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A multilingual ontology framework for R&D project management systems

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ABSTRACT

R&D project management systems are developed to facilitate the efficient management of R&D projects in government-funding agencies and universities. They should support R&D information sharing among researchers and research administrators from different nationalities using different languages. This paper presents an ontology-based methodology to the development of R&D project management systems with multilingual supports. In particular, a multilingual ontology is proposed, which consists of domain model, application model, user model and linguistic model. The methodology is used in the development of an R&D project management system for the Innovation and Technology Commission of the Hong Kong SAR Government. The system supports three languages and facilitates R&D information sharing among users with different culture backgrounds and usage preferences.

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1. Introduction

Research and development (R&D) project management is an important task for government-funding agencies and research institutions. It usually involves several phases, i.e., proposal submission, project selection, approved project administration and project deliverable dissemination. To support the critical decision making tasks in R&D project management, project related information needs to be shared among different parties with different knowledge backgrounds at organizational levels, e.g. project applicants and reviewers with different research interests or speaking different languages. Especially, for some countries/regions that use multiple official languages (such as Hong Kong and Switzerland), project related information and documentation must be stored, processed, and generated in different languages. Thus there is a need to provide R&D project management systems with multilingual supports and organizational knowledge sharing capabilities.

Current research on R&D project management shows increasing interests in developing decision models and methods to support components of the project management process (such as project selection) (Klapka & Pinos, 2002; Lee, Park, & Shin, 2009; Sun & Ma, 2005), or the whole process (Chen, Hsu, & Chang, 2008; Józefowska, Błażewicz, & Słowiński, 2009; Valls & Weglarz, 2005). But many methods are not being utilized or have limited impacts on real world R&D project management (Sun, Ma, Fan, & Wang, 2008; Tian, Ma, Liang, Kwok, & Liu, 2005). To facilitate the use of decision models in real world applications, decision support systems are developed (Klapka & Pinos, 2002; Lin & Hsieh, 2004; Turban, Aronson, Liang, & Sharda, 2007). However, these systems can hardly support multilingual information processing and knowledge sharing among parties with different backgrounds at the organizational level.

Information systems with multilingual support have been studied in several application domains, such as in medicine (Boyer, Baujard, Griesser, & Scherrer, 2001; Dejean, Gaussier, Renders, & Sadat, 2005; Lu et al., in press) and in astronautics (Bensaid & Astor, 2002; Walker, Bayer, & Monjar Bayer, 2002). From these studies, it can be seen that a domain-specific multilingual terminology (terminology is regarded as a collection of terms in a specific domain) is very important in supporting the multilingual information processing and sharing. However, no multilingual terminology is currently available for R&D project management. Furthermore, "terminology" is only a "vocabulary of a domain/field/discipline/specialized subject" (Temmerman & Knops, 2004), with more emphasis on language-specific "terms" instead of the "concepts" behind it.

With the current evolution in the artificial intelligence research, *ontology engineering* is becoming a popular technology to enhance terminology. An ontology is similar to a dictionary or glossary, but with a greater detail and structure that enables computers to process the ontology's content (Fensel, 2004; Plisson, Ljubic, Mozetic, & Lavrac, 2007). It consists of a set of concepts, axioms, and relationships that describe a domain of interests, and represents an agreed-upon conceptualization of the domain's "real world" setting. Thus, ontology can facilitate knowledge sharing within a specific domain (such as R&D project management) at the organizational level.

In this paper, a multilingual ontology framework is proposed for the development of R&D project management systems, where

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domain model, application model, user model and linguistic model are designed to handle related knowledge in R&D project management. The framework and corresponding methodology is applied in the development of a R&D project management system in the Innovation and Technology Commission (ITC) of the Hong Kong SAR Government. The system supports three languages (i.e. English, Traditional Chinese and Simplified Chinese as they are the official languages in Hong Kong), as well as the information sharing among different user groups (e.g. project applicants, project reviewers and administrators) from all over the world.

Section 2 of the paper presents the multilingual ontology framework and corresponding methodology. The application to ITC is reported in Section 3, including a project management workflow and the system architecture. Finally, Section 4 summarizes and discusses the results of our work.

2. An multilingual ontology framework for R&D project management

An ontology is a knowledge repository in which concepts and terms are defined as well as relationships between these concepts (Fensel, 2004). Implicit knowledge for humans is made explicit for computers by ontology.

A multilingual ontology framework is designed in this paper to support the representation of multilingual information in R&D project management. The knowledge in the multilingual ontology includes language-independent knowledge and language-dependent knowledge. Inside, the language-dependent knowledge refers to the knowledge that relies on a specific language, forming a set of linguistic models. And the language-independent knowledge refers to the knowledge that does not rely on any specific language. It is categorized into a domain model, an application model and a set of user models (refer to Fig. 1):

(1) *Domain model*. It contains domain knowledge, which is the general structural knowledge about the application domain. In our case, it is the knowledge about R&D project management.
(2) *Application model*. It contains knowledge about the software application, including functions, menu items, etc.
(3) *User model*. A set of user models are used to capture knowledge about users, including their profiles, behaviors and preferences. They can be used to generate personalized interface.
(4) *Linguistic model*. For each language supported by the multilingual ontology, there is a correspondent linguistic model. It defines the linguistic terminology of the concepts in the domain model and application model for a specific language.

Details of the models are given next.

(1) *Domain model* can be regarded as a domain ontology. The knowledge inside is presented as concepts in the domain and the relations among them. Domain concepts are basic building blocks of the domain model. Each concept is characterized by a set of attributes. Concepts are organized according to a special relation, i.e., concept–subconcept relation. Thus they form a tree-like concept hierarchy. According to previous work (Tian et al., 2005), certain key concepts can be identified for R&D project selection, and a domain model is as shown in Fig. 2. At the panel on the left, there is a concept-tree with a node *root* as the starting point of all concepts. Each of the other nodes is the subconcept of its parent (upper-level node). For example, *University* is a subconcept of *Organization*. Subconcepts represent the relationship of inheritance. Besides concept–subconcept relation, there are other normal relations. For example, in the central dialog box in Fig. 2, the relations of the concept "investigator" (project investigator) are shown on the right when the concept is being edited. Attributes of a concept are also regarded as special relations but related to a concrete range rather than another concept. In summary, domain model conceptualizes the application domain and organizes the domain knowledge explicitly in a computer-readable manner; it forms a basis for information sharing among people with different knowledge backgrounds at the organizational level.

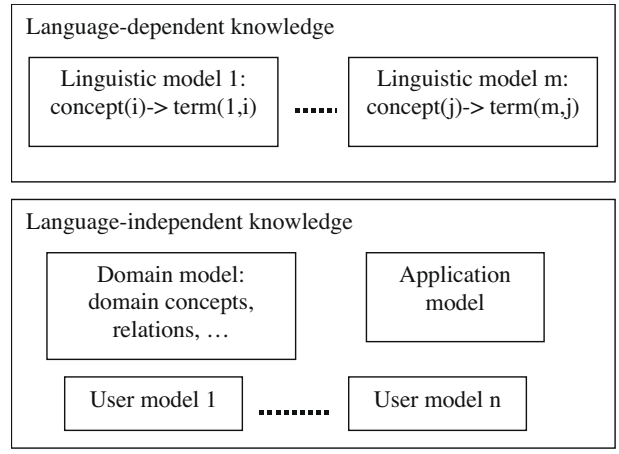

Fig. 1. High level structure of the multilingual ontology.

(2) *Application model* contains knowledge about the system functions organized by function–subfunction hierarchy. The knowledge is also related to the user interface elements (such as menu items) correspondent to specific functions.
(3) *User models* are utilized to capture knowledge about users, including their profiles, behaviors and preferences. A user model is a knowledge resource which contains explicit assumptions regarding all aspects of the user in interaction with the system; and the knowledge is useful when generating user-tailored interface or receiving information from the user. For example, the language of the system interface is chosen according to the user's language preference. Also, users with different roles or positions in the R&D project management lifecycle can use different authorized system functions with different system menus; other human-computer interface elements (like labels, messages and online helps) are also affected. Even more, user models can contain other information about users, such as usage preferences and behavior patterns.
(4) *Linguistic models* define the multilingual terminology of the concepts in the domain model and the application model. For each supported language, the linguistic model defines the mapping from the concepts to the terms in that language. Suppose that in a given context (such as R&D project management) there is one term expressed in a specific language corresponding to a concept, we can then define this mapping as:

$$\text{concept } (i) \xrightarrow{m} \text{term } (i), \text{ for each language } m.$$

A simplified data schema of linguistic models used in the Hong Kong ITC case is shown in Fig. 3. Note that linguistic models for the

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