Know-how Sharing Using a Knowledge Sharing System *KIDS*

− A Knowledge Management Practice at a Research Laboratory −

Yasuko Nakayama
Corporate R&D Center
Toshiba Corp., 212-8582 Japan
yasko.nakayama@toshiba.co.jp

Kazuo Sumita
Corporate R&D Center
Toshiba Corp., 212-8582 Japan
kazuo.sumita@toshiba.co.jp

Kouichi Sasaki
Corporate R&D Center
Toshiba Corp., 212-8582 Japan
kouichi.sasaki@toshiba.co.jp

Toshihiko Manabe
Corporate R&D Center
Toshiba Corp., 212-8582 Japan
toshihiko.manabe@toshiba.co.jp

Masaru Suzuki
Corporate R&D Center
Toshiba Corp., 212-8582 Japan
masaru1.suzuki@toshiba.co.jp

Abstract

We developed a knowledge and information on demand system, *KIDS*, which structures free-form text as knowledge to provide the user with knowledge fit for his natural language query. For a period of four years, we carried out knowledge sharing experiments using the system at a research center that includes around 1,000 researchers engaged in various fields such as computer science, display devices, advanced LSIs and mechanical systems. In the experiment we focused on sharing the knowledge processed by individuals; technical papers, patents and the like were excluded from the scope of the experiments because a document management system has already been implemented. An individual's knowledge includes a knack or tips useful in the performance of research. The result shows the feasibility of integrating organized domain knowledge and personal free-form know-how. We discuss key factors for success in knowledge sharing such as text structurization, building a knowledge sharing culture, knowledge quality maintenance.

1 Introduction

1.1 Rich stock of knowledge is key for success

There is growing recognition that intellectual capital, including individuals' know-how, technical skills and cognitive skills, constitutes a valuable resource for any enterprise. Consequently, how best to facilitate knowledge sharing within organizations has emerged as an important issue for management [Apo98]. The capability of individuals and organizations to gather, accumulate and dispatch information has improved due to information technology such as groupware, document management systems, and intra- or internet-based search. It has become clear that two factors, namely system architecture and richness of content, have a particular important bearing on the ability of a knowledge sharing system to function effectively.

Nonaka and Takeuchi modeled the knowledge creation in a company as a knowledge conversion cycle between explicit knowledge and tacit knowledge [Non95]. The explicit knowledge is knowledge that could be transmitted using formal and logical language such as a technical document or a manual. On the other hand, the tacit knowledge is difficult to formalize and could not be transmitted using formal and logical language, because such knowledge is contextual. An individual's tacit knowledge is difficult to transmit without his experiences and actions. By accumulating individuals' knowledge with the context and by making a network of the knowledge, the creativity of individuals is raised and the creativity of the whole organization increases.

In order to develop a method of accumulation, retrieval and practical use of useful knowledge for an organization and its individuals, it is first necessary to collect the organization's intellectual capital and promote knowledge externalization.

1.2 Background knowledge for comprehension

Among researchers there is keen interest in advanced information retrieval, classification, extraction, and automatic organization of information for detecting knowledge contained in extensive information, as evidenced by various studies [Fuj99], [Iwa96], [Mil95], [Gar98].

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In order to obtain knowledge useful for an individual from the stock of knowledge and information, the system has to perform not superficial retrieval but the smart retrieval according to the individual's intention situation. For the purpose, the system has to comprehend the stock of knowledge and information. Since the internet includes various types of information, it is very difficult to build general-purpose background knowledge or ontology to manage all of the information. However, a company engages in business with the aim of attaining certain specific goals, and consequently, it is easier to describe the specific background knowledge in order to manage the knowledge and information.

First, we developed a knowledge base, used for understanding the stock of information, which involves lexical knowledge and concept hierarchy. We also developed a knowledge and information sharing system (*KIDS*--Knowledge and Information on Demand System) which utilizes the knowledge base to comprehend both of the stock of text and users' queries [Nak97]. In order to verify the validity of the knowledge-sharing framework using the system, we have been accumulating content and performing an evaluation of the practice of knowledge sharing at the Corporate Research & Development Center, Toshiba Corp. [Rdc]

1.3 Know-how sharing practice

The purpose of the knowledge sharing practice here is not to manage explicit knowledge such as technical papers, patents, and manuals, but to share know-how such as a knack or tips useful in the performance of research. In this paper, we focus on know-how sharing for research scientists.

Various consulting firms have focused on knowledge management, but the systems they have developed, e.g. KnowledgeSpace [Kno], share only typical explicit-knowledge such as documents on best practice, presentation manuscripts, and educational materials. They exchange consulting know-how through teamwork or face-to-face communication. Explicit and tacit knowledge are complementary. A knowledge management system for sharing know-how or tacit knowledge, not a document management system, has to be developed.

A document management system has already been implemented at the Corporate Research & Development Center, Toshiba Corp., for sharing technical knowledge; it stores patents and technical reports. The patents and technical reports written by researchers based on their research are stored in the document management system. Presentation at a conference and publish of academic papers are an incentive for the researcher to write such documents. However, he has no motivation to impart his know-how to others. To facilitate the imparting of the know-how to others, a knowledge management system for know-how sharing is needed.

The main subjects of know-how sharing in this paper are
(1)acquisition of the knowledge possessed by individuals,
(2)knowledge retrieval according to the user's intention,
(3)cultivation of a knowledge-sharing culture, and
(4)reinforcement of the accumulated knowledge.

The following sections describe how we tackled these subjects in order to promote know-how sharing and what we learned as a result of the knowledge sharing.

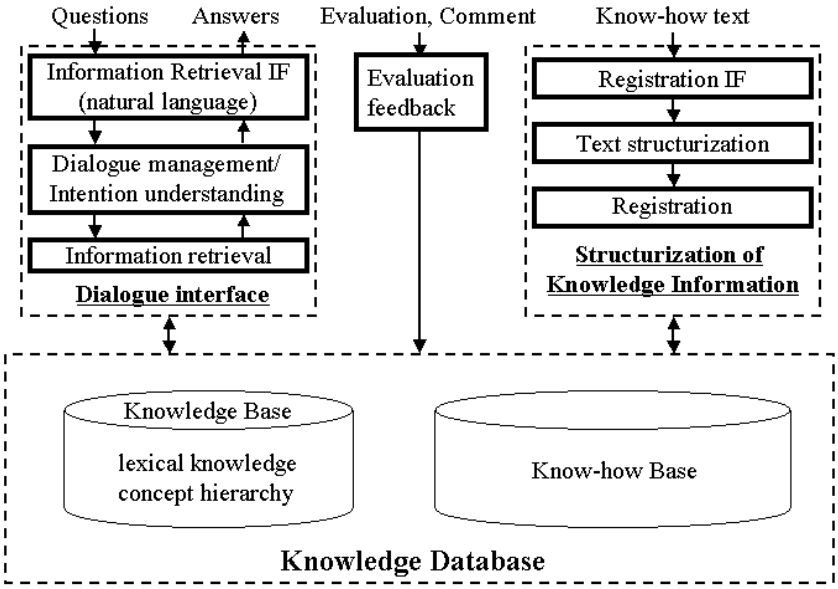

Figure 1: System configuration

2 Knowledge information sharing system

2.1 System configuration

Basically a knowledge information sharing system needs three functions: (1)acquisition of knowledge, (2)management of knowledge, and (3)retrieval of knowledge. In order to manage the accumulated knowledge and information at the semantic level or conceptual level, the system requires "knowledge" for comprehending them.

Figure 1 shows the configuration of *KIDS*. The system consists of a knowledge database, text structurization, and dialog interface. It stores know-how and enables users to access nuggets of know-how by using natural language as shown in Figure 1. A knowledge database consists of two types of databases: the knowledge base representing domain knowledge and the know-how base storing individuals' know-how.

The knowledge in the knowledge base includes concept hierarchy and synonym dictionary structurization rules. The concept hierarchy represents relations between words, e.g., *library* is a kind of *facility*. The concept hierarchy and the synonym dictionary are used to expand words extracted from a user's query. Currently, the number of words in the concept hierarchy and the synonym dictionary is about 9,200.

2.2 Text structurization and retrieval

The know-how base accumulates knowledge offered by the users. The know-how, which is stored in the form of text, includes a shallow semantic structure so that the know-how can be treated as a kind of knowledge with its context. We defined a descriptive structure required for the user to search and reuse know-how easily.

Figure 2 shows the steps of the text structurization process. There is no explicit word boundary in Japanese sentences because Japanese is an agglutinative language. The system executes morphological analysis to extract words in the text. The context presumption/structurization step, a context label is assigned to each phrase according to the structurization rules. In order to deal with ungrammatical sentences and phrases, a word and/or phrase spotting method is applied to extract the structure of the input know-how. For every phrase of a sentence, the context label is determined by referring to the structurization rules, and the terms are extracted by referring to the lexical knowledge.

In the example, the system assigns the context label "situation" to the first phrases, and extracts "*kokusai-kaigi* (international conference)", "*eigo* (English)", and "*happyou* (presentation)" as terms to be stored. Also the system assigns the label "advice" to the later phrases, and extracts "*happyou-genkou* (oral manuscript)", "*neitibu* (native)", and "*rokuon* (record)" as terms to be stored. These structure data are stored in the know-how base. Currently, the number of structurization rules is about 200, and the number of context labels is 12 for the know-how structurization.

At the time of retrieval, the system carries out the same analysis for the user's query, which is a natural language sentence or a phrase, and it matches the extracted structure with that of each nugget of know-how in the know-how base. Thus, since it retrieves a nugget of know-how based on a consideration of the natural language context, unlike a conventional keyword search system, text appropriate for a user's intention can be retrieved.

On the basis of the above structurization the similarity S_{qd} between document d, a nugget of know-how, and query q is defined as follows:

$$S_{qd} = S_{t \text{ in } d}\, d_{tq}\, W_{td}\, C_{tqd}\,.$$

Here, each variable is defined as follows:

$$W_{td} : ((1 - p_1) + p_1\,(TF_{td} / TF_d))\, log_2\,(D / D_t)\,,$$

$$C_{tqd} : ((1 - p_2) + p_2\,(TF_{tq} / TF_q))\, max_{\,u \text{ in } d}\, d_{tu}\, TC_{qu}\,(1 + p_3\,(K_{qu} - 1))\,,$$

p_1 , p_2 , p_3 : weighting factor (constant) ,

TF_{td} : frequency of term t in document d,

$TF_d : max_{\,t \text{ in } d}\, TF_{td}$,

TF_{tq} : frequency of term t in query q,

$TF_q : max_{\,t \text{ in } q}\, TF_{tq}$,

D_t : number of documents including term t,

D : number of all documents in DB,

d_{tq} : 1 if t in term q, otherwise 0,

d_{tu} : 1 if t in a field labeled by u, otherwise 0,

TC_{qu} : correlation factor between query q and field u,

K_{qu} : frequency of terms in query q occurring in a field u.

2.3 Know-how sharing functions

Every user is able to register his know-how and also accesses all know-how registered by other users. The system also has two functions to promote registration of know-how by users: a question registration function and a content evaluation function. If the user is unable to find an appropriate answer, he can register his question using the question registration function. The user can enter a comment for each nugget of know-how, with five rank evaluations: very useful, useful, old, incorrect, and other.

Figure 3 shows a snapshot of the system and the English translation. The figure shows the retrieval result acquired when a user made an inquiry in connection with an oral presentation to be made at the time of making an oral presentation at an international conference. The titles of the nuggets of know-how and the abstract are listed in

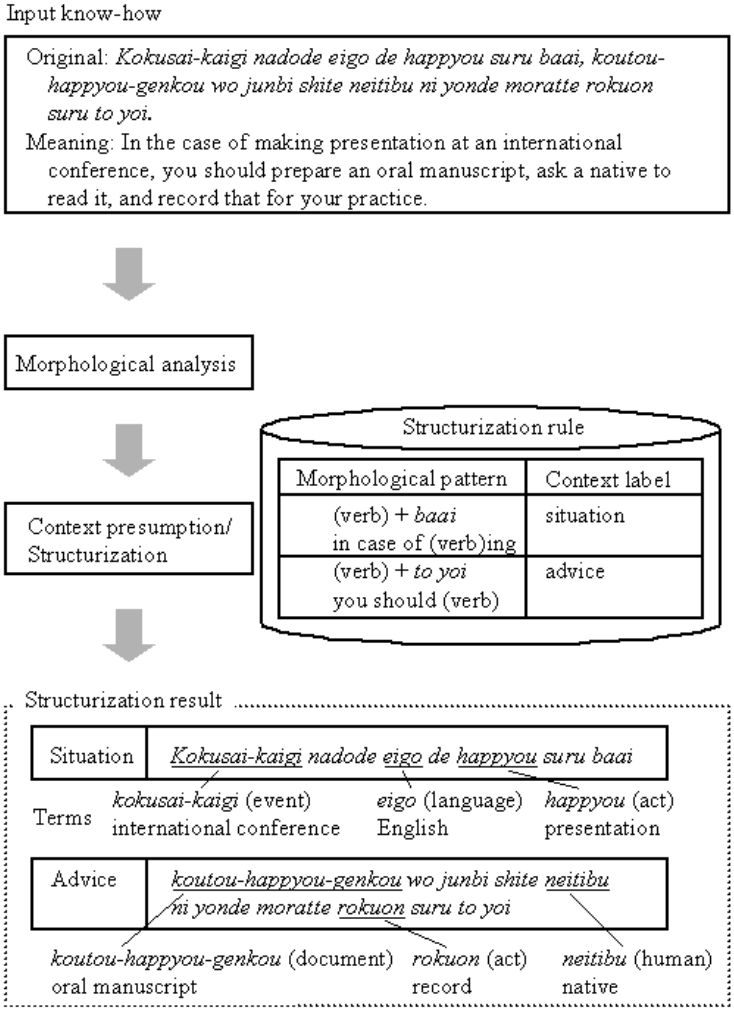

Figure 2: Structurization process

order of similarity to the user's query. Also the author's name, the date of registration, and the reference count are displayed under the title. The system is a web system, and so the server software works on a PC server whose OS is Windows NT and the user accesses it through a WWW browser.

3 Practice and evaluation

3.1 Practice history

We have been practicing knowledge sharing using the system described above for approximately four years at the Corporate Research and Development Center, Toshiba Corp. The extent to which rich, know-how content is accumulated has a decisive impact on the usefulness of the system.

The knowledge sharing system entered service in November 1996 and some 1,000 researchers and administrative staffs use it to share know-how useful in their work. The knowledge stored consists of explanations of expertise, glossaries of technical terms, miscellaneous tips respecting computers and peripheral equipment, hints respecting how best to tackle various research activities, links to useful web pages, and so on. It also includes information how to do perform various company procedures and how to compose document related to those procedures, as well as know-how concerning welfare and everyday life. Figure 4 shows the trend of the number of items of know-how registered.

The histogram in Figure 4 represents the number of items of know-how registered, and the polygonal line graph represents the cumulative number. Three knowledge administrators were assigned in May 1996. To

accumulate know-how and to construct a know-how base, they tried various methods: they questioned experts by e-mail, and interviewed them face to face. Approximately 3,500 nuggets of know-how were registered in the know-how base before entering the service. According to the result of an experiment we conducted using 2,500 queries collected from 36 people, the coverage rate of this know-how base was only 50% at the initial stage. Then, we collected 7,200 queries limited to company procedures from the same 36 people, and registered over 90% of the know-how corresponding to the gathered queries, so that the system could reply to any question about company procedures in the first phrase after its introduction.

We added a maintenance function so that the knowledge administrators could reply to a non-registered question and register the reply in the know-how base to surely reply to any question as soon as possible. After practicing for four months in a department consisting of about 300 people, the practice was expanded in March 1997 to include the entire Corporate Research & Development Center, Toshiba Corp., consisting of about 1,000 people. Also, we enacted guidelines for the copyright of know-how in July 1998, reviewed all the contents again, and deleted know-how that was violating the guidelines, useless or old. A commendation system, in which prizes are awarded to those users who contribute most know-how, was introduced in October 1998. With the aim of enriching the content of the system, knowledge managers were assigned to each technical field in August 1999. Since then, the amount of content has continued to increase and 11,600 nuggets of know-how were registered as of September 2000.

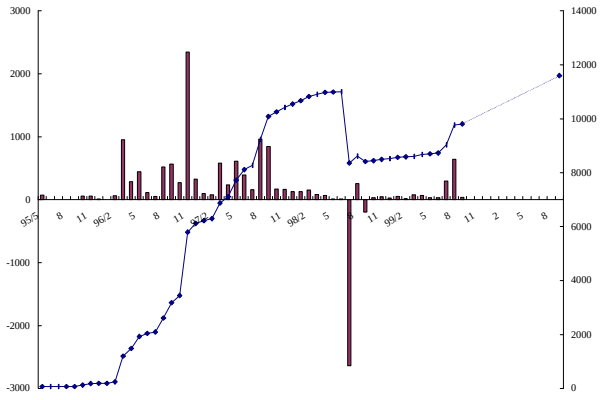

Figure 4: The number of items of know-how registered

3.2 Evaluation

Contents registered in the know-how base are classified into the following four categories.
(1)Tips on company procedures … 31%
ex. Procedure for contracting a NDA
Who could take a child-care holiday?
(2)Tips relating to research activities … 21%
ex. What is a `motion processor?'
Web links on wearable PC
(3)Tips on computers and software … 20%
ex. How to make LINUX recognize a network card
How to print a PDF file in multi-page format
(4)Other useful tips … 28%
ex. Be careful when you take a taxi in Greece
How to use a library of Tokyo University

Figure 5 shows a typical know-how example registered in the system, which is translated into English.

Title: How to insert a figure created using tgif in MS WORD?
Content: When you would like to insert a figure created using tgif, you should do the following. First, in tgif, save a figure by an eps file format. If you try to insert the eps file in MS WORD, an error may occur. So, second, edit the file to rewrite the first line "%!" into "%!PS-Adobe-2.0." Finally, insert the file in MS WORD document.

Figure 5: A typical know-how registered in the system

If they wish to, users can enter an evaluation for any nugget of know-how. The number of nuggets of know-how evaluated as very useful or useful was 970 (8.3%).

To evaluate contents registered in the system, we selected 90 queries at random from the system's query log. Then by investigating the know-how base, we found correct answers for 60 of those queries: the answers corresponding to 66% queries exist in the system. For the 60 queries, we calculated 11pt average precision, whose value was 0.73.

4 Problems in knowledge sharing

In this section, we discuss problems in knowledge sharing that have come to light in the course of our use of the system.

(1)Acquisition of an individual's knowledge
Regarding the externalization of an individual's knowledge, it is necessary to motivate the individual to impart his knowledge and an easy method of disseminating the knowledge is also required. We acquired knowledge by means of questions or interviews, and these approaches proved to be effective. Also, since it is impossible to externalize all tacit knowledge, face-to-face communication is important, too. "Know-who", which is a kind of knowledge about a person, e.g., what is his domain of expertise, is also important knowledge,

and so we are developing a know-who sharing system based on the profiles of people.

(2)Content retrieval of knowledge
In order to reuse knowledge efficiently, sophisticated retrieval according to the intention of the user is required. Natural language retrieval, especially the content retrieval using lexical knowledge and concept hierarchy of an object field improved retrieval efficiency. The knowledge base, which represents background knowledge, is the key to understanding the user's intention, and we intend to strengthen it.

(3)Organization culture conductive to knowledge sharing
For a member of an organization to offer his know-how proactively, it became clear that not only system functionality but also organizational culture and the individual's attitudes and values are decisive factors. In particular, it is important to provide motivation and implement guidelines regarding the offering of know-how. Ideally, everyone would be conscious of the desirability of offering knowledge to others, and act accordingly. In practice, it is necessary to raise people's consciousness and inculcate a proactive attitude throughout the organization toward the offering of know-how. The system introduced in August 1998, whereby prizes are awarded to those who offer the most know-how, motivated some, but by no means all members of the organization. This insufficient motivation is attributable, in part, to the lack of clarity regarding what types of knowledge should be stored in the system. Our experience indicates the desirability of clarifying the purpose of knowledge sharing.

(4)Reinforcement of the accumulated knowledge
The success of a knowledge sharing system is to a great extent determined by the quality of the content stored in the system. Regarding management of the quality of the unnecessary content, and avoidance of duplication of data. Initially, we concentrated on increasing the amount of know-how, and, reflecting that approach, some of the nuggets of know-how proved to contain useless or incorrect information. The evaluation feedback was effective for content management.

Also, with the aim of enriching the content of the system, knowledge managers were assigned to each technical domain from August 1999 onward. To be effective, a knowledge manager needs to have a sure grasp of the technical field, and be able to select the knowledge that should be registered, collect the knowledge, examine the content of the knowledge, etc. Currently, knowledge managers are not exclusively assigned to knowledge management, but do this work in addition to their regular work. To facilitate the knowledge manager's maintenance of his expertise, it is preferable for knowledge management to be one element in his overall work, and therefore, we are investigating a method that would enable knowledge managers to acquire knowledge and maintain it in the course of their work.

5 Conclusion

The practice of knowledge sharing using a knowledge and information on demand system, *KIDS*, was described. A thousand nuggets of know-how were gathered and made available for use. Individual's know-how was stored and managed by means of know-how base whose contents have a shallow structure and the knowledge base to enable the know-how to be shared and utilized effectively. Thereby, acquisition of individuals' knowledge became easy and the quantity and the quality of explicit knowledge improved. In order to achieve successful implementation and utilization of knowledge sharing, it is essential to give full consideration to both technology and organizational culture. In addition to providing the system, it is important to provide motivation and implement guidelines regarding the offering of know-how.

In addition to the study at the Corporate Research & Development Center, using *KIDS* we performed knowledge sharing at a customer service center for a period over two years. The system is used for sharing question-answer text, which the staffs store according to the questions received from the customers. Also, using *KIDS* we have started knowledge sharing at a systems integration department. In future, through the promotion of knowledge sharing at various departments, we intend to investigate effective methods of knowledge sharing that correspond to the objectives and characteristics of any given department.

We have enhanced *KIDS* to accommodate various types of file format and strengthen the file security. We have developed the commercial version, eFilingMeister/KnowledgeServer™.

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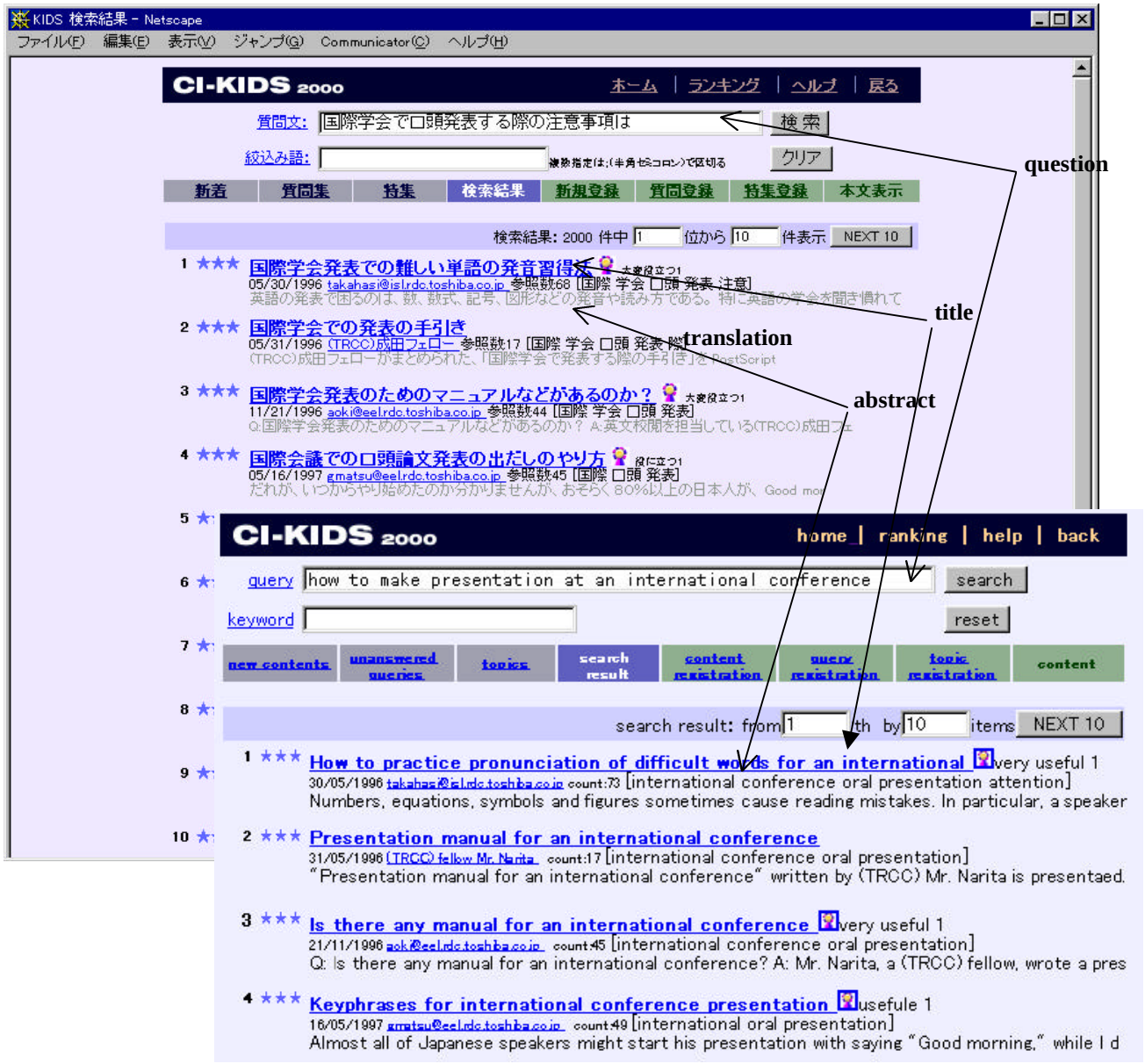

Figure 3: A snapshot of the system and the translation to English