A METHOD OF KNOWLEDGE MANAGEMENT FOR INFORMATION SYSTEMS ANALYSIS AND DESIGN

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ABSTRACT

Numerous cases of the application of knowledge management have been reported for non-routine task fields: planning, marketing, business management, sales support, manufacturing process management. In contrast, cases of application in fields for information systems are limited. This paper proposes a new method of knowledge management based on domain modeling and clarifies its effectiveness/characteristics with regard to improvement in the quality of information systems analysis and design processes through use with a transportation and delivery scheduling system domain.

INTRODUCTION

In recent years, the concept of business management called Knowledge Management (KM) has attracted attention in a number of different business fields. Davenport and Prusak (1998) defined as "Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowledge workers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms." Tacit knowledge is retained in quiet by individuals, who find it difficult to express this information; the basic idea behind KM is the transformation of this knowledge into explicit knowledge that can be easily coded. KM thus provides "the sharing, transfer, and reuse of knowledge among knowledge workers" and "business management actively using knowledge in an organization" (Nonaka, 1991; Nonaka and Takeuchi, 1995).

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

This paper proposes a new method of KM based on domain modeling for information systems analysis and design processes. Domain modeling is a process for obtaining and organizing domain models in order to effectively reuse practical activities in the development of information systems. The term "domain" in domain modeling indicates the objective area with a set of two or more similar information systems. Domain models include business knowledge, terminology, strategies for problem solving, system/software structures, and development processes residing in particular domains. Taking a Transportation and Delivery Scheduling (TDS) system domain as an example of the application of the KM method based on domain modeling, in this paper we describe a framework for the KM method and the effectiveness/characteristics of the method.

TDS SYSTEM DOMAIN

The development of physical distribution systems in Japan has recently focused on the needs for cost reduction, shorter delivery time, and better customer service. These new requirements can be attributed to changes in both the distribution structure and distribution costs in response to the current recession, as well as to the new diversification of customer needs, the physical deterioration of the roads used for delivery, and the increasing popularity of the more expensive, small-lot deliveries. These factors have affected manufacturers, retailers, wholesalers, and common carriers without exception.

To resolve these physical distribution system problems, many companies have considered constructing TDS systems to more efficiently make and manage their transportation/delivery schedules. Generally, transportation and delivery is distinguished in that conveyance between distribution bases is described as "transportation" and conveyance between distribution bases and customers is described as "delivery."

However, systems analysis/design on such TDS systems is problematic for the following reasons:

1. Mathematical analyses of Combinatorial Optimization (CO) problems and discussions of methods for solving them are required. In fact, information systems engineers in charge of TDS systems, who are expert in business application systems but weak in mathematical analysis. Such problems of TDS systems have often been addressed in theoretical studies in the field of Operations Research (OR) (Bodin *et al*, 1983; Golden and Assad, 1988). Lately in order to develop a large-scale practical system, it is essential to design an algorithm in which the characteristics of the business are thoroughly taken into consideration by, for example, combining OR methods, artificial intelligence methods (Zweben and Fox, 1994), and geographic information processing (Grimshaw, 1994).

2. An understanding of various complicated physical distribution systems is required. In addition, as supply chain management (Handfield and Nichols, 1999) become more popular, transportation/delivery processes must also be reanalyzed.

KNOWLEDGE MANAGEMENT METHOD BASED ON DOMAIN MODELING

Based on the idea that information systems analysis and design processes could be improved using a domain model, we design a framework of KM method based on domain modeling for the TDS system.

First, in order to clarify the goal of this domain modeling, we compare the TDS system with a PRoduction Scheduling (PRS) system that belongs to a similar domain. The PRS system , which is regarded as a subsystem of the production information system, makes production schedules and includes CO problems (Abe *et al*, 1997). The results of the comparison will be referenced when we set the requirements specifications of the domain model. Conducting domain modeling without clarifying its goal is not only inefficient but also heightens the possibility that the modeling itself may result in failure.

The steps of the domain modeling consist of comparing the TDS system with the PRS system (Step 1), setting the requirements specifications of the domain model (Step 2), analyzing similar systems (Step 3), describing the domain model (Step 4), and refining/enhancing the domain model (Step 5).

Secondly, we divide the description of the domain model into Problem Domain (PD) model and Application Domain (AD) model, as shown in Table 1. In domain modeling, it is important to understand the difference between PD, which is not dependent on application, and AD, which is to be actualized with software. The PD model consists of six 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 TDS transactions; and *CO Problem Types* clarify the mathematical characteristics contained in the TDS transactions. The elements of the AD model 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, *heuristics* is regarded as an element in addition to the *CO Algorithm*, since the expert system approach is more often adopted as a technique for developing a practical TDS system.

Table 1
Specifications of the domain model

PD Model

Elements	Description methods
Distribution Network	Object diagram
Materials / Information Flow	Event trace diagram, State transition diagram
Scheduling Transactions	Data flow diagram
Scheduling Knowledge	Rule representation
Schedule Preparing Forms	Gantt chart, etc.
CO Problems Types	Mathematical model

AD Model

Elements	Description methods
Database Schema	Object diagram
CO Algorithm	Flow chart, Relationship matrix
Heuristics	Rule representation
User Interface	Object diagram

Regarding the description of the domain model, we selected the best notation for each element, taking an object oriented methodology OMT (Rumbaugh *et al*., 1991) as a standard. The reason for adopting the object oriented methodology is that it actualizes natural modeling and enables easy refinement/enhancement of the domain model. Specifically, OMT has high descriptive power because it includes three models: object model, dynamic model, and functional model. The elements not described in OMT indicate the characteristics of this domain. *Scheduling Knowledge* and *Heuristics* 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 Problem Types* and *CO Algorithms*, it is natural that mathematical models and flow charts be used.

Thirdly, regarding the use of the domain model in information systems analysis and design, we focus on an understanding of CO problems and a discussion of their systematization. The information systems engineer in charge of the TDS system should be knowledgeable about the whole distribution business and a specialist in the development of information systems, although currently our knowledge of TDS transactions and CO problems is not fully arranged. The domain model aims to reduce the bottleneck areas in systems analysis/design of the TDS system, most immediately by providing a reference handbook for information systems engineers, though other applications will likely be developed in the future. The PD model is referred to during the analysis of the business in order to better grasp CO problems (systems analysis phase). The AD model is referred to during the discussion on CO-problem-solving and the formulation of systems specifications (systems design phase), and support for devising specifications of the whole TDS system is excluded.

EVALUATION

We next summarize the effectiveness of applying the KM method based on domain modeling to TDS systems analysis and design, as well as the several problems inherent in such an application. The information systems engineers who evaluated the application judged that the use of the domain model in actual requirements analysis had a satisfactory effect. The results may be summarized as follows:

1. The domain model enables information systems engineers to obtain basic knowledge in dealing with CO problems and conduct many parts of the discussion on the requirements specifications.

2. The domain model is effective in improving the communication between engineers who specialize in mathematical analysis to CO problems (called "mathematical engineers" for convenience) and information systems engineers.

Cooperation obtained from a mathematical engineer is essential since CO problems cannot be avoided in developing the system. So far, information systems engineers, who are expert in business application systems but weak in mathematical analysis, and mathematical engineers, for whom the opposite is true, have not had a particularly cooperative relations. The domain model can be used as a mutual reference to bridge the gap in their discussions.

However, the domain model is only a model in which findings obtained from past development systems are arranged and does not guarantee a discussion of the most suitable specifications. Depending on the circumstances, it may even discourage new points-of-view in a discussion on systematization. Though we provisionally recommend that the domain model be offered in handbook form, this may not be its best presentation in the long-term. It is important that users understand both the utility and limitations of its use.

DISCUSSION

We compare the proposed KM method with approximately thirty successful KM projects (Davenport, DeLong and Beers, 1998) and clarify characteristics of the method in terms of key factors involved in a KM project: objectives, organization, knowledge, and technology.

Davenport identified five broad types of KM project objectives: (1) create knowledge repositories for organizational sharing, (2) obtain knowledge from raw data, (3) improve access to knowledge, (4) enhance the knowledge environment, and (5) manage knowledge as an asset. Type (1) objective predominate, though the current KM method, which has transformed tacit knowledge for systems analysis/design embedded in past development cases into explicit knowledge, is closer to a type (2) objective.

Generally, organizational formations for the application of KM have an entire section, several sections, or a specific section in company organization for KM. Most organizations introduce KM using a top-down approach; for example, several successful companies appoint a chief knowledge officer for KM projects. In contrast, the current KM method has been applied to information system development projects in a specific system domain and is similar to a QC circle that improves business processes using a bottom-up approach and small units in the workplace.

KM technology for dealing with organizational knowledge consists of: (a) knowledge acquisition, for example, data mining and data warehousing; (b) knowledge storage, such as document-bases and knowledge-bases; (c) knowledge sharing, like WWW-Intranet and groupware; and (4) knowledge retrieval, like full-text search engines and intelligent agents. However, the current KM method did not adopt not only knowledge acquisition technology but other forms of KM technology as well. The explicit knowledge acquired has a complex representational structure: a graphic structure with object diagrams, data flow diagrams, and state transition diagrams; a matrix structure that has described the relationship between different viewpoints regarding system needs; and other structures. We transformed tacit knowledge into explicit knowledge using only a domain modeling approach.

CONCLUSIONS

We proposed the KM method based on domain modeling and verified its effectiveness/characteristics with regard to improvement in the quality of information systems analysis processes through use with the TDS system domain. Although the explicit knowledge embedded currently in the domain model is offered in a very accessible handbook form, this is not sufficient as a mechanism for knowledge sharing and widespread exchange. It is believed that construction of a knowledge repository that supports description, storage, exchange, and retrieval of domain models consisting of complex structures will able to extend use of domain models to several projects, sections, or to the entire company. We are planning to develop a domain model management environment based on eXtensible Markup Language (XML) (Bray, Paoli and Sperberg-McQueen, 1998), which is a description and manipulation language for digital documents in a future Internet environment.

REFERENCES

Abe, A., Shimada, T., M., Maeda, T., & Nakano, G. (1997) A Lot Sizing Combined Scheduling Method for Plastic Molding Process, *Systems and Computers in Japan*, 28(2), 73-85.

Ballou, R. H. (1987) *Basic Business Logistics: Transportation, Material Management, Physical Distribution*, Prentice-Hall.

Bodin, L., Golden, B., Assad, A., & Ball, M. (1983) Routing and Scheduling of Vehicles and Crews, *Comput.& Ops. Res.*, 10(2), 63-211.

Bray, T., Paoli, J., & Sperberg-McQueen, C. (1998) *Extensible markup Language (XML) 1.0 Specification*, http://www.w3.org/TR/REC-xml.

Davenport, T. H., DeLong, D. W. & Beers, M. C.(1998) Successful Knowledge Work Processes, *Sloan Management Review*, 39(2), 43-57.

Davenport, T. H. & Prusak, L. (1998) *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press.

Davis, W. S. & Yen, D. C. (1999) *The Information System Consultant's Handbook: Systems Analysis and Design*, CRC Press.

Golden, B. L. & Assad, A. A. (1988) *Vehicle Routing: Methods and Studies*, North-Holland.

Grimshaw, D. J. (1994) *Bringing Geographical Information Systems Into Business*, Longman Scientific & technical.

Handfield, R. B. & Nichols, E. L. (1999) *Introduction to Supply Chain Management*, Prentice Hall.

Rumbaugh, J., Blaha, M., Premerlani, W., Eddy, F., & Lorensen, W. (1991) *Object-Oriented Modeling and Design*, Prentice Hall.

Nonaka, I. (1991) The Knowledge-Creating Company, *Harvard Business Review*, November-December, 96-104.

Nonaka, I. & Takeuchi, H.(1995) *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press.

Zweben, M. & Fox, M. (Eds.) (1994) *Intelligent Scheduling*, Morgan Kaufmann Publishers.