# Context Information Service on the Project-based Knowledge Map

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## Abstract

The accomplishment of a project indeed involved various activities, models and solutions which are valuable working experiences. Hence, integrating the project knowledge from previous projects in a flexible and meaningful knowledge map is an important effort for facilitating further project development. Furthermore, responding the relevant part of project knowledge according to the situation of the user is more practical while disseminating the knowledge map. Therefore, context information is proposed for timely annotating situation or background information on the knowledge map. The advantage is helpful for improving the connection with the user and leading the user to understand the project knowledge instinctively.

Moreover, Topic Maps, the standard ISO/IEC 13250, is applied as the primary model of the project-based knowledge map, in which the distributed project resources, important concepts and internal associations are expressively linked and integrated. XML/RDF technology cooperated with data mining methods support the essential implementation and knowledge discovery task. Consequently, the construction of project knowledge and rational context information service are efficiently fulfilled in the framework of the project-based knowledge map.

## 1. Introduction

Forming projects for different goals of tasks is a popular work-type in most organizations [19]. The accomplishment of a project indeed involves many activities, models, tools and solutions which mostly carried working skills and experiences. Therefore, the project knowledge which is integrated from previous projects turns into the important intelligent asset for improving the further project development [18]. Furthermore, supporting the user to summarize the relevant part of knowledge is an inevitable undertaking while disseminating the project knowledge [5].

Recently, Internet technology facilitates projects to be processed by distributed resources of which projects teams and systems are located anywhere in the world without physical barriers. The convenience of network greatly encourages the development of project; oppositely, the distributed project resources surely raise the difficulty to integrate the project knowledge. The final outcome of a project is the only concern to be described and archived, yet the useful description of project development is likely forgotten in the distributed resources. Thus, providing such description becomes the primary foundation while developing the useful project knowledge. However, two major problems are frequently encountered.

- Inconsistent description: Different teams with different training backgrounds mostly describe the important concepts from their own viewpoints, so many conflicts in definitions or formations are therefore occurred. Accordingly, the further coordination and integration surely become laborious, and even dependent on humans' manual operations.
- Incomplete description: Inflexible operations for resource providers easily cause the incomplete description. The further manipulation will become difficult and sterile. Accordingly, the meaningful project knowledge is impossibly developed for users.

Therefore, Topic Maps ISO/IEC 13250 is proposed as the standard model for forming and collecting the description of project resources. The advantage is helpful for further generating the consistent project attributes which are essential for constructing project knowledge in this work. Besides, project context is designed for annotating the situation and background information of project development in this work. The advantage can offer resource providers the flexible operation for complete description and assist system users in comprehending project knowledge simply.

Inevitably, user context is also provided for interacting with users. The advantage is helpful for serving the relevant part of knowledge according to the situation of the user in this work. Oppositely, independent of users that is the undiscriminating response to all users, will imposes users heavy cost on separating relevant parts from other irrelevant parts. The consequent inconvenience always delays the progress of project development. Therefore, the context information service, which delivers project context and user context, is rather emphasized in this work while integrating and disseminating the project knowledge

The framework is proposed for systemically constructing the project-based knowledge map in which the project resources and knowledge patterns are expressively integrated. XML family technology is applied for the essential implementation, and data mining methods are used for extracting knowledge patterns. Consequently, the consistent project knowledge and the rational context

information service are efficiently fulfilled in the framework of project-based knowledge map.

## 2. PRELIMINARIES

### 2.1 The Application of Knowledge Map

A knowledge map is a visual display of captured information and relationships, which enables the efficient communication and learning of knowledge by observers with differing backgrounds at multiple levels of detail [9]. The nature of visualization raises the study of knowledge map technology in various applications. Wang designed the specific knowledge map model for improving web-based business [27]. Chung et al. proposed a knowledge map framework for discovering and displaying business intelligence to alleviate information overload on the web [7]; Lin and Hsueh maintained the knowledge map for conducting the virtual communities of practice [17]. Those applications developed the knowledge map to visually explain the underlying relationships and knowledge patterns in various structures of texts, trees, graphics or networks. However, the interchangeability and flexibility are rather considered in this work. Thus, Topic Maps are employed as the main structure of project-based knowledge map for conducting the interchangeable project knowledge.

### 2.2 Context information

Context can be a list of situational factors or any information to characterize the situation of an entity [11]. Many researches have discussed various applications on context, including information retrieval, document analysis and ubiquitous computing. Particularly, the applications of knowledge management on context are quickly raised. For example, Lawrence utilizes context information in web search to improve personalized knowledge search [16]. Schwotzer uses context to manage the exchange of knowledge in mobile spontaneous networks [24]. Salminen et al. proposed the document standardization by merging the documents and work contexts to improve the facility of document management [23].

Therefore, context is used for connecting with users for intelligent service in this work. Also, context is used for expressing the situational information along with the body of knowledge to increase the meaningful expression of project knowledge.

### 2.3 Topic Maps

Primarily, Topic Maps is employed herein to conduct the consistence of the framework. Topic Maps, the ISO standard ISO/IEC 13250, defines a model for the semantic structuring of link networks in 2000[12]. With growing information repository on Internet, the need for enhanced access mechanisms for linking, navigating and exploring information and knowledge from site to site is getting more and more evident. The structural information conveyed by Topic Map model typically includes: (1) groupings of addressable information objects around topics, and (2) relationships among topics [21]. Topics, occurrences of topics and associations between topics are major components [12]. A topic is concrete description to represent a real world subject, such as a person, a theme, or a concept. An occurrence is one of the real information objects link to related topics, such as a file, a video, or a report distributed in different sites. Associations are used to describe the relationships between topics. A topic is an abstract label, and the occurrences are substantial references. An association is a formally meaningful link that specifies a relationship among topics.

Therefore, Topic Maps is employed as the major structure of project-based knowledge map in which the consistent project attributes, contexts, classification system and association rules are integrated and linked. Therefore, the interchangeability, maintenance and extension of knowledge map are systematically managed in Topic Maps.

### 2.4 XML/RDF

Extensible Markup Language (XML), derived from SGML, is a core technology that defines a universal standard for structuring data. XML version 1.0 was defined in 1998 by the World Wide Web Consortium and the Second Edition was published in 2000 [28]. XML is a global standard for storing structured data in an editable file that is useful for data storage, data exchange and document publishing on the Internet. Document Type Definitions (DTD) describes the custom tags and grammar for consistent XML data. Notably, a DTD is a set of declarations that incorporate XML data to describe their structure and permissible format.

RDF (Resource Description Framework) provides the foundation for metadata interoperability across different applications via a Syntax specification and Schema specification [22]. The concrete RDF syntax uses the XML by which RDF can specify semantics for data in a standardized and interoperable manner.

We apply the basic model of RDF statement for interpreting associations with the consistent transformation manner. Therefore, the algebra-like associations, which are extracted in this work, can be interpreted as the correspondent rule statements to increase the semantics of the knowledge map.

### 2.5 Data Mining

Data mining is powerful for extracting patterns of business interests, including associations, changes, anomalies and significant structures from information repositories, in efficient and productive ways. Data mining involves several tasks for different mining purposes, including association rule mining, clustering, classification, prediction, and time-series analysis [4][14]. This work employs the clustering method, generalization mining and constraint-based association rule mining to extract different patterns of project knowledge.

Clustering is to apply a specified objective criterion consistently to form the groups, and to maximize similarity within each cluster and dissimilarity among different clusters [3].

Generalization Mining is a process that abstracts a large set of task-relevant data from a relatively low conceptual level to higher conceptual levels. Generalization mining, one of descriptive data mining methods, is helpful to describe the data set in a concise manner and present in interesting properties or attributes. Attribute removal and attribute generalization are two efficient methods for generalization [14].

Constraint-based mining is performed under the guidance of various kinds of constraints, such as data constraints and rule constraints [14]. Association rule mining finds interesting associations or correlations among large sets of data, and creates practical rules that describe how frequently events or objects have occurred together. It has been applied in numerous applications and successfully applied in market basket analysis, recommender systems, user behavior analysis, and other areas [4].

*Apriori* algorithm finds patterns of items that are frequently associated together for creating association rules from sets of items. The user-given minimum support and confidence are used to filter the rules. Support is used to measure the statistical significance of a rule, and confidence is a measure of the strength of a rule [1].

## 3. The Generic Framework of project-based knowledge map

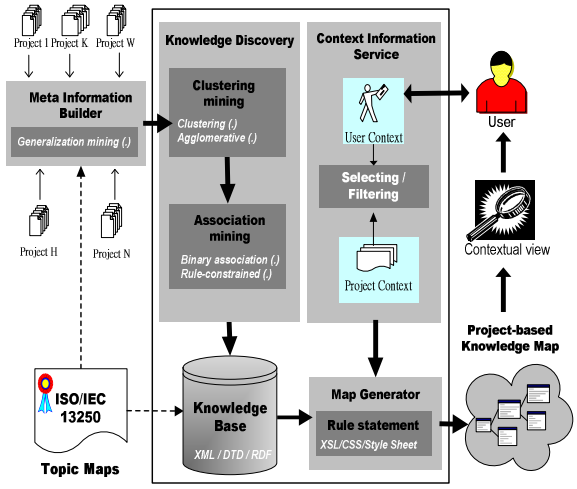


**Fig. 1. The generic framework of the project-based knowledge map with context information service.**

As shown in Fig. 1, unifying the description of project resources, extracting the knowledge patterns, and displaying the project-based knowledge map dependent on the user context are performed by four major modules in this framework, including meta information builder, knowledge discovery module, map generator module and context information service. Besides, knowledge base stores and manages the consistence of the important definitions, contexts, descriptions, methods and rules in the system.

## 4. Meta Information Builder for Generating Project Attribute and Project Context

A shown in Fig. 2, generalization miming is useful for summarizing the project attribute and context from the primitive meta information. Meta information usually contains the primitive opinion and raw explanation to describe the project objects which are busily engaged in fulfilling a project. Therefore, generalization mining is employed for reducing ambiguities and conflicts to generate the consistent project attributes and project contexts for each project. The standard notation of Topic Maps is formally applied to define the outcome. Beside, the links between project attributes/contexts and original project are surely maintained for further reference.

Generalization mining, including attribute removal and attribute generalization operations, are used to regulate the project attributes and contexts. Also, the generation rules are centrally conducted in the meta information builder for ensuring the consistence of generalization extensively.

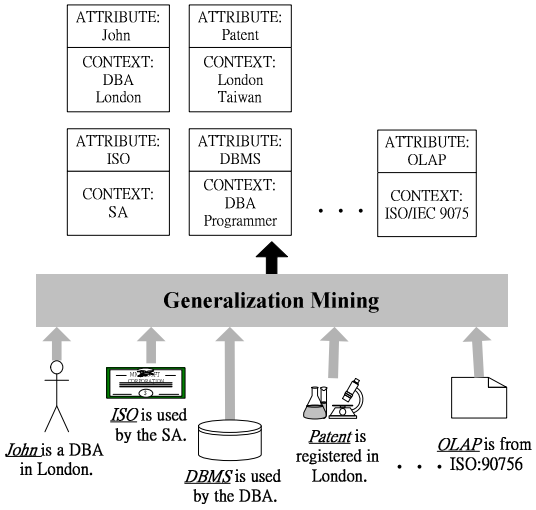


**Fig. 2. Generalization miming is useful for summarizing the project attribute and context from the primitive meta information**

## 5. Knowledge Discovery

Clustering projects and constraint-based association mining are two major phases in the module. Clustering mining is useful to group projects in various clusters [3]. In a cluster, the well-defined project attributes and contexts form the important topic names of the knowledge map. Then, association mining methods aims to extract the associations among these topic names to describe how frequently some topic names have occurred together [1]. However, with the growth of knowledge maps, the found frequent items in various patterns and lengths increase the difficulty of manipulation and understanding. Therefore,

constraint-based association mining, including data constraints and rule constraints, is herein applied [14].

First, data constraints are used to specify the set of context-relevant data. Then, rule constraints specify the form of rules to be minded. The binary association of the form "A→B" is confined in this work, A and B are two topic names in the knowledge map. The advantage of binary association rule mining is helpful to unify the representation of association for facilitating the further interpretation in RDF model and rule statements [22].

For example, "OLAP ➔ CRM Project" is an extracted binary, and the corresponding RDF grammar is explain in Table 1.

**Table 1**
**An excerpt of RDF model for the binary association**

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns: kmap="http://www.iim.nctu.edu.tw/Project/kmap"
:
 <rdf:Description rdf:ID="OLAP">
     <kmap:engage_in>CRM Pproject</kmap:engage_in>
 </rdf:Description>
:
```

## 6. Context Information Service

Context information service delivers project context and user context to increase the connection with resources providers and knowledge seekers, as shown in Fig. 3. Project context is useful for annotating the background information of project attributes. For example, a tool of OLAP is defined as a project attribute, the background information is also available in project context, such as the department or branch which bought the tool and the role of worker who manipulated the tool. Thus, upon the flexible context, the resource providers can give the sufficient description for developing meaningful project knowledge.

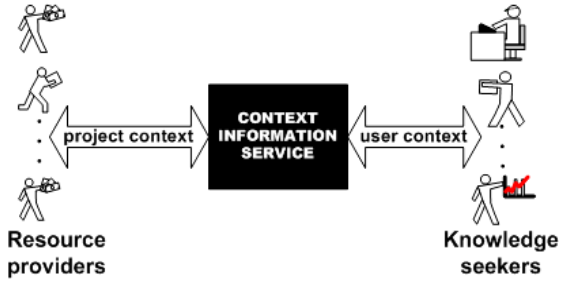


**Fig. 3. Project context and user context in context information service**

The user context is used for increasing the interaction with users. A project worker with different roles will look for different references. For example, a system analyst (SA) may be interesting in the description of models; a programmer would like to know more about the programming tools. When the user context is explicitly given by the user to express the situation, the context information service is triggered to set the criteria for determining the context-relevant part of knowledge map by measuring the equivalence between project context and user context. The discriminative and intelligent service is helpful for shortening the cost of knowledge seeking and understanding the project knowledge rapidly and easily.

## 7. The Architecture of Knowledge map

As shown in Fig. 4, the structure of knowledge map is proposed to contain four layers for systematically representing the integrated project knowledge. The first layer is the root entrance; the second layer contains the category names which are meaningful classification; the third layer contains the important topic names and associations; the bottom layer collects project resources with bidirectional links connecting to proper topic names.

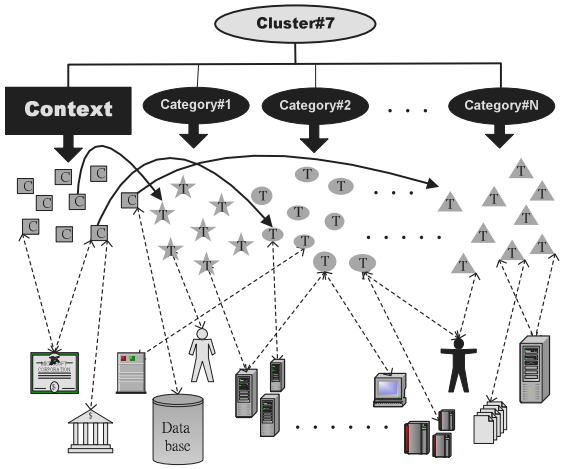


Fig. 4. The architecture of the project-based

### 7.1 Category names

Category names basically correspond to the predefined topic types, which are helpful to classify and organize topic names. Hence, a set of through category names have to be predefined attentively. However, to conclude the category name is a laborious yet important task for classifying manifold topic names in the knowledge map. The human expert, domain experience and ontology are mostly helpful. To keep the completeness is important for covering most topic names in a knowledge map, the consistence is useful for avoiding the conflicts, and the comprehensibility is useful for assigning topic name to the proper category. Currently, a set of category names includes Member, Tool, Goal, Activity, Standard and Cost are accordingly proposed to classify the topic names of project attributes. Some category names are proposed to classify project context. The advantage is helpful to have the consistent annotation from the view of users. Currently, the category names of Role, Location and Sponsor are used to systemize the topic names of project context in this work.

### 7.2 Topic names

Topic names practicably correspond to the features of knowledge maps. Project attributes and project context are described as the formal topic names. The standard notation of Topic Maps for topic names is helpful to unify the concepts. The base name of a topic is required, plus display name and sort name to increase the expression [12]. The base name is a name by which a topic name may be mostly used; the display name specifies the name to be formally explained to users, and the sort name specifies a name that is used in sorting procedures. For example, Extensible Markup Language/XML/eXML, is the base/display/sort name, respectively. This advantage is helpful to reduce the conflicts and misunderstanding of topic names in various applications. Particularly, the consideration of category names and three-deck formation of topic names ensures the project-based knowledge map to extensively integrate more cross-discipline or interdisciplinary projects.

Occurrences practically correspond to the project objects which are described in different topic names in knowledge map. A group of multiple project objects may contain reports, files, videos, or program codes in which the important methods, models or theories are described in the well-defined topic names in knowledge maps. The timely links connecting project objects and proper topic names are very helpful for users to efficiently find the detailed reference in the distributed network. Notably, the flexible and agreed grammar is useful for describing occurrences in the uniform electronic representation. Therefore, the further computation and manipulation is likely operated for knowledge maps.

### 7.3 Associations

Associations are used to indicate the certain relationships between topic names in the project-based knowledge map. Data mining methods are applied to extract the internal associations between project attributes. An abstract association is formally a link element that asserts a relationship between two topic names. However, the defined association names can increase the understanding for the link and relation [18]. In this work, we simplify the association names in this work dependent on the category names of the involved topic names. The definition is very important for the implementation in RDF model and the further interpretation for rule statements.

**Table 2**
**The simple-defined association names**

| Association name | Description |
|---|---|
| **work_with** | Connecting two topics which belong to the same category. |
| **support** | Connecting two topics which belong to different categories. |

## 8. Generating the Interface of the Project-based Knowledge map

Since XML is proposed to implement the body of knowledge, XSL technique is currently applied to filter the relevant part of knowledge map according to user context and represent the result in navigable browser pages. As shown in Fig. 5, the explicit user context given by the user is helpful for determining the relevant part of knowledge. Moreover, as shown in Fig. 6, the timely project context delivering the background information instinctively leads the user to understand and apply the rules appropriately.

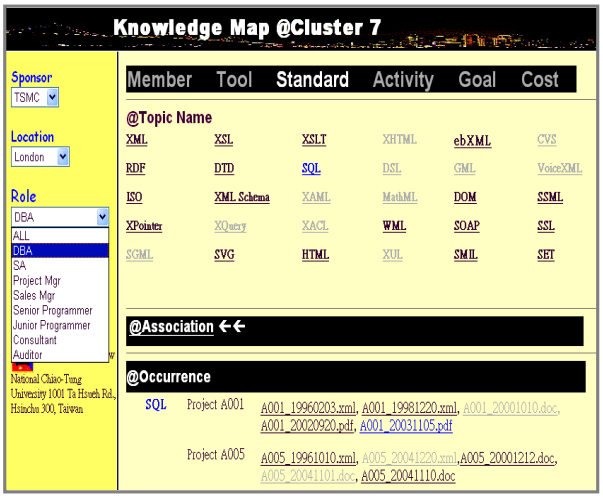


**Fig. 5. The project-based knowledge map with user context**

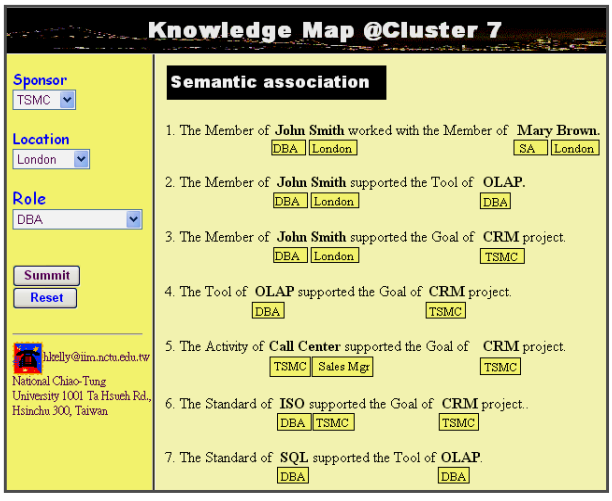


**Fig. 6. The association rule statements with context information**

## 9. Conclusion and Future work

This framework deliberately unifies the definitions and concepts from resource description up way to knowledge representation. Uniform topic names, association patterns, meaningful links and contexts are systematically organized

in the project-based knowledge map. Notably, the context information service, offering project context and user context, actively facilitates the knowledge integration and knowledge dissemination in this work.

Currently, the implementation in primitive XML/RDF standard is helpful for implementing the meaningful and interchangeable project-based knowledge map. The continuous efforts aim to employ various adaptable models for further synthesis tasks, such as union or comparison operation. Moreover, applying various data mining methods is continuously in progress for extracting more hidden and valuable knowledge patterns in the work.

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