

# ***Kfarm*: A Knowledge Management Support System Based on Dual Loop Model**

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## **ABSTRACT**

This paper presents ontology-based framework of information systems for knowledge management focused on a learning system in organization. Major characteristics of this framework are derived from “Ontology” which is used as an index of knowledge and “Dual loop model” which represents the flow of knowledge in an organization. Since these two things make the framework possible to grasp the meaning of knowledge and the progress of organizational learning, it can provides appropriate support for knowledge management. Then we will introduce a knowledge management support environment: *Kfarm* as an implementation of our idea.

## **1. INTRODUCTION**

With the recent development of an information infrastructure such as the Internet, the quantity of knowledge that individuals and organizations come across daily is increasing markedly, and requires a major upgrading of knowledge management abilities. In such circumstances, the development of a basis of knowledge management that supports knowledge creation, operation, and inheritance under the slogan ‘knowledge management’ [1, 2] has drawn attention.

In this study, we aim to develop an information system for knowledge focused on two points shown below:

- Ontology, used as an index of knowledge
- A Computer-aided model which supports knowledge creation activities in an organization

Ontology can be regarded as a conceptual system describing states of being, with a common denominator in which humans and systems share knowledge. This is the basis of expressing such ‘behavior’ in knowledge management, to consider ‘who has what knowledge’, ‘who must be informed of what knowledge’, and the ‘contents’ and ‘significance’ of that knowledge. This study aims to positively consider how such knowledge construction and manipulation techniques with ontology can be the initial basis of a knowledge management supporting technique.

To clearly express the design principles of the system in this paper, the suggested dual loop model reflects the key idea of our approach referencing the theories of ‘Learning Organization’ [3] and Nonaka’s ‘Organizational Knowledge Creation’ [2]. It also acts as a reference model

for system design. In this model, knowledge management is considered:

*It is necessary that the relations between individuals and organizations be properly understood and encourage the creation, the spreading and inheriting of new knowledge.*

In this paper, we introduce the dual loop model and state the role of ontology in knowledge management. We also introduce a knowledge management environment *Kfarm* as an implementation of our idea.

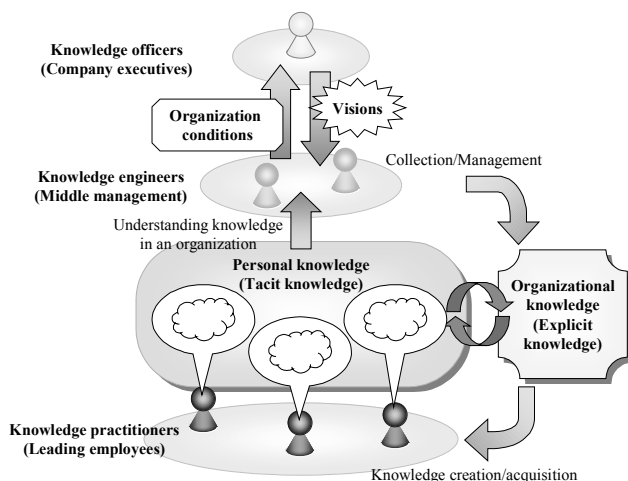
## **2. CORRELATION OF THE KNOWLEDGE CREATION PROCESS BETWEEN ORGANIZATIONS AND INDIVIDUALS**

### **SECI model**

Nonaka and Takeuchi proposed that the knowledge of an organization is created by two different types of mutual conversions of knowledge, which are ‘*format explicit knowledge*’ and ‘*tacit knowledge*’, and by individual interactions that have having different knowledge contents. They modeled a knowledge creation process in an organization as a SECI model in which knowledge creation in an organization was taken as *explicit knowledge* and *tacit knowledge* and was a composite of the following four modes:

- ‘**socialization**’ which shares tacit knowledge through shared experience
- ‘**externalization**’ which creates explicit knowledge from shared tacit knowledge (expressed by languages)
- ‘**combination**’ which creates systemic explicit knowledge with the combination of existing and new explicit knowledge
- ‘**internalization**’ which acquires tacit knowledge through experience based on systemic explicit knowledge

This model is constructed as a spiral process, starting at an individual level, expanding by shared degrees to organizational knowledge. Additionally, the more sophisticated and enriched knowledge from the sharing process goes back to



**Figure 1:** Middle up-down management

individuals. In the spiral, the individual knowledge becomes more enriched and leads to new knowledge creation.

### Middle Up-Down Management

In addition to the SECI model, Nonaka and Takeuchi suggested ‘middle up-down’ management as an example of an organizational model that promotes a knowledge creation process. As shown in figure 1, knowledge officers (K-officers), knowledge engineers (K-engineers), knowledge practitioners (K-practitioners), from a knowledge creating viewpoint layers, correspond to with top (executives), middle (middle management), and lower (employees) from organizational viewpoint layers, respectively. The K-engineers in the knowledge creation viewpoint layer are expected to coordinate between the top’s visions and the employees’ practical activities, and to promote innovative knowledge creation within a particular order of the organization.

## 2.1 Dual loop model

Our goal is to present a framework that supports all the activities from the practical ones in an organization to the knowledge creation ones. In this research, based on the two ideas set out in previous section, some activities relating to the formation of organizational knowledge are explained from both viewpoints of the ‘individual’ as the substantial actor in an organization and the ‘organization’ as the aggregation of the individuals. The two viewpoints are modeled as two separated loops of activities and related each other by making the interaction between the loops clear. The whole model called “Dual Loop Model” is roughly illustrated in figure 2. It is also the reference model for designing a knowledge management support environment, *Kfarm*, we will see in the next chapter. The dual loop model is constructed from an individual’s knowledge conversion process (figure 2 (A), personal loop) and organizational knowledge conversion process

(figure 2 (B), Organizational loop), and it represents the flow of knowledge between them. The flow of knowledge creation activities in this dual loop model is explained herein and functions supporting each activity are detailed in the next chapter.

### 2.1.1 Personal loop

The personal loop is a loop of individual activities of knowledge acquisition and creation. As shown in figure 2 (A), it consists of four processes: internalization, amplification, externalization and combination. This loop has a learning mode, in which an individual acquires knowledge from his/her surroundings, and a creative mode, in which he/she creates new knowledge. A typical activity in a learning mode is one in which the members acquire knowledge of which the significance is approved in an organization. Systems supporting the leaning and the creation modes can be considered the learning support and creative thinking support systems respectively. A possible common basic requirement for supporting these two modes is:

- Easy access to useful knowledge for knowledge acquisition and creation activities.

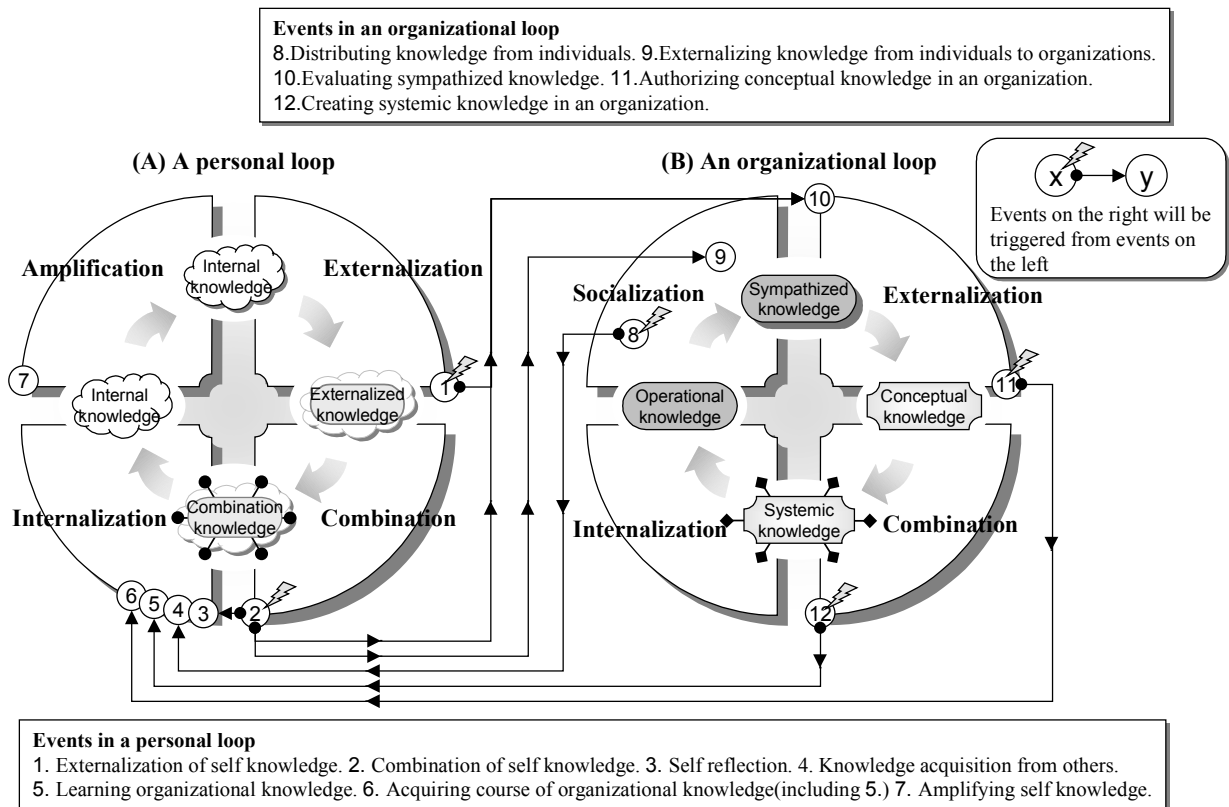
This is closely equivalent to the considerations in the study of Ogata et al’s knowledge awareness support [4] and in Takeda et al’s kMedia [5]. We develop this idea in a framework that promotes the ‘appropriate creation/distribution’ of knowledge in an organization based on knowledge management theory. In the learning mode:

- Create a rational learning process for an organization
- In the creative mode, a basic requirement is:
- Support acquiring knowledge and sending it to others as the basis of individual amplifying process

In figure 2, (1)-(7) represent the events of the K-practitioner’s activities. Typical start events for the learning and creative modes assumed in the dual loop model are (5) and (7) respectively in figure 2. (5) represents an event in which ‘significant knowledge in an organization’ should be acquired, and (7) is an externally-triggered event that represents a start of the creation of new knowledge. These are defined in connection with a user’s activity conditions and an organization’s loop events.

### 2.1.2 Organizational loop

An Organizational loop is an abstracted model, reflecting members’ activities in personal loops in an organization as knowledge inheriting and creating activities from an organizational viewpoint. The typical activities include acquisition and creation of knowledge inside and outside an organization. The loop consists of internalization, socialization, externalization and combination. In the organizational structure of the middle up-down management, the processes of internalization and socialization (on the left), and



**Figure 2:** Dual loop model (partly simplified)

the processes of externalization and combination (on the right) are the activities for K-practitioners and K-engineers respectively. In figure 2, (8), (11) and (12) represent the events that trigger off a K-practitioner's activities performed in the personal loop process. For example, (8) represents such an event as 'knowledge distributed by individuals', (4) represents 'obtaining knowledge from others'. The arrow from (8) to (4) shows a causal link between the two events.

Furthermore, this dual loop model can explain learning conditions in an organization. For example, an organization that frequently has events in the socialization process (at the top left) and rarely has events in the combination process (at the bottom right) mean that even though a K-practitioner actively carries out knowledge acquiring and creating activities, they are not likely to be recognized as 'organizational knowledge'. Lack of activities of K-practitioners and K-engineers can be identified as the causes. Further, when an organizations have events only in the internalization process in the Organizational loop (at the bottom left), it can be seen that a tendency of the organization leans to practice acquisitional activity. Thus, the dual loop model is also useful as a reference for analyzing the proper flow of knowledge acquisition, passing down and creation in an organization.

## 2.2 Knowledge management support

In an Organizational loop, a typical example of highly creative organizational behavior is that 'members have appropriate knowledge, exchange the knowledge and create innovative ideas. At the same time, the organization immediately adopts the ideas and clarifies the value of the idea from organizational viewpoint. To develop such a knowledge creation process, information technology is thought to be able to support the maintenance of the creation process. In the following, K-practitioners and K-engineers are related to the dual loop model in the middle up-down management, and necessary support in *Kfarm* is discussed.

### 2.2.1 Support for K-practitioners

K-practitioners acquire knowledge in the socialization and internalization process of the Organizational loop, and create innovative ideas based on the acquired knowledge. Socialization can be regarded as knowledge communication among K-practitioners, and can be supported by the information communication technology improve accessibility of other's knowledge in organizations. Internalization, however, is regarded as inheritance of systemic knowledge that is *explicit knowledge* externalized and

combined in an organization. This systemic knowledge has *tacit knowledge* behind it, and depending on the *explicit knowledge*, it needs inherited knowledge (*explicit knowledge and tacit knowledge*) that is meaningful for the organization.

The inheritance process of knowledge process may include both on the job learning process and an intentionally planned learning process in an educational context. In *Kfarm*, we plan to respond to the former with promotion support tools for spontaneous knowledge communication, and to the latter with learning support systems that support the progress of knowledge acquisition in the personal loop. Especially for the learning support system, rationality in the organizational perspective of the provided learning process becomes important. From this viewpoint, we will have been developing design support tools for learning contents connecting with organizational knowledge management, and learning scheduling functions connecting with understanding of organization members' knowledge state (personal profile).

### 2.2.2 Support for K-engineers

On the basis of the organizational vision, K-engineers, in the externalization and combination processes in the Organizational loop, are expected to certify what created knowledge from the organization's activities is highly useful, to certify the value of the knowledge from organizational viewpoint, and then they are also expected to encourage knowledge creation by distributing that knowledge to individuals.

To support this, *Kfarm* has following function:

- Notification to K-engineers of events that have occurred in the personal loop.
- The visualization functions of the knowledge state of an organization.
- Knowledge systematization support systems.

## 3. KNOWLEDGE MANAGEMENT SUPPORT ENVIRONMENT BASED ON ONTOLOGY

In this chapter, as an embodiment of ideas set out thus far, we introduce the knowledge management support environment that has been developing in this study; *Kfarm*. We have been designing and developing *Kfarm* centered on documents and folder handling, in which users can participate in organizational learning in an easy way that has no major differences to that in an ordinary computer environment.

### 3.1 Documents as knowledge expressions

'Knowledge' handled in *Kfarm* is expressed in the form of documents, and summarized concepts related to the documents that are the system's subjects:

**Document:** a document that expresses knowledge

**Folder:** a document's storage. Indexes explaining contents are attached.

**Term index:** describes contents of documents and folders in terms designed for easy use by K-practitioners.

**Conceptual index:** conceptually describes contents of documents and folders and is converted from the term index based on ontology.

**Ontology:** a system of concepts representing a state of being – a conceptual index. It includes mapping with terms.

Since directly referencing the conceptual definition of ontology would cause unnecessary work for users, *Kfarm* provides simple indexing scheme to K-practitioners.

Documents managed in *Kfarm* are characterized, from the viewpoint of the dual loop model, as the following knowledge types:

- **Personal knowledge document:** documents before publication
- **Sympathized knowledge document:** published to organizations. Sympathy with the contents advances in

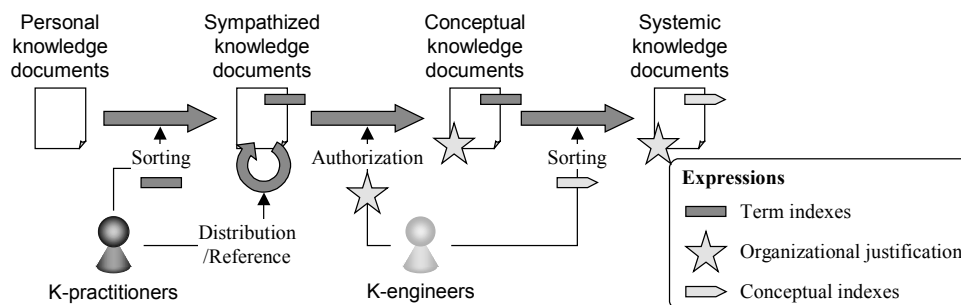


Figure 3: Processes change documents conditions

the process of document distribution and referencing

- **Conceptual knowledge document:** documents with Term indexes such that their efficiency in an organization's activities is recognized by K-engineers.
- **Systemic knowledge document:** documents with conceptual indexes attached by K-engineers.

These knowledge types are used by *Kfarm* to understand and support events, and are not presented to K-practitioners. Figure 3 shows a typical state transition process of these documents. Individual and sympathy knowledge documents correspond to personal subjective knowledge, and to *tacit knowledge*. For Nonaka and Takeuchi's *tacit knowledge* includes *operational knowledge*, though we exclude it in *Kfarm* because it can hardly be documented. Also, learning contents are treated as a kind of systemic knowledge document.

### 3.2 A role of ontology

When designing *Kfarm*, we closely looked at the following two points:

- Support designing according to the process described in the dual loop model
- Detect meaningful events to understand the progress of the process

Ontology is the basis for realizing this function [6]. In this study, we define the concept and vocabulary for expressing knowledge contents as organizational ontology, and as the basic information for sharing and managing knowledge in an organization. Ontology in *Kfarm* works as meta-information that defines basic knowledge conception in an

organization where document (knowledge) contents are to be described. A support system based on knowledge contents becomes possible by using knowledge ontology in an organization. In *Kfarm* only K-engineers are privileged in managing ontology, and they provide editing tools such as ontology editors [7].

### 3.3 Constructing *Kfarm*

*Kfarm* is a system referencing the organization structure of the middle up-down management in figure 1, and aims to share and manage documents based on ontology. Figure 4 shows a system structure. *Kfarm* is distributed system and consists of a server, at least one K-engineer environment and some K-practitioner environment. In a server (figure 4 (B)), it supervises stored documents in the personal folders of each K-practitioner and in the organizational folders shared with the whole organization according to the terminology trees and ontology. It controls their upgrading and referencing conditions. Based on information from this server, K-practitioners and K-engineers carry out document management in each of the environments (figure 4 (A), (C)).

Figure 5 shows the relation between the system structure and Dual loop model. On a K-practitioner environment, a K-practitioner acquires, sorts and exchanges knowledge in the form of documents with term indexes. A series of these activities represent behavior of personal loop and are monitored by a K-engineer through K-engineer environments of *Kfarm*. The K-practitioners' activities collectively drive an Organizational loop in the

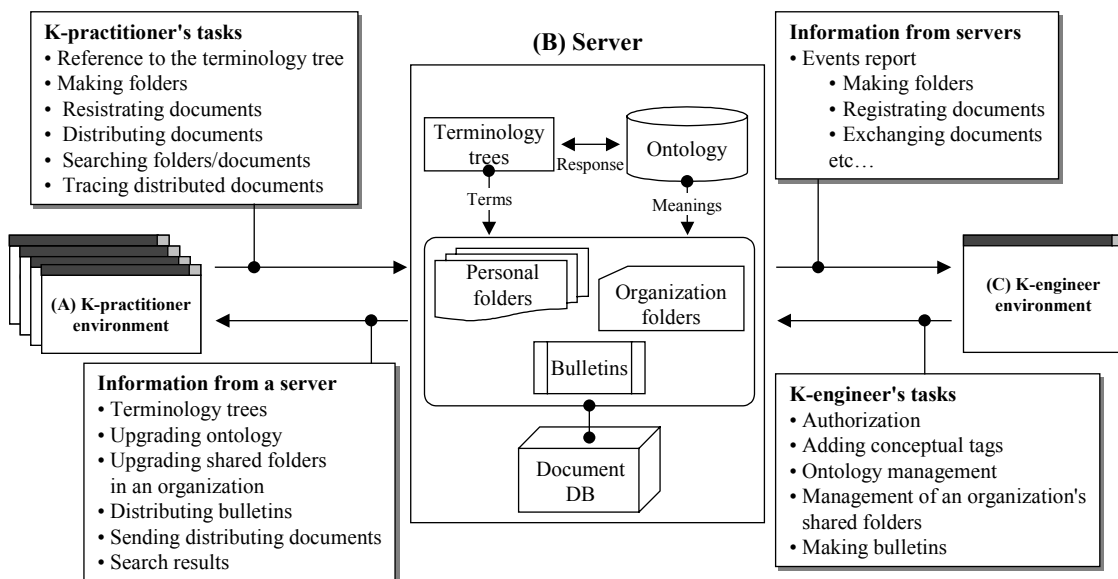
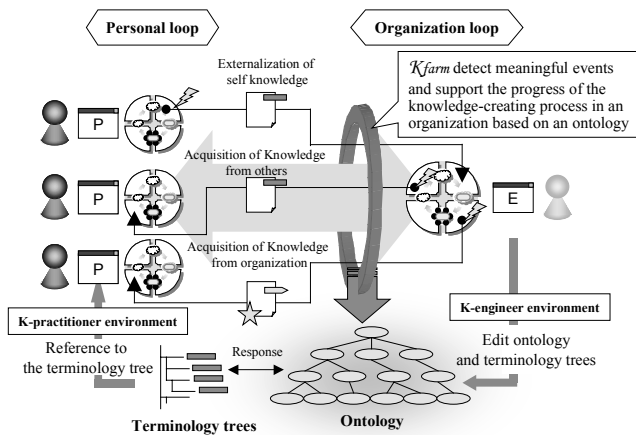


Figure 4: Construction of *Kfarm*



**Figure 5:** the relation between the system structure and Dual loop model

organization. With the understanding the K-practitioners' behavior, the K-engineer can foster the desirable tendency of the personal behaviors in either direct or indirect manner.

As we have discussed, the harmonization of behavior of the two loops in dual loop model is very important to realize highly creative behavior of organization. Our design goal of *Kfarm* is to provide organization members with the useful information to maintain the harmony.

A core function of *Kfarm* is to trace knowledge management behavior of organization. *Kfarm* interpret a series of individual's activities as the knowledge management behavior in dual loop model and identify object knowledge of the activities. This can be done based on the dual-loop model and ontology, since all the possible user's activities in *Kfarm* are associated with events in dual-loop model and knowledge documents are indexed with ontology. This makes *Kfarm* possible to derive next desirable behavior from organizational viewpoint. When new document is created by an individual, for example, *Kfarm* can find the others who might be interested in the document and suggest him/her to look at it. *Kfarm* can grasp 'who has what knowledge' and 'who must be informed of what knowledge' in an organization and accelerate the flow of them. Figure 6 and 7 show the interfaces of each environment. Although five buttons correspond to functions 5 and 6 in figure 7 are provided only to K-engineers, K-practitioners will be provided similar main interfaces except for those five.

### 3.3.1 K-practitioner environment

K-practitioners participate in organizational learning through either their own documents or documents obtained

from outside. K-practitioners' basic tasks and their support functions are as follows:

**Sorting:** select a term from the terminology trees (figure 6 (c)) and put a term index on a folder. Store documents in the indexed folder. The documents have the same indexes as the folder and are converted to conceptual indexes in *Kfarm* (e.g. function 1).

**Support:** providing terms based on ontology, making clear term descriptions

**Distribution:** distribute one's documents with term indexes to interested people (e.g. function 3-2).

**Support:** knowledge awareness support

**Reference:** search and reference documents and bulletins of others and organizations based on terms (e.g. function 2,3)

**Support:** visualize know-who/know-what information

**Learning:** search learning contents that fit one's situation and learn (e.g. function 3)

**Support:** search based on ontology

### 3.3.2 K-engineers environment

K-engineers lead organization learning, based on the organization's visions, by adopting created knowledge and conceptions in an organization. Therefore, all behavior/events in a K-practitioner environment will be informed to K-engineers. This information will give K-engineers more opportunities to collect new concepts of K-practitioners. K-engineers' basic tasks are as follows:

**Understanding circumstances:** make folders for K-practitioners, understand document exchange events (e.g. function 6)

**Support:** informing distributing events, visualizing knowledge exchange

**Editing:** make systemic knowledge documents as bulletins in order to make clear the direction of an organization (e.g. function 5-1)

**Support:** functions for making bulletins

**Authorization:** authorize the useful documents from sympathized knowledge documents in organizational activities and use them as conceptual knowledge documents (e.g. function 5-2)

**Support:** inform distributing events, visualizing knowledge exchange

**Sorting:** sorting of conceptual knowledge documents, set up conceptual indexes as official meanings in an organization, and use as systemic knowledge documents (e.g. function 5-2)

**Support:** organizational shared folders, ontology editing functions

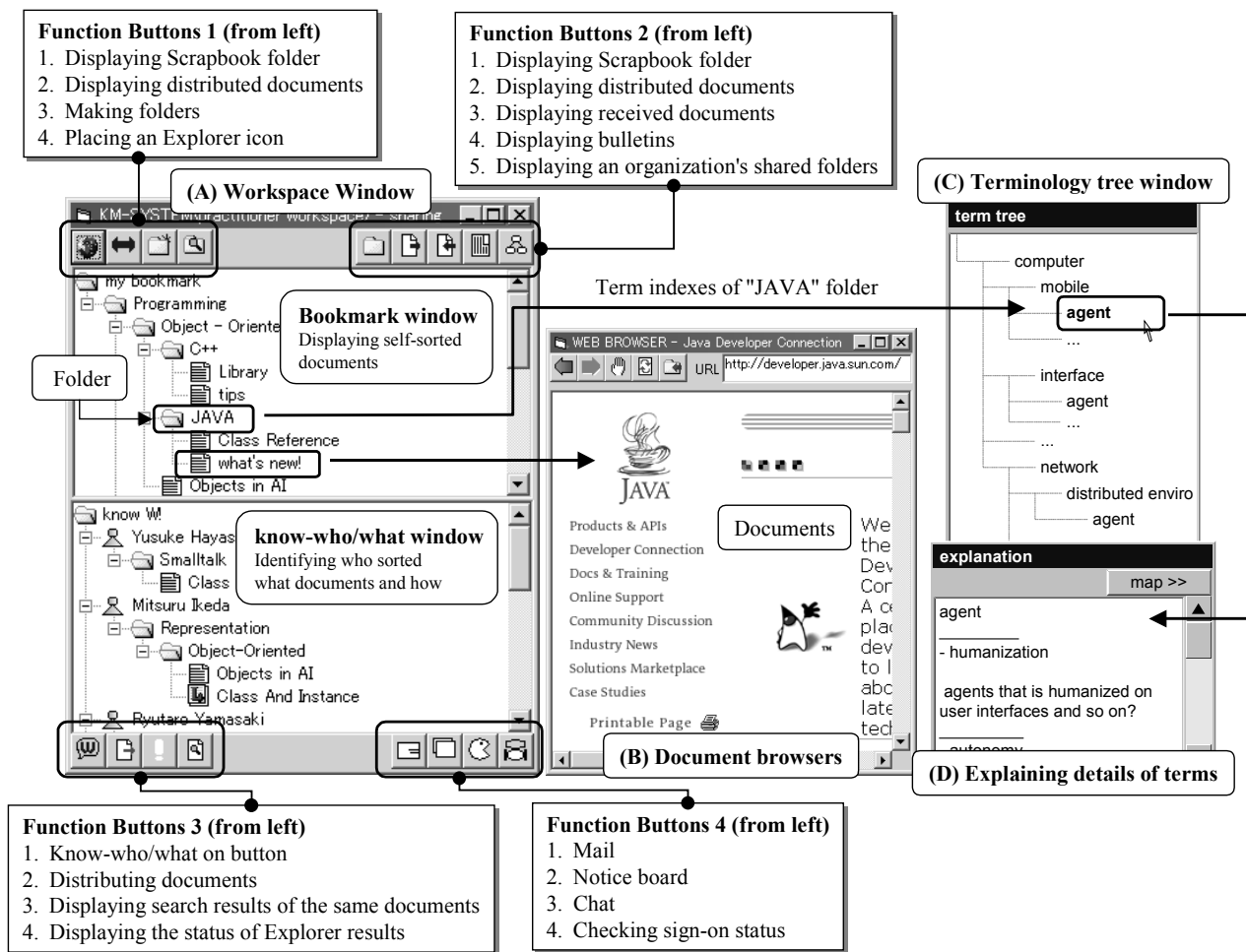


Figure 6: User interfaces in  $Kfarm$  (K-practitioner environment)

**Distributions:** distribute K-practitioners systemic knowledge documents according to the situation of an organization (e.g. function 3-2)

**Support:** visualizing know-who

**Searching learning contents:** search learning contents and target people that match the situations of an organization, and distribute (e.g. function3)

**Support:** visualizing organization conditions, searching based on ontology

#### 4. CONCLUDING REMARKS

We discussed ontology-based framework of information systems that supports knowledge creation activities in an organization. In this research, we considered that it is important to harmonize personal activities with organizational activities in an organization and proposed the dual loop model and ontology as the basis of the support. The dual loop model presents the flow of activities for knowledge creation in an organization and acts as a reference

model for system design. Ontology is a system of the concept and vocabulary for expressing knowledge contents in documents. These two things make information systems possible to clarify activities of members in an organization and the organization itself and meaning of knowledge and provide function and information suitable for users.  $Kfarm$  we have introduced in this paper is an embodiment of this idea. It supports choosing courses based on organization visions by K-engineers and the cooperating of knowledge creation by K-practitioners.

A further direction of this study will be to consider knowledge creation activities in organization from viewpoint of learning. Knowledge acquisition activity is regarded as a basis of knowledge creation activity. It is important for acceleration knowledge creation in organization to support individual's learning process appropriately based on the visions in an organization's visions. By placing learning contents under the management of  $Kfarm$ , we aim to support a learning mode in the personal loops to ensure proper progress. We have developed Smart-

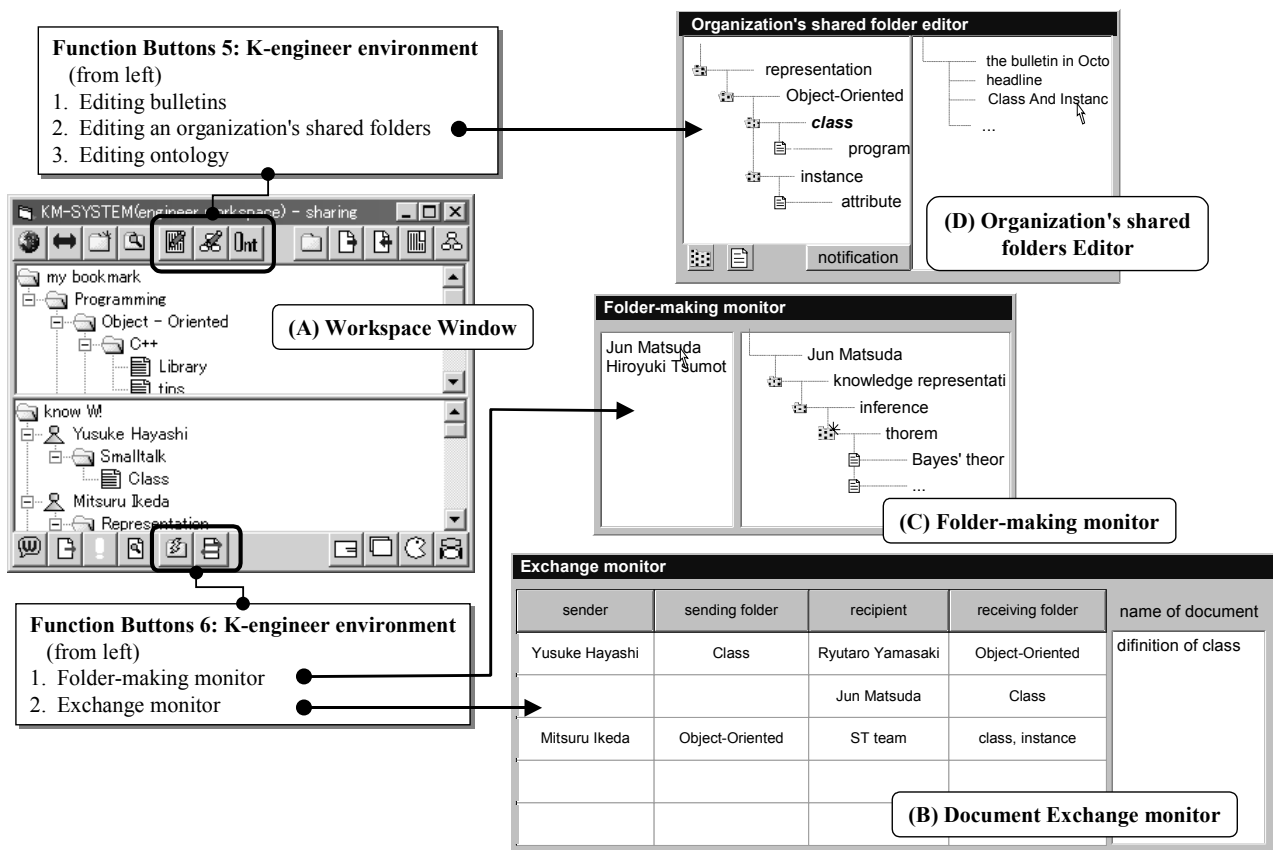


Figure 7: User interfaces in *Kfarm* (K-engineers environment)

Trainer/AT as a general-purpose learning content design support environment and its deeper cooperation with *Kfarm* can be a future subject. For example, it will be possible to better fulfill learning support in an organization's activities by connecting user models in *Kfarm* with learner models obtained with the use of learning contents.

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