Technical Knowledge Dissemination in Industries
- Foundation and Practice -

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Abstract

Because the lifetime employment system is disappearing in Japan, "knowledge transfer" is becoming a more significant issue in industry. Knowledge-based systems will support the knowledge transference among workers via knowledge base. A job support system and an employee training system are the core of knowledge transfer. It is important to build a knowledge base that can be reused. Ontology makes a basis for it. We are building a knowledge management system for the electric power industry. The philosophy of building the system and examples of the system are introduced.

Keywords:

1. Introduction

In the field of power networks, there are few opportunities to transfer knowledge for novices, that is,

(1) No learning opportunity: Each worker performs his duty by himself in order to save labor, so he does not have enough opportunity to be taught by experienced workers.
(2) Few chances to operate: As faults and troubles seldom occur due to the high reliability of equipment, workers have few chances to operate it under actual conditions.
(3) Concealment of knowledge in automations: The reason for accomplishing and the way to execute a certain operation are hidden in automation processes, so novices cannot see them.

In addition, the disappearing of the lifetime employment system is resulting in,

(1) Increasing numbers of people who were hired by a company after having worked somewhere else. So, requirement for education and training in business to take the minimum time.
(2) Increasing numbers of workers who resign. To cope with this, enterprises have to accumulate knowledge as the knowledge of organizations instead of the expertise of each worker.

Therefore the knowledge transference system is required, and it is good under these circumstances to transfer knowledge person to person through the knowledge base (KB) as shown in Fig. 1. To transfer knowledge via KB, reusability of the KB is a critical point and

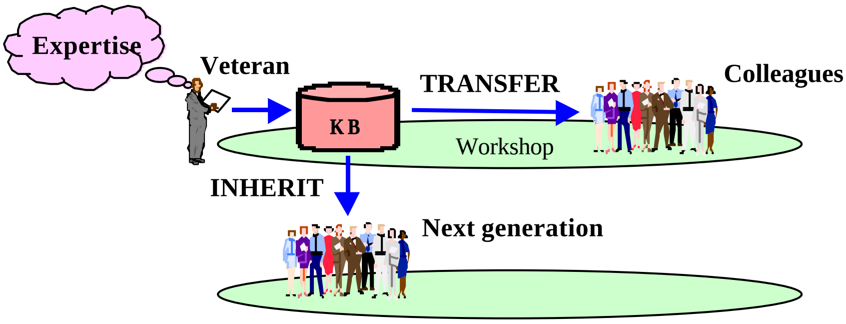

Fig. 1 Transference of technical knowledge through the knowledge base

ontology guarantees the reusability of the KB.

We will show you two examples of prototypes to explain our method concretely, and examples of ontology will be introduced in the prototype.

2. Fruits and flaws of knowledge-based systems

2.1. Problems of knowledge-based systems

We have tried some knowledge engineering approaches to build systems that automate jobs and inherit know-how for the next generation of workers as described in [1] and [2]. Through the experience of building expert systems, we were able to put knowledge-based systems to practical use in an electric power company, and also able to clear problems of knowledge-based systems. The problems are mostly caused by poor reusability of a KB, that is,

(Problem-A) The expense of building KB: There are no common concepts between domain experts and computer engineers, so they spent an incredible amount of time acquiring knowledge. Lack of communication basis also causes a lack of contents on transfer expertise.

(Problem-B) The opaqueness of KB: Because of the difference of conceptual levels between a veteran's expertise and knowledge in the system, domain engineers are not able to understand the contents of the KB.

(Problem-C) The poor applicability of KB: It is difficult to apply most of the knowledge in the system to other systems, because the knowledge in the system was compiled, or specified, for a certain problem.

2.2. Key technology for technical knowledge transfer

To meet the requirement of the times and make good use of our experience in developing knowledge-based systems, the author wanted to develop a knowledge processing technology not only for expert systems but also for systems to support transference of the technical knowledge in business. It is too wide for us to target the whole realm of technical knowledge for all enterprises, so we limit the scope to the knowledge of the operation and maintenance tasks to electric power companies.

The transference of the technical knowledge has two aspects shown in Fig. 1, that is, (1) Inheritance expertise from veteran to the next generation workers. (2) Transferring know-how to colleagues, or sharing personal knowledge in the organization. Problems of knowledge-based systems, solutions to them and keywords of solutions are arranged according to the viewpoint of knowledge transfer as follows:

(1) On inheritance from veterans to novices

a. Problem: knowledge tends to be hidden in automations. Solution: make explicit

Table 1 Key to solve the problems

◆Form of the system
- **Job Support System**
- **Employee Training System**

◆Key technologies to realize the system
- Knowledge acquisition, sharing and reuse : **Ontology**
  - →***Provide the common concepts***
  - →***Make explicit the design rationale***
  - →***Make the knowledge-base applicable to other systems***
  - →***Search the needed knowledge smart***
- **Multimedia**
  - →Use pictures and video movies to represent expertise
- **Intranet** : Network Computing
  - →Use the knowledge-base without the spatial and temporal constraint

KB's design rationale that gets other personnel to understand and use it in future design tasks. Keywords: knowledge reuse and ontology.

b. Problem: there are few opportunities to carry out the operations because faults seldom occur due to the high reliability of power facilities and some tasks need to be carried out only occasionally. Solutions: create chances to have experiences and support the operations. Keywords: employee training systems and job support systems.

(2) On transference from a person to personnel

a. Problem: existence of knowledge which is difficult to put into text. Solution: use expressive media instead of character based document. Keyword: multimedia.

b. Problem: difficulty in finding the required knowledge in the enormous numbers of references. Solution: smart search for the knowledge that someone built. Keywords: knowledge sharing and ontology.

c. Problem: lack of process for sharing the personal expertise as knowledge in the workshop. Solution: prepare media for knowledge sharing. Keyword: intranet.

The above keywords are arranged in table 1. In our discussion, knowledge reuse means to select and use reusable knowledge after a fine analysis of the contents in a KB and an understanding of the meanings of knowledge. So, the KB must be a white box. Knowledge sharing is getting a solution to a problem by inquiring to a KB. The KB needn't be a black box in this case.

3. Ontology and its effect

We will discuss ontology which is the most important keyword to realize knowledge reuse among the keywords in table 1. Ontology is a term in philosophy and its meaning is "Theory of existence". In the artificial intelligence field, ontology is defined as "An explicit representation of conceptualization" [3]. In the KB community, ontology is defined as "A system of primitive vocabulary/concepts used for building artificial systems" [4].

It is true that every software has an ontology in itself and every company has its own ontology for their business. But, such an ontology is "implicit", not explicitly represented. In our research, explicit representation of ontology is used in a practical setting. The ultimate purpose of ontology engineering is: "To provide a basis for building models of all things in the world, in which information science is concerned" [5]. And, ontologies have to be intelligible both to humans and computers.

We discussed the merits of ontology-based systems from the viewpoint of the solutions to the problems in section 2 (See Fig. 2). In Problem-A, ontology provides common concepts between domain experts and computer engineers. In Problem-B, ontology helps to conceptualize the target world. Its formalized description represents the specifications of the logical structure of knowledge and the functions of concepts, and it can strictly define the result of the conceptual design. As a result, implementation that has a continuity from a conceptual design can be established and a KB that is transparent to experts can be built. Ontology works as a common concept between humans and computers in this case. In Problem-C, we can build a reusable KB because ontology makes implicit expertise and preconditions explicit and represents design rationale.

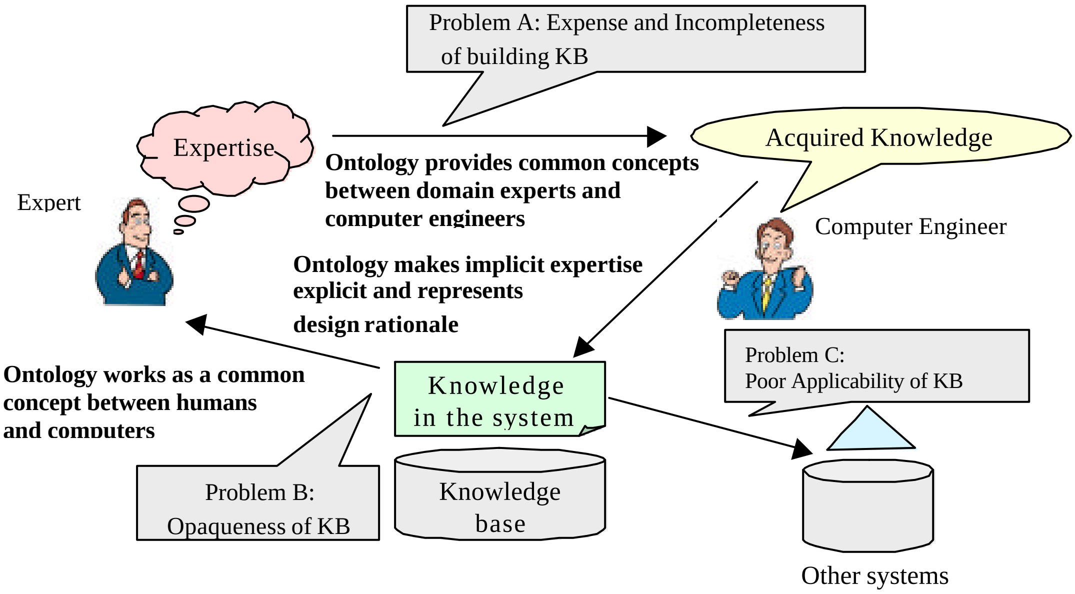

Fig. 2 How ontology contributes to solve the problems

We can define ontology in our task as "A clear definition of concepts and relations among them shared by a human and a computer in their cooperative work". The key to the solutions of above problems are stability and acceptability of ontology. We believe that ontology forms the IT foundation on which we can build variety of ontology. In the next section knowledge-based systems to promote knowledge transfer in enterprise, we will introduce two ontology based systems.

4. Prototypes

4.1. SmartButler/KS

We have discussed the importance of knowledge transfer in industry and how ontology plays an important role in it. Table 1 shows that a job support system and an employee training system are core systems for the transference of knowledge. SmartButler/KS is a ontology based knowledge management system. Its purposes are as follows;

(1) Use the stored knowledge as an answer of a question or a requirement, not a result of data search.

(2) Use the stored knowledge among different systems. In more detail, the KB can be used in multiple purpose or usage.

(3) Relate the stored knowledge to the data contained in conventional databases to make full use of existed data.

As shown in Fig. 3, SmartButler/KS acts as a pivotal agent for knowledge-level communication among agents, that is, human, knowledge systems and legacy systems and serves the stored knowledge in the form appropriate for the requests from the agents.

4.2. SmartTrainer

SmartTrainer is a computer-based employee training system in the area of electric power systems. The goal of the training conducted by SmartTrainer is to not only improve the capability of skill-based or rule-based reasoning but also knowledge-based reasoning. The set of the scenarios incorporated into SmartTrainer has been designed by experienced trainers. In order to help the trainee master the principle knowledge, SmartTrainer first lets them practice then teaches them the first principle behind it depending on their mistakes and, finally, checks their learning results by practicing again.

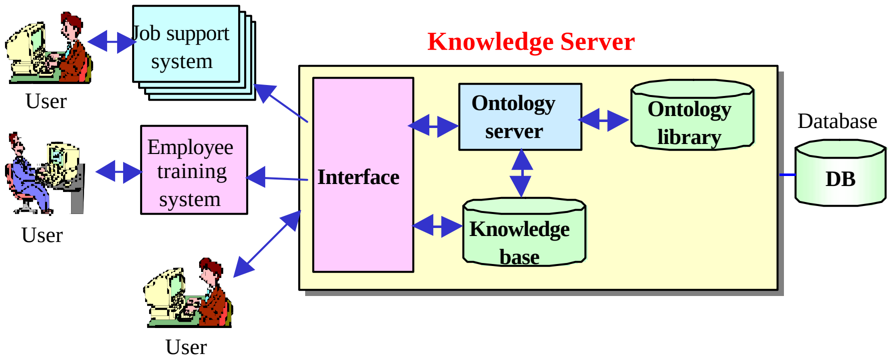

Fig. 3 SmartButler/KS acts as a pivotal agent

To realize the above goal, the SmartTrainer has an ontology-based framework, SmartTrainer/AT, that leads to easy courseware building [6] as follows:

(1) Task ontology for training tasks has been provided in SmartTrainer/AT as shown in Fig. 4: A trainer can build courseware according to the guidance from the SmartTrainer/AT. For instance, frameworks for questions which is one kind of ontology introduces a way of making questions easy, that is, fill-in type, multiple-choice type, etc. After making the question, the author chooses typical types of errors concerned with the types of the questions. As the system has a common framework for teaching strategy, the teacher is not needed to define the strategy of each problem.

(2) SmartTrainer/AT has a methodology to build the ontology: A trainer easily defines the ontology that is used in order to build the model which is targeted in the courseware. According to this model, the system simulates the functions of the target system to teach trainees the behavior of the target model. The model contributes to searching automatically for devices related to certain devices while executing teaching operations. As example of domain ontology is shown in Fig. 4.

Ontology contributes to the improvement of the reusability of courseware because it makes the educational intentions of the courseware explicit.

5. Conclusion

The author comprehended the problem of knowledge transfer in business as a problem of knowledge reuse, and described the importance of ontology in knowledge processing. The effectiveness of using ontology has been proven by some examples of ontologies and their applications in SmartTrainer. As a result of the ontology-based technology, we can easily build a courseware and novices can learn to adapt to their skill levels and their learning intentions [7][8]. We have applied the SmartTrainer to some problems in electric power systems. SmartTrainer is now being integrated into the environment for knowledge transfer shown in Fig. 3

However, a prevalent methodology to build ontology has not been established. Now, we are researching the methodology to reduce the effort to build ontology, and are developing the environment for knowledge transfer, as one of the approaches of the methodology. In this environment, a job support system, a training system and an authoring tool to build ontology are integrated.

The word knowledge sounds as if it is eternal, but it is not. For example, the knowledge concerned with power systems is changing according to the continuous improvement of power facilities. The technique of knowledge reuse is important not only for the original meaning of reuse but also for the daily renewals of KB.

```
1  (|Teaching Materials
2      d*@n backbone stream: backbone stream
3      d*@n rib stream: rib stream|)
4   (|backbone stream
5      p+teaching content: A
6      p+question list: series of questions
7   {+corresponding path[?P2]: path }
8     p+corresponding path[?P1]: path
9     p+object accident: accident|)
10  ~[?p1]=[?p2]
11  (|rib stream
12    p+knowledge: learning item
13    p+correspoding label: learner's label
14    p*@ nteaching behaviors: teaching strategy|)
15  (|questions
16     p+question: question
17     p+question intention: question intention
18     p+object scope: workflow
19     p*@n treatment: treatment|)
20   (|series ofquestions
21     p+correspoding path[?P2]: path
22     p+questions: questions|)
23  {+object scope[?P-n]: workflow }
24  (|question intention
25    p+learning content: A
26    p+thinking procedure: thinking|)
27  (|question
28    p+question content: A
29    p+correct answer: A
30    p+incorrect answer:
31    p+standard: difficult/easy
32    p*@n error pattern: error pattern|)
33  -(|multiple-choice question
34    p*@n multiple-choice option [?ASI-i]:
                          multiple choice option
35    p+correct answer[?ASI]:
                          multiple choice option|)
36  error pattern
37  - multiple-choice question error pattern
38    -(|lack of correct answer
39        p+correct answer:
                          multiple choice option|)
40    -(|insertion of incorrect answer
41        p+incorrect answer:
                          multiple choice option|)
42  (|Teaching Strategy
43     p+goal goal
44     p*@sub goal:goal|teaching behavior|)
45  (|equipment
46     p+joining terminal: equipment
47     p+operation: operation
48     p+parameter: parameter set|)
49  -main circuit equipment
50  -(|power cable
51     p+jointing terminal: equipment|)
52  -bus
53  -(|transformer
54     p+jointing terminal: connecting line|)
55  -(|protection relay
56     p+jointing terminal: connecting line
57     p+adjacent equipment:circuit breaker/
                          dsiconnecting switch|)
58  (|operation
59     p+subject:
60     p+object:equipment/media
61     p+application condition:
62     p+function: |)
63  -(|confirm
64     p+subject: operator
65     p+subject: 30F display
66     p+application condition: alarming
67     p+function: object goes into the head of
                          subject)
```

Note: "p+": Part-of "d+": Division-of "a+": Attribute-of "r+":Other relations "*@n": the plural "p+)": Inherited slot
"(|": Begining of the classs definition "|)": End of the class definition "-": Is a sub class
"x:y": "x" represents the slot name, "y" represents the class constraint "{...}": Explanation

Is-a: Describe the relations between general concept and specific concepts.

Part-of: Describe the relations between whole and part. Attribute-of: Means in the slot is the value of the attribute.

Division-of: Means in the slot are the divisions of the class. Compared with the part-of relation, the content in the slot of division-of relation has to be mutually exclusive.

Fig. 4 Training Task Ontology and Domain Ontology (A portion)

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