KNOWLEDGE MANAGEMENT PROCESS FOR INFORMATION SYSTEMS ANALYSIS AND DESIGN

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ABSTRACT

Cases of the application of knowledge management in information systems fields are limited except for trouble shooting, project management, and software quality improvement. This paper describes the knowledge management process by referring to the SECI model, which is a representative theory of organizational knowledge creation, with regard to improvement in the quality of information systems analysis and design. The proposed knowledge management process is divided into four phases of knowledge conversion and is discussed in term of the IT and methodology needed to support each phase of knowledge conversion.

INTRODUCTION

In recent years, the concept of business management called Knowledge Management (KM) has attracted attention in a number of different business fields. So called acit knowledge is retained implicitly by individuals and it is difficult to describe explicitly. The basic idea behind KM is to transform tacit knowledge into explicit knowledge that can be easily coded. KM thus realizes "the sharing, transfer, and reuse of knowledge among knowledge workers" and "business management that utilizes knowledge within an organization" (Davenport & Prusak, 1998).

At this stage, numerous cases of the application of KM have been reported for non-routine task fields such as planning, marketing, business management, sales/customer support, and manufacturing process management. On the other hand, cases of application in information systems fields are limited except for trouble shooting, project management, and software quality improvement (Davenport, DeLong & Beers, 1998).

We propose a domain modeling-based KM method for Information Systems Analysis and Design (ISAD) and clarifies its effectiveness/characteristics with regard to improvement in the quality of ISAD processes through applying the method to actual cases (Abe, 2000). As for ISAD, it is especially important to understand the characteristic features of a target domain. The term omain indicates an application field to which a set of two or more similar information systems belongs. A domain model is explicit knowledge that systematize tacit knowledge residing in particular application domains such as business knowledge, problem solving strategies, system/software structures, and development processes. Application of the proposed KM method to several projects revealed that it is important not only to transform tacit knowledge into explicit knowledge and reuse the explicit knowledge but also to clearly define the KM process that covers as far as continuous knowledge creation.

This paper describes the KM process for ISAD by referring to the SECI model (Nonaka & Takeuchi, 1995; Nonaka & Konno, 1998) which is a representative theory of organizational

knowledge creation. First, taking the transportation/delivery scheduling systems domain as an example, basic structures of the domain model are explained. Next, the KM process is divided into four phases of knowledge conversion: socialization, externalization, combination, and internalization. The characteristics of knowledge in each phase are described. Then, the IT and methodology to support each knowledge conversion are discussed. Finally, a comparison of the proposed KM method with related work is discussed.

DOMAIN MODEL

Many companies have considered constructing a transportation and delivery scheduling system as a method for improving the efficiency of physical distribution. However, requirements analysis of the system is problematic because mathematical analysis of Combinatorial Optimization (CO) problems (Bodin et al, 1983; Golden & Assad, 1988) and an understanding of complicated physical distribution systems are required. In order to improve the efficiency of requirements analysis using a domain model, we have applied the domain modeling-based KM to a company. The obtained domain model has been refined and enhanced repeatedly through on-trial evaluation in actual requirements analysis and has almost reached a practical level.

Table 1: Example of Domain Model

Business Knowledge

Elements	Description Methods
Distribution network	Class diagram
Material/information flow	Sequence diagram, State diagram, Collaboration diagram
Scheduling transactions	Activity diagram
Scheduling knowledge	Rule representation
Scheduling preparing forms	Gantt chart, etc.

Design Knowledge

Elements	Description Methods
System providing services	Use case diagram
Database schema	Class diagram
CO solutions	Mathematical model, Activity diagram, Rule representation

We divide the description of the domain model into business knowledge and design knowledge, as shown in Table 1. In domain modeling, it is important to understand the difference between business knowledge, which is not dependent on information systems, and design knowledge, which is to be actualized with information systems. The business knowledge consists of five elements: *distribution networks* and the *materials/information flow* are useful in understanding the scheduling objects; *scheduling transactions*, *scheduling knowledge*, and *schedule*

preparing forms are useful in understanding the transportation/delivery scheduling system transactions. The elements of the design knowledge are limited to the information necessary for the specifications of the input, processing, and output of those system areas dealing with CO problems. Especially with respect to processing, *CO solutions* clarify the mathematical characteristics contained in the transportation/delivery scheduling transactions and useful CO algorithm.

Regarding the description of the domain model, we selected the best notation for each element, taking an object-oriented language UML (Fowler & Scott, 1997) as a standard. The reason for adopting the object-oriented language is that it actualizes natural modeling and enables easy refinement/enhancement of the domain model. The elements not described in UML indicate the characteristics of this domain. *Scheduling knowledge* and a part of *CO solutions* are suitable for rule representation since business rules and expertise are described in them. For *schedule preparing forms*, various charts established as an industrial engineering tool are used. For *CO solutions*, it is natural that mathematical models be used.

KM PROCESS BASED ON THE SECI MODEL

We define the KM process for ISAD by referring to the SECI model which is a representative theory of organizational knowledge creation, as shown in Figure 1 and Table 2. Nonaka and Takeuchi (1995) defined as he assumption that knowledge is created through the interaction between tacit and explicit knowledge allows us to postulate four different modes of knowledge conversion. They are as follows: (1) from tacit knowledge to tacit knowledge, which we call socialization; (2) from tacit knowledge to explicit knowledge, or externalization; (3) from explicit knowledge to explicit knowledge, or combination; and (4) from explicit knowledge to tacit knowledge, or internalization. Socialization is a process of sharing experiences and thereby creating tacit knowledge such as shared mental models and technical skills. Externalization is a process of articulating tacit knowledge into explicit concepts. Combination is a process of systemizing concepts into a knowledge system. Internalization is a process of embodying explicit knowledge into tacit knowledge. Organizational knowledge creation is a spiral process, starting at the individual level and moving up through expanding communities of interaction, that crosses sectional, departmental, divisional, and organizational boundaries.

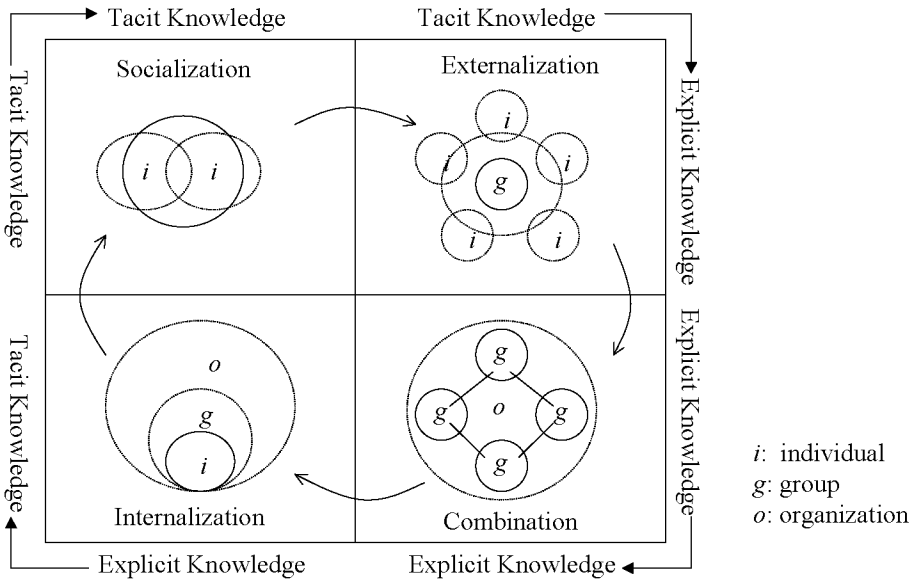

Figure 1: Four Phases of Knowledge Conversion on the SECI Model
Source: Nonaka & Konno, 1998.

Socialization Phase

Experiences of domain experts and examples of system development are converted into reuse requirements and domain expertise. As for IT, a system to promote individual communication is available. As for the knowledge acquisition method, synergistic work methods such as on-the-job training and brainstorming camps are effective and social scientific methods such as case studies, action research, and ethnomethodology for social activity analysis are available.

Externalization Phase

Reuse requirements and domain expertise are converted into a domain model. Generally, conversion into a domain model is conducted by a information modeling method like UML via a human analyst. If necessary, reverse engineering, data mining, and text mining are introduced to support the human analyst. Members of a group level such as a system development project can share explicit knowledge by using a domain model.

Combination Phase

The domain model is stored in a knowledge repository, which can share explicit knowledge at an organizational level, and is embedded into Computer-Aided Software Engineering (CASE) tool for ISAD. The knowledge repository consists basically of database, retrieval engines such as full-

text searching and intelligent agent, and groupware. However, as shown in Table 1, we think that the current functions of the knowledge repository will be insufficient because the domain model has complex and varied structures. So it is necessary to research and develop the knowledge repository for ISAD immediately.

Internalization Phase

Through use of the knowledge repository and CASE tool in practical ISAD work, new, tacit knowledge is converted from explicit knowledge and is accumulated into individuals. Continuous knowledge creation processing from the socialization phase to the internalization phase can be achieved by converting the new, tacit knowledge into explicit knowledge. Although the internalization phase is very important to create new knowledge, the IT and methodology for supporting this phase has not yet been found.

Table 2 : KM Process Based on the SECI Model

		Socialization Phase	Externalization Phase	Combination Phase	Internalization Phase
Input		<Tacit knowledge> Domain experiences, Development examples	<Tacit knowledge> Reuse requirements, Domain expertise, Development examples	<Explicit knowledge> Domain model	<Explicit knowledge> Knowledge repository, Domain-oriented CASE tool
Process		Understanding of target domain	Analysis/modeling of domain	Sharing of domain model, Embedding domain model to tool	Practice of ISAD based on explicit knowledge
Output		<Tacit knowledge> Reuse requirements, Domain expertise	<Explicit knowledge> Domain model	<Explicit knowledge> Knowledge repository, Domain-oriented CASE tool	<Tacit knowledge> New development examples, New experiences
Support Tool	IT	Communication support system	Reverse engineering, Data and text mining	Groupware, Document database, Full text searching, Intelligent agent, CASE tool	———
	Method-ology	On-the-job training, Brainstorming camps, Ethnomethodology, Action research, Case studies	Information modeling	———	———

DISCUSSION

KM for ISAD, the subject of this study, has still not been discussed sufficiently. Cases of KM study in information systems and software fields are limited to a part of application such as

trouble shooting, project management, or software quality improvement. Baskerville and Pries-Heje (1999) showed a framework of software development management based on knowledge capability and maturity. Kudou (2000) proposed a design review-report-oriented knowledge management method for software development management. Kuroda (2001) achieved success with a KM project in a major computer vendor. In order to improve the efficiency of systems engineering, cases of systems employment and trouble shooting are placed on a company intranet to be shared.

KM for ISAD is also closely related to the research field of software reuse. Technologies of design patterns (Gamma, 1995) which systematize know-how for general purpose use in software design is being increasingly introduced in development projects. Several problems, however, such as bridging the gap between concrete applications and patterns of general purpose use are pointed out. Technologies of reusing application specific software frameworks and components (Sodhi, 1999) have the point of domain view which is common to our KM method. However, these technologies are mainly for the reuse of software components and are not discussed in terms of the similarities between the KM concept and the reuse technologies.

CONCLUSION

In summary, we designed the process of domain modeling-based KM for ISAD by referring to the SECI model and discussed the IT and methodology to support the four phases of knowledge conversion: socialization, externalization, combination, and internalization. We think the study presented in this paper gives a definition of the KM process that covers as far as continuous knowledge creation and takes a look at improving the feasibility of applying the proposed KM method to practical cases. The next step, while applying the KM process to actual projects, is to consider the following: a suitable framework of knowledge repository for ISAD, some tools to support the internalization phase, and evaluation of KM effectiveness.

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