DEVELOPMENT OF AN EMPIRICAL KNOWLEDGE MANAGEMENT FRAMEWORK FOR PROFESSIONAL VIRTUAL COMMUNITY IN KNOWLEDGE-INTENSIVE SERVICE INDUSTRIES

Yuh-Jen Chen
Department of Accounting and Information Systems, National Kaohsiung First University of Science and Technology Kaohsiung, Taiwan, China

Meng-Sheng Wu
Institute of Manufacturing Information and Systems, National Cheng Kung University, Tainan, Taiwan, China

Wei-Kun Kuo
China Steel Corporation, Kaohsiung, Taiwan, China

Keywords: Knowledge-intensive service industries (KISI), Professional virtual community, Knowledge management, Empirical knowledge.

Abstract: With the advent of service-oriented knowledge economy in the 21st century, knowledge-intensive service industries (KISI) have become a trend nowadays for industrial development. In knowledge-intensive service industries, enterprise activities have highly creativeness. By performing and achieving each enterprise activity, the domain professional knowledge and experiences involving various ideas such as service innovation or service value-added are employed. Therefore, it is most urgent task for implementing knowledge management effectively, to quickly accumulate knowledge assets of enterprise and increase the efficiency of knowledge-intensive service industries. Professional virtual community is an interactive platform for enterprise experts to mutual creating and sharing empirical knowledge in knowledge-intensive service industries. The platform has recorded high-volume rubbish information and empirical knowledge during the expert discussion. Therefore, how to manage and share these useful contents of knowledge discussion has become an important issue for empirical knowledge management in professional virtual community. This study presents a systematic approach to developing a framework for empirical knowledge management to support professional virtual community in knowledge-intensive service industries. The approach presented in this study comprises three phases: (i) proposing an empirical knowledge management model for professional virtual community, (ii) designing an empirical knowledge management system framework for professional virtual community, and (iii) implementing an empirical knowledge management system prototype for professional virtual community. Results of this study facilitate efforts within the professional virtual community to extract, verify, store, and share empirical knowledge in order to effectively assist knowledge-intensive service industries enhancing service innovative abilities and creating the best services for customers' requirements.

1 INTRODUCTION

With the advent of service-oriented knowledge economy in the 21st century, knowledge has become an important source for an enterprise to promote its competition advantage while service is a critical value for enterprises to push the economic growth. Thus, knowledge-intensive service industries (KISI) have become a trend nowadays for industrial development (Bryson and Rusten, 2005; Chen 2009).

Enterprise activities have highly creativeness in

Chen Y., Wu M. and Kuo W..
DEVELOPMENT OF AN EMPIRICAL KNOWLEDGE MANAGEMENT FRAMEWORK FOR PROFESSIONAL VIRTUAL COMMUNITY IN KNOWLEDGE-INTENSIVE SERVICE INDUSTRIES.
DOI: 10.5220/0003430200050014
In *Proceedings of the 13th International Conference on Enterprise Information Systems* (ICEIS-2011), pages 5-14
ISBN: 978-989-8425-55-3

knowledge-intensive service industries. By performing and accomplishing each enterprise activity, the domain professional knowledge and experiences involving various ideas such as service innovation or service value-added are used. Therefore, it is most urgent task for implementing knowledge management effectively, to rapidly accumulate knowledge assets of enterprise and enhance the efficiency of knowledge-intensive service industries.

Enterprise knowledge management can be implemented as either a systematization strategy or a personalization strategy (Hansen, Nohria, and Tierney, 1999; Nonaka and Takeuchi 1995). Systematization strategy is to manage explicit knowledge and enhance the spread and distribution of explicit knowledge through information systems. Personalization strategy allows an expert to share other experts' own tacit knowledge (empirical knowledge) by cooperating and communicating with those experts. Meanwhile, tacit knowledge symbolizes the value of an enterprise and is generally hidden inside of personal mental models. The inability to transfer tacit knowledge to organizational knowledge (explicit knowledge) would cause it to be disappeared while knowledge workers leave their posts, ultimately losing important intellectual assets for enterprises.

Professional virtual community is an interactive platform for enterprise experts to mutual creating and sharing empirical knowledge in knowledge-intensive service industries (Pan and Leidner, 2003; Wenger 1998). The platform has recorded high-volume rubbish information and empirical knowledge during the expert discussion. Therefore, how to manage and share these useful contents of knowledge discussion has become an important issue for empirical knowledge management in professional virtual community.

In recent years, the proposed researches for virtual community are increasingly (Lin and Hsueh, 2006, Chang et al., 2008, Li and Wu, 2010). However, these recent studies focused mainly on managing and searching for explicit knowledge from documents and information in virtual community. They still do not have a completed solution for managing and sharing empirical knowledge from professional knowledge and experiences. Therefore, experts' empirical knowledge requirements in professional virtual community can not be satisfied, and furthermore can not create services that would meet customer's satisfaction.

Hence, this study develops a framework for empirical knowledge management to support professional virtual community in knowledge-intensive service industries and effectively assist knowledge-intensive service industries enhancing service innovative abilities. To accomplish this objective, the following tasks are performed: (i) propose an empirical knowledge management model for professional virtual community, (ii) design an empirical knowledge management system framework for professional virtual community, and (iii) implement an empirical knowledge management system prototype for professional virtual community.

2 DESIGN OF EMPIRICAL KNOWLEDGE MANAGEMENT MODEL FOR PROFESSIONAL VIRTUAL COMMUNITY

This section first defines the knowledge-intensive service industry and analyzes its characteristics. Then, empirical knowledge for professional virtual community in knowledge-intensive service industries is modeled. Based on the modeled empirical knowledge, an empirical knowledge management model is finally designed to pave the way for system framework design.

2.1 Definition and Characteristics Analysis for KISI

Knowledge-intensive service industries (KISI) are a service value chain of higher knowledge contents, which have been established by utilizing cooperation modes as well as by combining sources from science, engineering and academia. Knowledge-intensive service industries use innovative operational modes and technology application techniques to pursue the innovations of product, brand management, operation mode and service through conducting technologies, internet, professional knowledge, and services. Knowledge-intensive service industries involve business services, communication services, financial services, educational services, legal consultation services, distribution services, and health services.

Based on the definition of knowledge-intensive service industry, it has the following characteristics:

(1) Knowledge-oriented: In knowledge-intensive service industries, the performance and accomplishment of each enterprise activity must highly rely on the utilization of domain knowledge and experience to ensure that their business models

would normally be operated. Finally, the customers' satisfaction and the enterprise market competitiveness are increased.

(2) Knowledge expertise: Knowledge-intensive service industries are a service value chain of higher knowledge contents. The establishment and supply of these professional services are mostly based on professional knowledge. Therefore, the knowledge expertise must be checked in collecting knowledge to create quality services for customers' requirements.

(3) Knowledge innovation: Service innovation is the goal for knowledge-intensive service industries. To provide better services to customers, enterprises generally promote their service innovative abilities by knowledge innovation that relies on the exchange and communication of empirical knowledge.

(4) Knowledge value-added: Collaboration is one of the important strategies of increasing competitive advantage for knowledge-intensive service industries. Thus, the scope of knowledge requirement has been extended from the "point" mode in the past into the "plane" mode nowadays so that more completed knowledge value-added services can be provided to customers.

2.2 Empirical Knowledge Modeling for Professional Virtual Community

Empirical knowledge in a professional virtual community can be exchanged and shared effectively through interaction among experts, and it involves extensive knowledge range. Thus, the empirical knowledge exchanged and shared among experts in a professional virtual community is modeled, as shown in Fig. 1. In understanding the empirical knowledge, experts first focus on the discussion topic for exchanging and sharing empirical knowledge. Then, the definition, purpose, and implementation steps for the topic are shared and understood respectively. Meanwhile, experts can use the function of document search in virtual community to search for and refer to other related definitions, purposes, and implementation steps for the topic. From these reference documents, related discussion topics can be identified. Moreover, the published dates and publishers would be referred while experts understand the topic definitions.

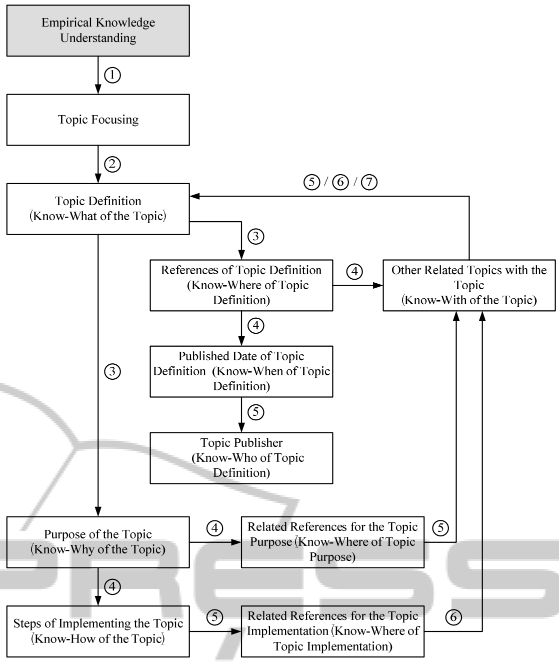

Figure 1: Empirical knowledge model for professional virtual community.

2.3 Empirical Knowledge Management Model Design for Professional Virtual Community

Based on the above characteristics of knowledge-intensive service industries and the empirical knowledge model for professional virtual community, the empirical knowledge management model for professional virtual community is designed. As shown in Fig. 2, the business model of knowledge-intensive service industry must be performed and achieved by knowledge workers using empirical knowledge to satisfy customer groups from different service activities. However, to enhance customers' satisfaction degree effectively, knowledge workers generally use the professional virtual community to mutually create and share each other's empirical knowledge to promote themselves knowledge innovative abilities and create quality services that meet customers' satisfaction. In the professional virtual community, knowledge discussion contents during the expert discussion are important sources for accumulating an enterprise's empirical knowledge. This precious empirical knowledge can be managed and reused effectively through knowledge extraction, verification, storage, reasoning, adaptation, and expert recommendation and consultation in order to achieve the goal of service innovation for knowledge-intensive service industries.

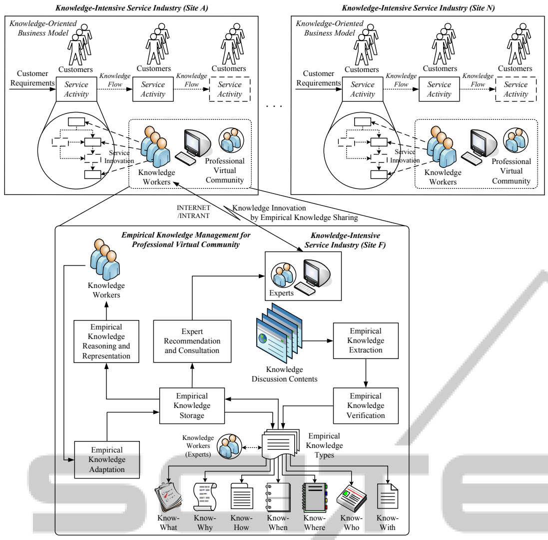

Figure 2: Empirical knowledge management model for professional virtual community.

3 DESIGN OF EMPIRICAL KNOWLEDGE MANAGEMENT SYSTEM FRAMEWORK FOR PROFESSIONAL VIRTUAL COMMUNITY

To effectively support the characteristics of knowledge-intensive service industries and the empirical knowledge management model for professional virtual community as well as manage the identified empirical knowledge from professional virtual community in Section 2, this section first analyzes the functional requirements for empirical knowledge management system. Based on these functional requirements, the agent-based empirical knowledge management system framework is then designed by utilizing software agent technology.

3.1 Functional Requirements Analysis

The aim of empirical knowledge management system is two-fold: (i) to manage the empirical knowledge from each service activity in knowledge-intensive service industries and (ii) to share the empirical knowledge based on the knowledge workers' knowledge requirements, in order to facilitate the knowledge innovation and the service innovation in knowledge-intensive service industries.

To accomplish the system objective above, the functional requirements analysis is performed through two phases of "system environment management functions" and "system use functions". They are discussed follows.

(1) System environment management functions

(i) Service process configuration management: Service process in knowledge-intensive service industries is a mutual-participation process with one leading enterprise and several allied enterprises according to different service requirements. Thus, the leading enterprise must be able to perform service process reconfiguration and system reconfiguration for allied enterprises which are comprised with different service requirements.

(ii) Distributed management: Distributed collaboration has become one of the important strategies for knowledge-intensive service industries to enhance their competitive advantage. To effectively support the distributed collaborative environment, the abilities of remote control, coordination, and communication should be provided in exchanging and communicating empirical knowledge.

(iii) Empirical knowledge maintenance: To supply correct empirical knowledge to suitable knowledge workers at right time, the system must periodically maintain empirical knowledge to ensure the correctness and completeness of empirical knowledge.

(iv) Knowledge access control: Service innovation in knowledge-intensive service industries depends on the innovation of domain knowledge, while the innovation of domain knowledge thus relies on managing and sharing knowledge. To assist knowledge workers in sharing correct empirical knowledge at the right time and place, the system needs to set different knowledge access authorizations according to different users' authorities in order to protect the confidentiality of empirical knowledge in sharing empirical knowledge.

(2) System use functions

(i) Knowledge worker registration: Knowledge workers are important sources of empirical knowledge. Hence, knowledge workers must perform the knowledge registration before they enter into a professional virtual community and post knowledge discussion contents. The way can facilitate the expert recommendation for empirical knowledge sharing.

(ii) Expert withdrawal: Service process in a knowledge-intensive service industry is dynamic. Experts in allied enterprises can flexibly choose to join or withdraw from the collaborative environment. In this situation, the function of expert withdrawal must be considered to ensure the time effectiveness of empirical knowledge sharing.

(iii) Empirical knowledge extraction: In the expert discussion in professional virtual community, high-volume and precious empirical knowledge hidden behind the knowledge discussion contents should be effectively extracted to be managed and shared.

(iv) Empirical knowledge verification: According to the extracted empirical knowledge, the logics of empirical knowledge should be verified effectively before archiving such valuable empirical knowledge into an enterprise knowledge repository to ensure the correctness of empirical knowledge and provide knowledge workers with reliable knowledge decision support.

(v) Empirical knowledge storage: After verifying the empirical knowledge, it can be represented by a structured knowledge representation method and stored into an enterprise knowledge repository for later reuse.

(vi) Empirical knowledge reasoning: To satisfy knowledge workers' empirical knowledge requirements, knowledge workers can describe and inquire the encountered problems in the topic discussion to match and obtain related empirical knowledge and solutions by using the knowledge reasoning.

(vii) Empirical knowledge adaptation: According to knowledge workers' past usage behaviors, the suitable empirical knowledge ontology can be adapted to satisfy every knowledge worker's knowledge requirements, and ultimately to enhance the reuse value of knowledge.

(viii) Expert recommendation: Based on knowledge workers' knowledge requirements, they can search for appropriate experts from the enterprise knowledge repository for knowledge consultation to increase the sharing effect of empirical knowledge.

(ix) Empirical knowledge communication: As recommended appropriate experts, knowledge workers can consult and communicate the empirical knowledge with these experts through online video conference systems such as VidiNOW, Co-Life, and NetMeeting.

3.2 Agent-based Empirical Knowledge Management System Framework Design

According to the system functional requirements analyzed in Subsection 3.1, this section adopts the concept of software agent technology (Danesh and Jin 2001, Luck, Ashri, and D'Inverno, 2004) to design an agent-based empirical knowledge management system framework. As shown in Fig. 3, the system environment management functions include agents of system management, service process, collaborative activity, empirical knowledge maintenance, and knowledge access. Meanwhile, each collaborative activity agent can collaboratively perform and complete a service activity by one or more personal knowledge management agents. Through the empirical knowledge management agent, each personal knowledge management agent can use system use functions including knowledge extraction agent, knowledge verification agent, knowledge storage agent, and expert recommendation agent to extract, verify, and store empirical knowledge as well as recommend experts. Based on the recommended experts, knowledge workers can actually consult and communicate empirical knowledge with these experts through the knowledge communication agent. Furthermore, each personal knowledge management agent can reason and retrieve empirical knowledge through the knowledge access agent and the empirical knowledge reasoning agent. In reasoning and retrieving the empirical knowledge, the empirical knowledge adaptation agent can adapt a suitable empirical knowledge ontology according to knowledge workers' use behaviors so that the reasoned and retrieved empirical knowledge would be better to satisfy knowledge workers' knowledge requirements. Finally, the knowledge worker registration and withdrawal agent is provided to register or withdraw an expert for sharing empirical knowledge.

4 MODELING OF EMPIRICAL KNOWLEDGE MANAGEMENT SYSTEM

System modeling defines system-level details in terms of a set of models.

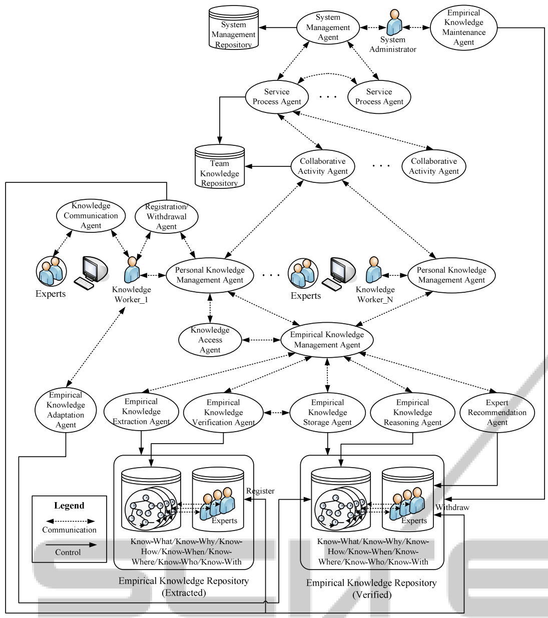

Figure 3: The agent-based empirical knowledge management system framework.

Two rationales are applied to system modeling. First, to fully embrace and comply with industry standard object models and architectures to enable the interoperability with other empirical knowledge management modules and a wide variety of other software systems. Second, to employ industry best-practice modeling techniques in a proposed development process to facilitate the management of system complexity.

As Unified Modeling Language (UML) (Booch, Rumbaugh, and Jacobson, 1999; Jacobson, Christerson, Jonsson, and Overgaard, 1992) has emerged as the notational standard for object-oriented modeling and is relatively comprehensive, UML was utilized during the system modeling phase. Using standard modeling techniques may standardize and facilitate the development process (Rational Unified Process, RUP) by using common concepts, notations and supporting tools, and consequently increase system compatibility with other software systems.

System modeling can be classified into dynamic aspect and static aspect. Meanwhile, the dynamic aspect mainly describes system behavior (i.e., behavioral diagrams) which includes use case diagram and sequence diagram. The static aspect represents system structure (i.e. structural diagrams) which includes class diagram and deployment diagram. They are described below.

4.1 Behavioural Diagrams (Dynamic Aspect)

4.1.1 Use Case Diagram

Use case diagram mainly describes the interactive behavior between actor and system. Figure 4 presents the use case diagram of empirical knowledge management system.

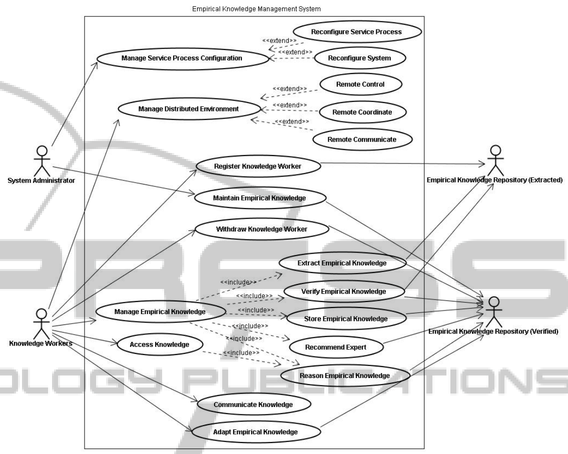

Figure 4: Use case diagram for empirical knowledge management system.

4.1.2 Sequence Diagram

Sequence diagram describes the dynamic behaviors of message transmission among objects in a system. Figures 5 and 6 depict the sequence diagrams of empirical knowledge reasoning and verification, respectively.

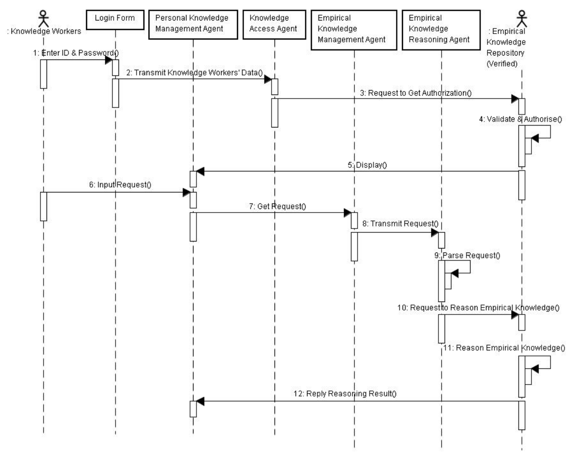

Figure 5: Sequence diagram for the "Empirical Knowledge Reasoning".

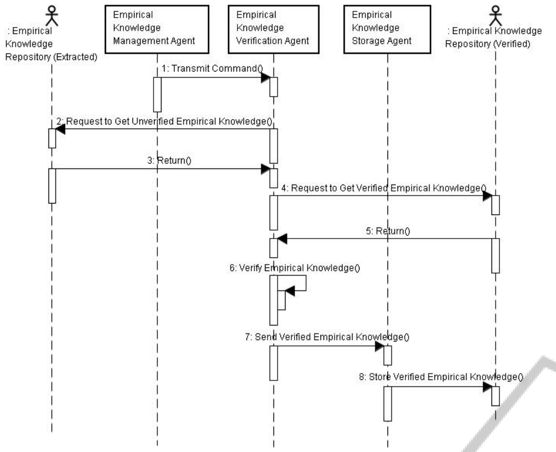

Figure 6: Sequence diagram for the "Empirical Knowledge Verification".

4.2 Structural Diagrams (Static Aspect)

4.2.1 Class Diagram

Class diagram presents the types of classes in a system and the static relationships between classes. Figure 7 shows the class diagram of empirical knowledge management system.

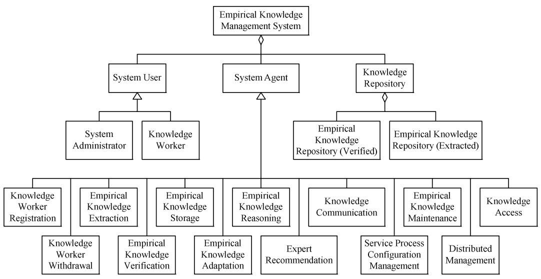

Figure 7: Class diagram for empirical knowledge management system.

4.2.2 Deployment Diagram

Deployment diagram represents the static structural relationship between hard/software components in a system and explains the details of its establishment. As shown in Fig. 8, it displays the deployment diagram of empirical knowledge management system.

5 SYSTEM IMPLEMENTATION

According to the above results of system framework design and system modeling, a prototype was implemented to demonstrate the proposed empirical knowledge management system for professional virtual community. The implementation environment and implementation results with an illustrative example were explained below.

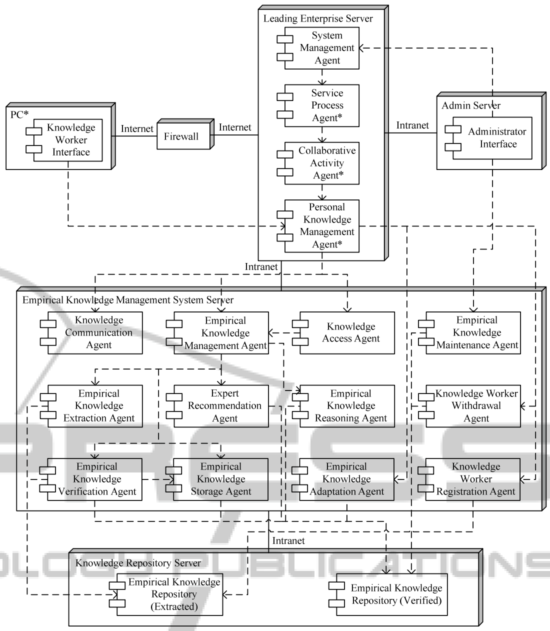

Figure 8: Deployment diagram for empirical knowledge management system.

5.1 Implementation Environment

The implementation environment of this empirical knowledge management system prototype for professional virtual community was as follows:

• PCs: Two Intel Pentium4-2.8G PCs.

• Operation systems: MS Windows XP Professional with Service Pack 3 and Linux Red Hat 9.0.

• Web server: Tomcat 5.5 (Apache).

• Web pages and core components: The Java Serve Pages (JSP) programming language and Java Agent Development Framework (JADE) were utilized to build the web pages and work on agent development.

• Databases: My SQL 5.1.41 and Xindice XML database.

• Knowledge reasoning tools: Protégé 3.4.4 and Pellet 1.5.2.

5.2 Implementation Results with a Stock Investment Example

Based on the results of system modeling in Section 4, this section utilizes an example of stock investment to explain the implementation of functions of empirical knowledge verification and reasoning.

- Empirical Knowledge Verification: Figure 9 presents an empirical knowledge structure of stock investment that has not yet been verified. Meanwhile, the knowledge concepts “Share Issue” and “Commercial Paper” are the sub-concepts of the knowledge concept “Stock Exchange Market”, while the knowledge concept “Government Bond” is the sub-concept of the knowledge concept “OTC Market”. By performing the knowledge verification, the logic errors in the knowledge structure are detected. Thus, the knowledge concept “Share Issue” is modified as a sub-concept of the knowledge concept “Corporate Bond” as well as the knowledge concepts “Commercial Paper” and “Government Bond” are modified as sub-concepts of the knowledge concept “Stock”, as shown in Fig. 10. Figure 11 shows the OWL-based stock investment knowledge representation before verification and Fig. 12 shows the OWL-based stock investment knowledge representation after verification.

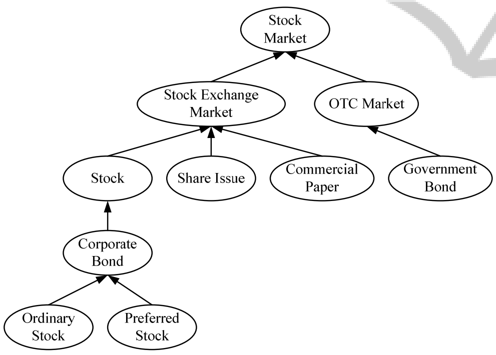

Figure 9: Stock investment knowledge before verification (conceptual model).

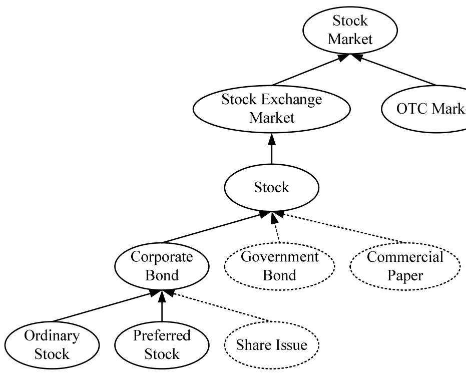

Figure 10: Stock investment knowledge after verification (conceptual model).

Table 1: The empirical knowledge reasoning rule.

OWL Reasoning Syntax	(?P rdf:type owl:TransitiveProperty)^ (?A ?P ?B)^(?B ?P ?C)→(?A ?P ?C)
Empirical Knowledge Reasoning Result	(?Is_a rdf:type owl:TransitiveProperty)^ (?Stock ?Is_a ?Corporate Bond)^ (?Corporate Bond ?Is_a ?Ordinary Stock)→(?Stock ?Is_a ?Ordinary Stock)

NOTE: Parameter P denotes the transitive property. Parameters A, B, and C represent the concept names of empirical knowledge. Symbol “^” indicates the logical operator AND.

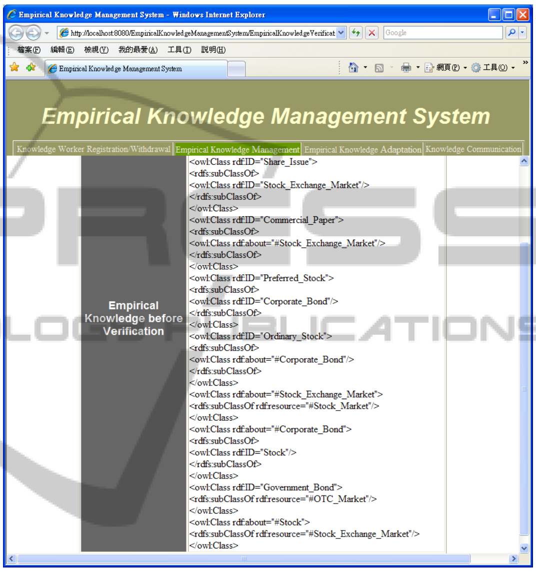

Figure 11: OWL-based stock investment knowledge representation before verification.

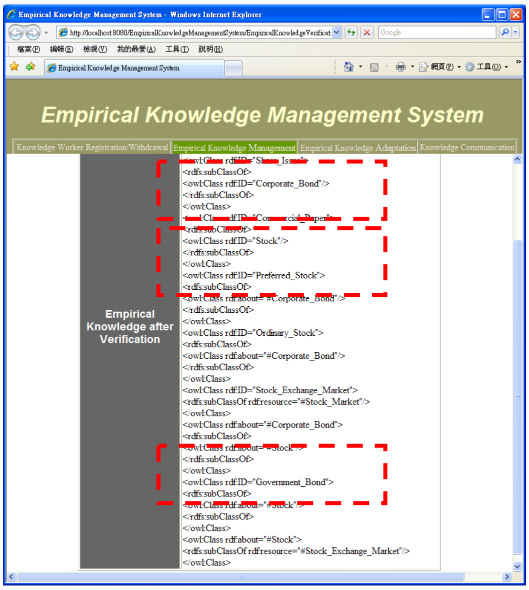

Figure 12: OWL-based stock investment knowledge representation after verification.

- Empirical Knowledge Reasoning: Figure 13 displays a stock investment ontology constructed by the ontology editor Protégé. According to the defined reasoning rule in Table 1, the relationship “Is_a” between knowledge concepts “Stock” and “Ordinary Stock” can be reasoned, as shown in Fig. 14.

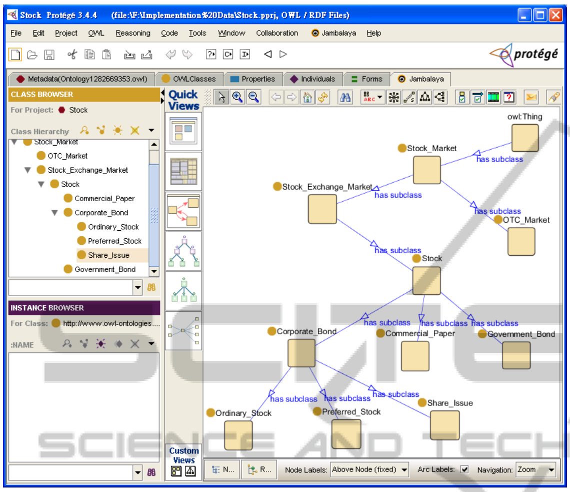

Figure 13: Stock investment knowledge before the rule reasoning in Protégé.

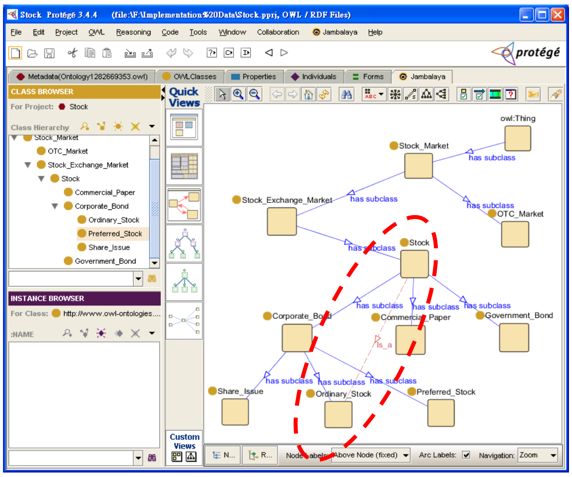

Figure 14: Stock investment knowledge after the rule reasoning in Protégé.

6 CONCLUSIONS AND FUTURE WORKS

This study first defined the knowledge-intensive service industry and analyzed its characteristics. Then, the empirical knowledge from professional virtual community was identified and modeled. According to the definition, characteristics, and empirical knowledge of knowledge-intensive service industry, the empirical knowledge management model for professional virtual community was designed. Moreover, the software agent technology was adopted to design the agent-based empirical knowledge management system framework. Finally, the empirical knowledge management system and core techniques were implemented using UML modeling techniques, object-oriented programming language, and JADE. The primary results and contributions of this study are summarized as follows:

(1) Empirical knowledge management model for professional virtual community: This study proposed an empirical knowledge management model for professional virtual community, which can be an important reference model for implementing the empirical knowledge management in other learning organizations.

(2) Agent-based empirical knowledge management system framework and core techniques: The developed system framework and core techniques can effectively extract, verify, store, reason, and adapt the empirical knowledge from knowledge discussion contents in professional virtual community, to assist enterprises in fulfilling the empirical knowledge management.

Results of this study facilitate the realization of empirical knowledge management for knowledge-intensive service industries to satisfy experts’ empirical knowledge requirements, and thus promote service innovative capabilities, and ultimately increase customers’ satisfaction as well as enhance industrial competitiveness.

For the proposed core techniques in this study, the following future research issues are recommended: (i) In the process of empirical knowledge verification, the knowledge structure is validated and modified by experts. Thus, an artificial intelligent-based method for automatic validation and modification should be considered, and (ii) Empirical knowledge is associated with situation property. Situated empirical knowledge can comprise basic elements such as spatial relation and temporal relation. Therefore, future studies should consider the situation property of empirical knowledge to develop a method of situated empirical knowledge representation and reasoning in order to deduce a more suitable empirical knowledge that would satisfy the requirements from a knowledge requester under certain circumstances.

ACKNOWLEDGEMENTS

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract Nos. NSC98-2221-E-327-039 and NSC99-2221-E-327-036.

REFERENCES

Booch, G., Rumbaugh, J., and Jacobson, I., 1999. *The unified modeling language user guide*. MA: Addison-Wesley.

Bryson, J. R. and Rusten, G., 2005. Spatial divisions of expertise: knowledge intensive business service firms and regional development in Norway. *The Service Industries Journal*, 25(8), pp. 959-977.

Chang, C. K., Chen, G. D., and Li, L. Y., 2008. Constructing a community of practice to improve coursework activity. *Computers and Education*, 50(1), pp. 235-247.

Chen Y. M., 2009. Determinants of industry performance: region vs. country effects in knowledge-intensive service industries. *The Service Industries Journal*, 29(3), pp. 297-316.

Danesh, M. R. and Jin, Y., 2001. An agent-based decision network for concurrent engineering design. *Concurrent Engineering: Research and Applications*, 9(1), pp. 34-47.

Hansen, M. T., Nohria, N., and Tierney, T., 1999. What's your strategy for managing knowledge?, *Harvard Business Review*, 77(2), pp. 106-116.

Jacobson, I., Christerson, M., Jonsson, P. M., and Overgaard, G., 1992. *Object oriented software engineering: a use case driven approach*. MA: Addison-Wesley.

Li, N. and Wu, D. D., 2010. Using text mining and sentiment analysis for online forums hotspot detection and forecast. *Decision Support Systems*, 48(2), pp. 354-368.

Lin, F. R. and Hsueh, C. M., 2006. Knowledge map creation and maintenance for virtual communities of practice. *Information Processing and Management*, 42(2), pp. 551-568.

Luck, M., Ashri, R., and D'Inverno, M., 2004. *Agent-based software development*. Boston: Artech House.

Nonaka, I. and Takeuchi, H., 1995. *The knowledge-creating company*. Oxford University Press.

Pan, S. L. and Leidner, D. E., 2003. Bridging communities of practice with information technology in pursuit of global knowledge sharing. *The Journal of Strategic Information Systems*, 12(1), pp. 71-88.

Wenger, E., 1998. *Communities of practice, learning, meaning, and identity*. USA: Cambridge University Press.