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The Management of Debris Flow in Disaster Prevention using an Ontology-based Knowledge Management System

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Abstract

In recently years, the government, academia and business have applied different information technologies to disaster prevention and diverse web sites have been developed. Although these web sites provide a large number of data about disaster-prevention, they are knowledge poor in nature. Furthermore, disaster-prevention is a knowledge-intensive task and a potential knowledge management system can overcome the shortcoming of knowledge poor. On the other hand, ontology design plays the key role toward designing a successful knowledge management system. In this paper, we introduce a three-stage life cycle for ontology design for supporting the service of disaster prevention of debris flow and propose a framework of an ontology-based knowledge management system with the KAON API environment. In addition, by appealing to the technology of component reuse, the system is developed at lower cost thus knowledge workers can focus on the design of ontology and knowledge objects. The objectives of the proposed system is to facilitate knowledge accumulation, knowledge reuse and dissemination for the management of disaster prevention. This work is expected to enable the promotion of the traditional disaster management of debris flow towards the so-called knowledge-driven decision support services.

Keywords: knowledge management system, ontology, disaster prevention of debris flow, ontology, component reuse

1. Introduction

In the information overloading age, one has to not only concern the way of how to collect information, but also needs to focus how to utilize the existing information. In recently years, many experts and researchers have devoted to the disaster prevention. They collected large numbers of data such as weather and geology which are related to disaster factors. In order to reduce the occurrence of debris flow and to protect people's life and property, the government, academia and business have applied diverse information technologies for disaster prevention. A number of information systems including decision support systems and expert systems have been developed in addition to different kinds of web sites. Although these web sites provide large data about disaster prevention but they are usually knowledge poor. Moreover, they lacks of the ability of transforming disaster-prevention data into resource of decision support strategically.

Knowledge is an important factor in the application of disaster prevention, which is a knowledge intensive task. Decision makers usually need to analyze changes of the environment, to ignite the alarm and to plan rescue work and procedure. It is obvious that one who can contribute to disaster prevention should own the essential knowledge for disaster prevention. It will be greatly helpful if the essential knowledge of disaster prevention can be retained and enhanced by successors or the community. This is the time which knowledge management can contribute to. Therefore, in the data rich disaster-prevention environment, it is important for moving the focus from data to knowledge management for disaster prevention.

In the knowledge management the most important issues is knowledge integration [2, 4], which focuses on the issue of the integration of different databases and different forms of knowledge representation [5]. In disaster prevention, there are two reasons that we should apply knowledge management. First, data format is adherent to uniformity. For example, many researchers collected data and then tried to explore the reason causing the occurrence of disaster. However, the data sets under investigation did not follow the standard format, therefore, the reusability of data is hindered. Secondly, documents of disaster prevention are usually semi-structured or non-structured so that reusing the knowledge and data existing in the documents is difficult as well. There are different approaches to define knowledge representation [7, 8], however, if one wants to achieve an objective of semantic search in a knowledge base and to suit in the open communication environment, ontology should come in to play. Ontology defines shared vocabulary of knowledge management systems to facilitate knowledge communication, search and knowledge representation [6]. It can help data integration and avoid data inconsistency. In terms of knowledge sharing and reusing, it also can reduce developing cost of knowledge management systems. Ontology has played a key role toward a

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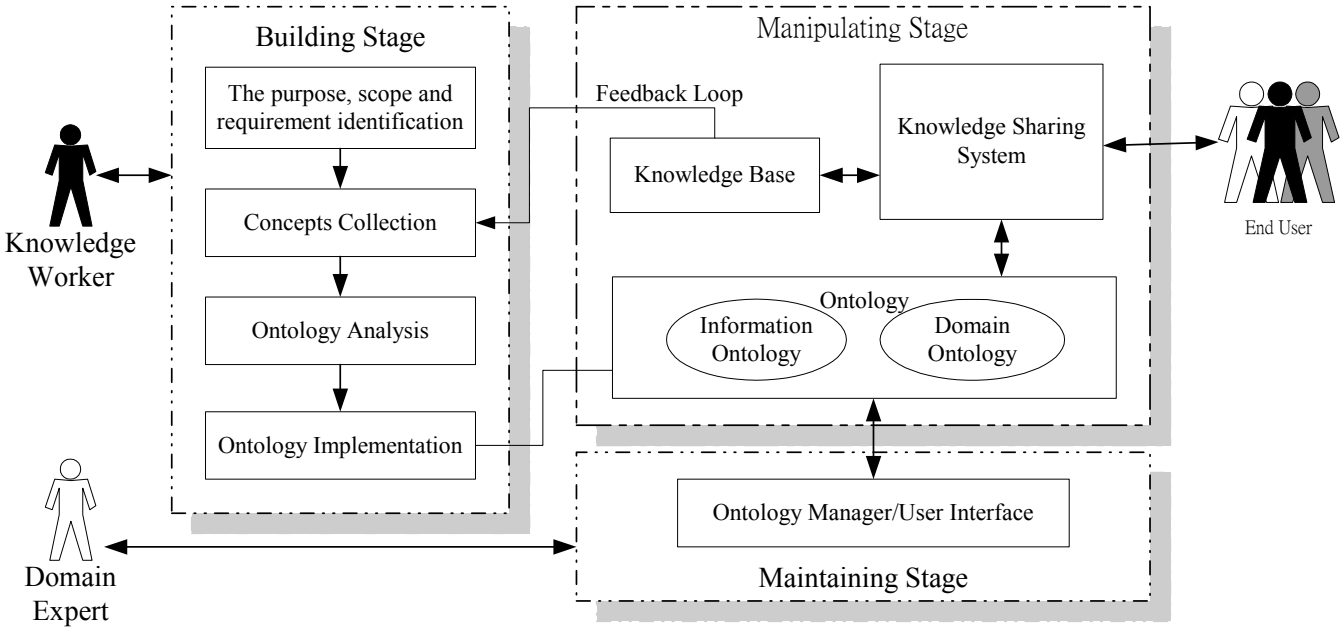


Figure 1. The framework of ontology-based knowledge management system

successful knowledge reuse in many projects [3].

In [1], we proposed a framework of a knowledge management system for the disaster prevention and designed a web-based knowledge management system for supporting disaster management of debris flow. In this paper, we focus on the discussion of system design and aim at knowledge sharing and knowledge dissemination. We propose a framework of the an ontology-based knowledge management system. The system can provide a semantic searching and facilitate knowledge sharing in the disaster prevention of debris flow.

This paper is organized as follows. Section 2 gives brief background knowledge for knowledge management and ontology. The ontology-based knowledge management system is presented in Section 3. Experiments conducted in disaster prevention of debris flow are demonstrated in Section 4. Section 5 concludes the paper.

2. Knowledge Management and Ontology

The basic activities of knowledge management are knowledge acquisition, creation, sharing/diffusion, and utilization. There also exist different knowledge management systems (KMS) that facilitate the activities of knowledge management [2, 9, 10]. In 1990s, the knowledge reuse and sharing already became the major issue in knowledge engineering [11]. In order to achieve the goal of knowledge reuse, the concept of object orientation has been introduced to knowledge management systems. In the sense a knowledge entity can be treated as a knowledge object (KO). KOs can be numerical data, text streams, validated models, meta-models, movie clips, or animation sequences [7], how to integrate and share KOs among different KMS is of great necessity and is a crucial challenge. In the literature, metadata has been widely used in the integration of existed knowledge bases [12] whereas the ontology has been considered as a meta-level description of knowledge presentation [13]. Thus using ontology could made knowledge generalization and promoted knowledge sharing quickly.

Ontology is to play the important role of knowledge representation and represent knowledge domain hierarchy. Ontology could promote sharing and commonness and push knowledge sharing more quickly. The ontology can be divided into information ontology and domain ontology [14]. The information ontology is a meta model that describes knowledge objects and contains generic concepts and attributes of all information about knowledge objects, such as the title, authors, date, keywords, and other related information. The domain ontology consists of the concepts, attributes, and instances of domain.

In [14], a three-level architecture for intelligent decision support has been proposed. It contains application level, description level, and object level. The object level comprises various information and knowledge sources, the so-called KOs. Ontologies are in the description level, which enable users in the application level to intelligently access object-level sources. Ontologies are metadata that provide the search engine with the functionality of a semantic match. It is different from traditional search engines that directly search for the contents of data. From the viewpoint of ontology, XML is not suited to describe the interrelationships of resources in the Internet [15].

KAON, Ontoprise, and Ontopia [16] provide a complete set of ontology tool suites for building, maintaining and utilizing ontologies. In particular, KAON and Ontopia these tool suites can be deployed onto Java J2EE [17] architecture, a distributed component-based architecture, which makes the ontology-based system

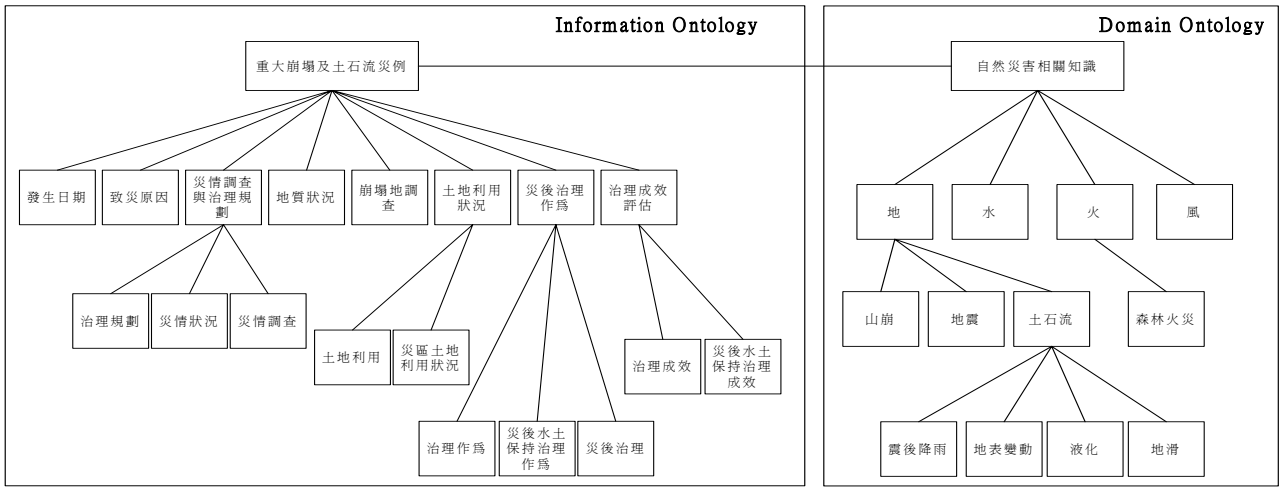


Figure 2. Disaster prevention of debris flow ontology

more flexible and robust. For this reason and the consideration of open source, KAON is chosen as the ontology development platform in this study.

In the past years, many information systems have been developed for different purposes. However today we should emphasize that the important of component reuse. The advantages of reusing components are faster developing time, better quality, and cheaper costs [21]. In this paper, we hold on the view of component reuse and reuse the system components that we developed an ontology-based knowledge management system for the metal industry to help develop this system [20].

3. Ontology-Based Knowledge Management System

This section describes how ontology can be built and interacted with a knowledge management system. We propose a framework of ontology-based knowledge system for disaster prevention of debris flow that exhibit in Figure 1. According to the literature [18], the life cycle of ontology design can be divide into three stages: building, manipulating and maintaining. In the building stage, we identify the purpose, scope and requirement of ontology. When we identified all requirements clearly, then we could begin to collect data and information about concepts of disaster prevention of debris. Next, we analyze the collected data and information. In the ontology implementation step, the ontology can be classified information ontology and domain ontology [19]. The information ontology is a meta model that describes knowledge objects and contains generic concepts and attributes of all information about knowledge objects, such as the title, authors, date, keywords, and other related information. The domain ontology consists of the concepts, attributes, and instances of disaster prevention of debris flow. In our research, we discussed with domain expert and defined the ontology display in Figure 2. The purpose of domain ontology is to achieve the objective of semantic match when searching for knowledge objects. In the manipulating stage, the ontology is deployed to knowledge management system and supports the knowledge management tasks and searching when an end-user accesses the knowledge base. There is a feedback loop between knowledge base and ontology through both ontology analysis and implementation. With more and more various types of knowledge objects in knowledge base, the feedback loop provides the capability of expanding information ontology. In the maintaining stage, domain experts can add, update, and remove ontology via a user interface.

The architecture of the proposed system is composed of three layers: knowledge description layer, application layer and integration and presentation layer. We briefly describe the functionality of each layer as follows and more details can be found in [20].

(1) Data layer

All knowledge objects are stored in knowledge description layer. It contains several databases: system database, user database, personal knowledge base, common knowledge base, information ontology base, and domain ontology base.

(2) Business Logic layer

The proposed knowledge management system is built upon the Java J2EE environment, a distributed component-based platform. The J2EE server is deployed in application layer. It contains three major components: basic components, knowledge management components, and ontology management components.

(3) Presentation layer

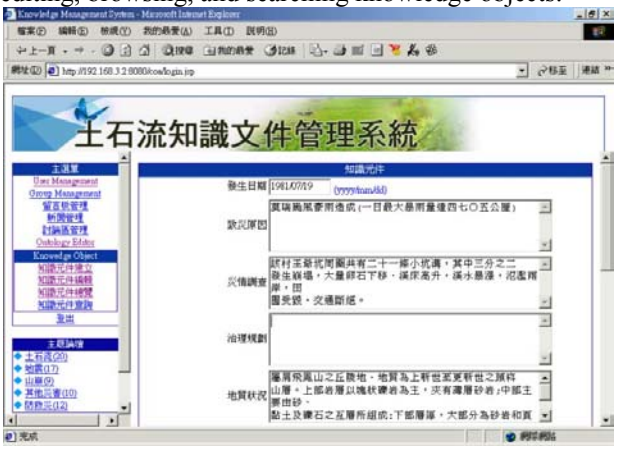
The integration and presentation layer contains several JSP pages and Java servlets (lightweight Java applications in the server side). The major components are News, Forum, System Manager, Personal Knowledge Manager, and Knowledge Search Engine. All information in the forum can be treated as a part of information ontology.

4. Experiment

In our research, we apply knowledge management and information technology to disaster prevention of debris flow and propose a framework of the knowledge management system. The technologies of web and software component are used in designing the system. For knowledge management, it can reduce cost of development and maintenance, and one is supported by the functionality of searching related information quickly but also making right decision at the right time. The snapshots of system demonstration are shown in Figures 3, 4, 5 and 6.

Figure 3. The entry of knowledge management system

Figure 3 is the entry point of the system. The user has to login the system first and then start to engage in the activities of knowledge management, including creating, editing, browsing, and searching knowledge objects.



The creation of knowledge object with information ontology is shown in Figure 4. The domain ontology editor is shown in Figure 5. Information and domain ontology have to be established by the system administrator that follow Dublin Core. The left side in the Figure 5 is the hierarchical classification of metal ontology, and the right side is the viewer of concept.

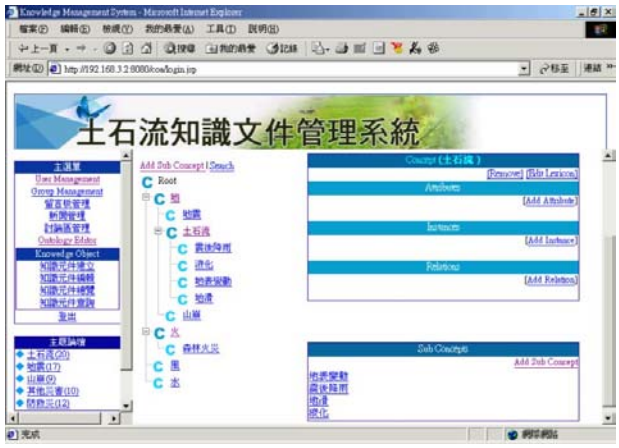


Figure 5. Domain Ontology Editor

When users want to search knowledge objects, they only needs to fill out parts of Dublin Core then the knowledge search engine retrieves the matched objects from Information Ontology database as shown in Figure 6. In our system, we used semantic search, for example when we want to search some thing about typhoon, our system can retrieves information in disaster prevention of debris flow domain. And if we defined ontology include Chinese and English when we use Chinese to search information then we will find Chinese and English information both.

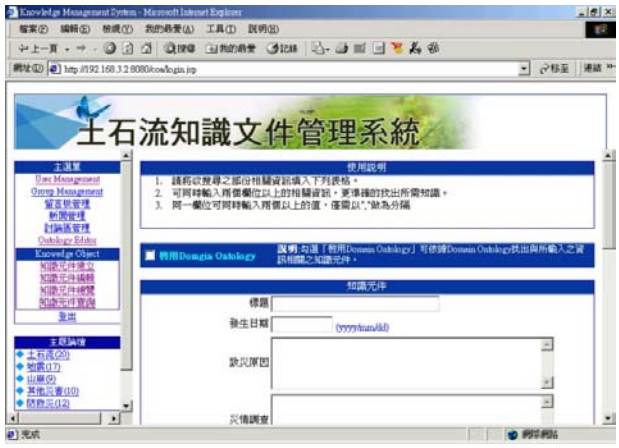


Figure 6. Search Knowledge object

5. Conclusions

For knowledge management, knowledge reuse and sharing already became the most important issue. In this paper, we proposed a framework of ontology-based knowledge management system and reused a prototype that we developed for supporting knowledge management in the metal industry in Taiwan previously. The system was built upon Java J2EE architecture for the sakes of flexibility and robustness, and it utilized KAON API to communicate with KAON service for maintaining information ontology and domain ontology. This major advantage of the proposed system results from the salient features of component reuse so that researchers can focus on the design of knowledge objects and ontology without

the overhead of developing a new system.

In this study, we introduced knowledge management into the disaster prevention of debris flow and developed a pioneering prototype of ontology-based knowledge management system. Users can search relevant information and knowledge with the ability of semantic match. The system focuses on the issue of knowledge sharing and provides a simple way for knowledge searching. It is the objective of this study to accumulate knowledge about disaster prevention and to make people can get knowledge more easily. In such way, the traditional disaster management of debris flow can be prompted towards the so-called knowledge-driven decision support services.

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