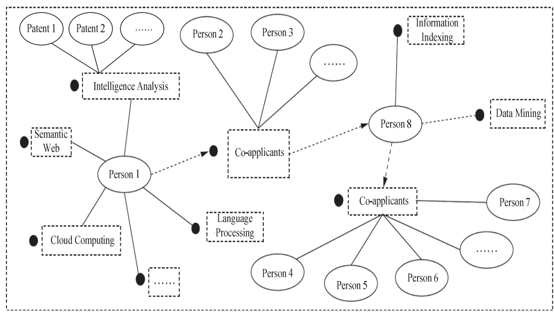

Figure 3: A segment illustration of the knowledge map.

1) Knowledge Map

The knowledge map is originally extended from the cognitive map introduced in (Brookes, 1981), and afterwards it becomes a visible knowledge management method which is widely adopted in many domains (Eppler, 2008; Rao, 2012; Semenza, 2012). Knowledge map is useful to perform the knowledge navigation and progressive guide service. As shown in Fig.3, from “Person 1”, one may extend more relevant information, e.g., all his applied patents in the intelligence analysis and the knowledge about his co-applicants, through the visible browsing guide provided by the knowledge map. The knowledge ontology would include all the knowledge in this domain, however the concealed knowledge, e.g., the relevant information, is hard to be attained and thus needed to be revealed by knowledge inference and data mining. In Fig. 4, the correlation coefficient between “Person A” and

"Person B" is illustrated by the knowledge map as inspired by (Yan, 2007). Normally, the correlation information is not included in the domain ontology but can be attained by the knowledge inference.

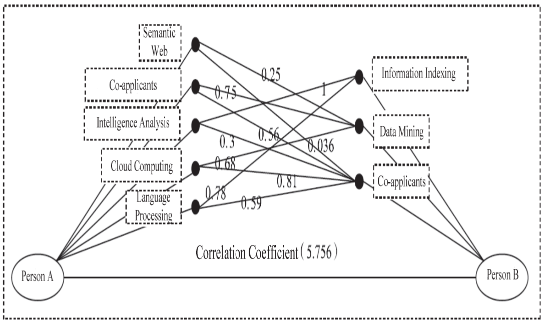

Figure 4: An illustration of the knowledge inference using the knowledge map.

2) Knowledge Searching

About the knowledge searching, there is no determined definition. In a broad sense, it imitates the intelligent cognitive methods of the human being (Zhang, 2003). In this paper, we follow (Cheng, 2011) to consider it as an information retrieval technique. More specifically, we adopt the semantic searching technique introduced in (Kiryakov, 2004) to improve the searching quality, allowing users to attain required resources more precisely and more conveniently. Its function can be described as the follows. ① Indexing service used in the domain knowledge resource. For example, one user would not only attain the required patent information, but also other relevant knowledge according to the semantic matching proposed in (Jiang, 2009). ② Extended searching in other domain resources based on the knowledge information. After building the domain ontology, it can also be used for searching the same or relevant resources. For example, the knowledge searching in our technology novelty consulting system would also refer to other domain ontology, e.g., in IEEE database.

3) Knowledge Innovation

The knowledge innovation is an important method to enhance the maturity and extension of the domain knowledge ontology. For the example as shown in Fig. 4, the correlation between two persons can be attained by knowledge inference. Suppose there is a fixed threshold, the knowledge about one person shall be involved into the domain knowledge ontology of the other person in Fig. 4, when their correlation coefficient is larger than the threshold. In this manner, the original knowledge ontology is extended. The knowledge innovation mode is summarized as follows. ①the knowledge innovation based on the internal knowledge inference as shown in Fig. 5(a). It reveals the concealed knowledge through methods such as comprehensive and comparative analysis, logic reasoning, machine learning and data mining, etc. For example, from the frequency of subject keywords, the research trends of the hot topics can be concluded. ②the knowledge innovation by considering the external knowledge as shown in Fig. 5(b). Such example is mentioned before, which is that Michael Jackson's patent "method and means for creating anti-gravity illusion are patented" is widely known related with his song "Smooth Criminal".

3 CASE EXPERIMENT

We adopt the aforementioned system model in our patent knowledge management and embed it in the technology novelty consulting system in our patent library. Fig.6 describes the knowledge management workflow in this case experiment, for which we choose the defense patent documents applied by a

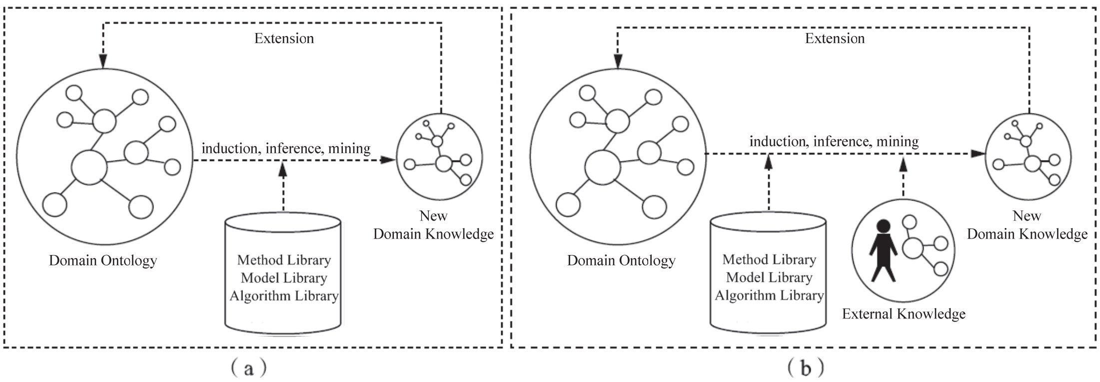

Figure 5: Ontology-Driven Knowledge Innovation.

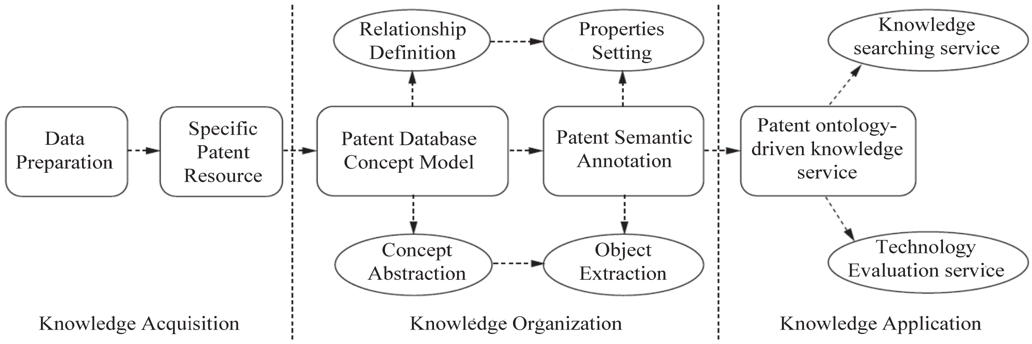

Figure 6: Patent Ontology-Driven Knowledge Management Workflow.

chosen institution from 2006 to 2014 as the data resource. These data exist in a text database form stored in our patent library. Based on the features of these patents, we perform the knowledge acquisition.

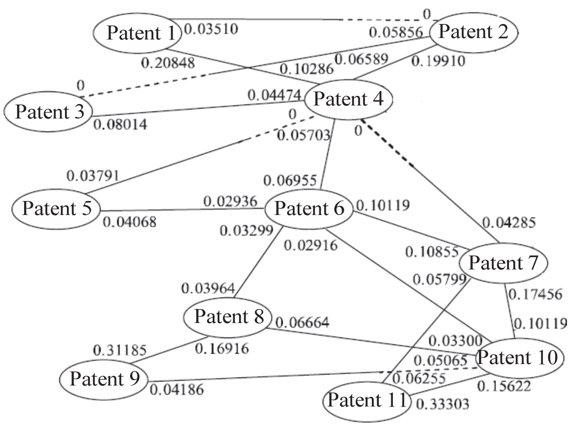

Figure 7: Correlation Cloud Map of Selected 11 Patents.

For organizing the knowledge, we first abstract the acquired knowledge to build the ontology concept model, which is described in a manner illustrated in Fig. 2. Then the semantic annotation is completed by performing object extraction and setting the object properties. For these knowledge, the correlation cloud map of the selected 11 patent objects is generated using the semantic analysis described in (Yan, 2007) and the map is shown in Fig. 7. In comparison, we also apply (Yan, 2007) to generate the cloud map in our case. The numerical results show that our method is 1.21 times faster. One reason is that the adopted model in this paper has already given clear and complete workflow for the knowledge management system, which acts like a certain pre-progress procedure to help accelerate the knowledge management efficiency. Moreover, the feature of patents can not be used in the of the knowledge management system of (Yan, 2007) but we can in this paper.

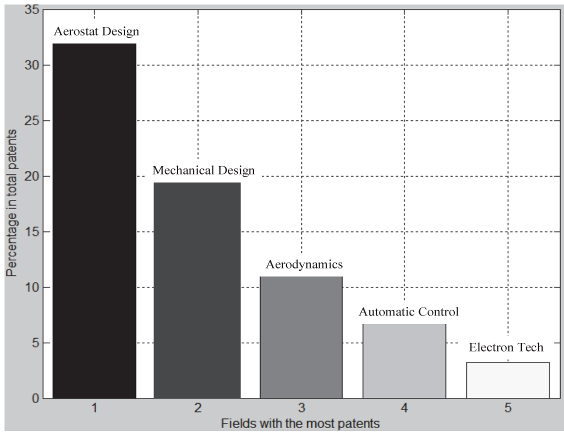

Figure 8: Fields with most patents in the test database.

Furthermore, we analyze the keyword frequency in the tested patent database and depict Fig. 8, illustrating the fields with most patents in the test database. As a knowledge application, this figure indicates that the major expertise of the chosen institution lies in the field of the aviation and aerospace.

4 CONCLUSIONS

In this paper, a complete structure of ontology-driven knowledge management system model is introduced, and the detailed workflow is described. Based on the proposed model, a case study applied to the patent knowledge management is performed to validate the system model.

However, this work is still in progress, since it still lacks efforts on the semantic analysis on the patent information, the ontology-driven searching and the patent-evaluating service. These functions have been already known highly required by the users, and thus will be our tasks in future.

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REFERENCES

Razmerita, L., et al, 2003. Ontology-based user modeling for knowledge management systems, *Proceedings of the User Modeling*.

Davies, J., et al, 2007. Semantic-Web-based knowledge management, *Internet Computing*.

Zhou, Y., et al, 2009. The design and implementation of digital archives knowledge management system in e-government domain based on ontology, *Library and Information Service*.

Yu, S., et al, 2009. Research on multiuser-oriented medical knowledge management model based on ontology, *Journal of Medical Intelligence*.

Bian, W., et al, 2004. Ontology-based knowledge management modeling of scientific research, *Application Research of Computers*.

Xia, L., et al, 2014. Research on e-government knowledge management based on ontology, *Information Science*.

Dieng-Kuntz, R., et al, 2006. Building and using a medical ontology for knowledge management and cooperative work in a health care network, *Computers in Biology and Medicine*.

Chau, K., et al, 2007. An ontology-based knowledge management system for flow and water quality modeling, *Advances in Engineering Software*.

Cheng, H., et al, 2009. An ontology-based business intelligence application in a financial knowledge management system, *Expert Systems with Applications*.

Dong, H., et al, 2006. Research on the ontology-based retrieval model of digital library, *Journal of the China Society for Scientific and Technical Information*.

Sureephong, P., et al, 2007. An ontology-based knowledge management system for industry clusters, *IEEM'2007*.

Huang, X., et al, 2005. Research of knowledge management system based ontology, *Science Technology and Engineering*.

Chen, R., et al, 2007. Research of knowledge mangement based on ontology, *Science Technology Association Forum*.

Jiang, Y., et al, 2009. Hotspots analysis of research on ontology-based knowledge management, *Computer Knowledge and Technology*.

Zhan, Y., et al, 2010. Knowledge management models based on ontology, *Wireless Internet Technology*.

Benjamins, V. R., et al, 1998. Knowledge management through ontologies, *Proceedings of PAKM98*.

Sun, W., et al, 2009. Anontology-based manufacturing design system, *Information Technology Journal*.

Maedche, A., et al, 2003. Ontologies for enterprise knowledge management, *Intelligent Systems*.

Antezana, E., et al, 2009. Biological knowledge management: The emerging role of the semantic Web technologies, *Briefings in Bioinformatics*.

Dong, H., et al, 2006. Research on the ontology-based retrieval model of digital library(Ⅲ)-History domain ontology building, *Journal of the China Society for Scientific and Technical information*.

Yan, D., et al, 2007. Visualized searches of domain ontologies, *Journal of Library Science in China*.

Uren, V., et al, 2006. Semantic anannotation for knowledge management: Requirements and a survey of the state of the art, *Science, Services and Agents on the World Wide Web*.

Zhang, X., 2002. Semantic web and semantic-based networked information retrieval, *Journal of the China Society for Scientific and Technical Information*.

Zou, L., et al, 2004. Comparison and analysis of semantic anannotation tools based on ontology, *Journal of Computer Applications*.

Brookes, B. C., et al, 1981. The foundations of information science Part IV, *Journal of Information Science*.

Eppler, J., et al, 2008. A process-based classification of knowledge maps and application examples, *Knowledge and Process Management*.

Rao, L., et al, 2012. Building ontology based knowledge maps to assist business process re-engineering, *Decision Support Systems.*

Semenza, J., et al, 2012. Knowledge mapping for climate change and food-and waterborne diseases, *Critical Reviews in Environmental Science and Technology.*

Zhang, Y., et al, 2003. On knowledge retrieval and information retrieval, *Journal of Library Science in China.*

Cheng, H., et al, 2011. Research on development of studying on domestic knowledge retrieval, *Library and Information Service.*

Kiryakov, A., et al, 2004. Semantic anannotation, indexing, and retrieval, *Science, Services and Agents on the World Wide Web.*

Jiang, X., et al, 2009. Learning and inferencing in user ontology for personalized semantic Web search, *Information Sciences.*