# Collaborative Ontology Construction using Template-based Wiki for Semantic Web Applications

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***Abstract*— Collaborative ontology construction and management have become an important issue for allowing domain experts to build domain knowledge that are needed for Semantic Web applications. However, it is normally a difficult task for domain experts to create an ontology-based model and to produce knowledge elements based on the model. In this paper, we propose a Wiki-based environment where domain experts can easily and collaboratively organize domain knowledge. In this approach, templates can be defined and associated with ontology to enable users to arrange knowledge components in a Wiki pages and to store them based on an ontology-based model. We have developed and tested a Template-based Semantic Wiki for u-health applications.**

***Keywords-Collaborative Ontology Construction, Semantic Wiki, Template***

## I. INTRODUCTION

Semantic Web applications normally need to deal with domain knowledge that is organized by domain experts. Domain knowledge is usually represented and stored based on an ontology-based model. In many cases, domain knowledge cannot be built by a single expert in a short amount of time. Therefore, collaborative ontology construction and management have become an important issue for allowing domain experts to build domain knowledge that are needed for Semantic Web applications.

However, it is normally a difficult task for domain experts to create an ontology-based model and to produce knowledge elements based on the model. Domain experts, who are not experts in ontology engineering, cannot effectively identified essential domain objects to be included in a model. It is also hard for them to extract important properties of domain objects and relation among the objects, and to represent them in a model.

In this paper, we propose a Wiki-based environment where domain experts can easily and collaboratively organize domain knowledge. In this approach, templates can be defined and associated with ontology to enable users to arrange knowledge components in a Wiki pages and to store them based on an ontology- based model. A Wiki template can be extended and reused for making Wiki pages that organize more specialized knowledge. As more Wiki pages are created, the structure among the Wiki pages is automatically reflected to the ontology hierarchy.

We have developed a prototype of the Template-based Semantic Wiki, and tested it for u-health applications. We also defined the process of collaboratively editing, refining, and storing domain knowledge by using the Wiki-based environment.

This paper is organized as follows: Section 2 explains about requirements of constructing domain knowledge for Semantic Web applications. In Section 3, related works of collaborative ontology construction are compared and discussed. Section 4 describes the process of constructing ontology by using the Semantic Wiki. In Section 5, we explain about a prototype implementation of a Semantic Wiki, and its application to the u-health domain. Section 6 concludes this paper with discussing about the contribution and the future work.

## II. REQUIREMENTS OF CONSTRUCTING DOMAIN KNOWLEDGE FOR SEMANTIC WEB APPLICATIONS

Semantic Web applications can provide their intelligent services by using the machine consumable knowledge which is constructed as ontology [1]. Therefore, the ontology construction is the main part of Semantic Web application development. Semantic Web application developers have to consider how they can define good quality of ontology for Semantic Web applications. Followings are major requirements of constructing domain knowledge for Semantic Web applications.

- Collaborative knowledge accumulation by domain experts
- Populated knowledge evaluations and refinements
- Refined knowledge semi-automatic conversion to ontology

First of all, collaborative knowledge accumulation by domain experts is needed, because a few domain experts cannot cover whole domain knowledge. They can just cover partial domain knowledge. In addition, the business requirements of semantic web applications and target domain knowledge can be changed dynamically [2]. Therefore, spontaneous domain experts should be able to participate in knowledge accumulation collaboratively. Second, there can be missing parts of domain knowledge. Therefore, Semantic Web application developers cannot be convinced whether the domain knowledge is enough to be used for their Semantic

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Web applications. The domain knowledge has to be evaluated and refined by domain experts. Lastly, refined knowledge needs to be formalized as the ontology representation. In other words, the refined knowledge is converted to ontology classes, class instances, properties, and relations semi-automatically.

## III. Related Works of Collaborative Ontology Construction

There have been numerous researches for collaborative ontology construction. They can be classified by two kinds of approaches; add collaborative features on the simple ontology construction [3, 4] and add Semantic Web techniques on the collaborative knowledge systems to formalize knowledge [5, 6]. They almost developed by using web applications. Recently, web applications are widely used, because they don't ask users additional program installation and maintenance and they allow users can access to them anywhere, anytime if internet or intranet is accessible. In this section, we introduce existing ontology management approaches briefly and analyze them.

OntoLingua is the one of the initial collaborative ontology construction tool [3]. It provides collaborative environments by using the server-client model. The main contribution of the OntoLingua is constructing reusable ontology. It allows users to use predefined ontologies to construct a new ontology as well as ontology editing, browsing, and searching.

Another related research is Collaborative Protégé [4]. Protégé is the well-known ontology management tool. However, it supports only a single user. Collaborative Protégé extends the Protégé. It includes an annotating function for ontology management as well as server-client environments for collaborative ontology construction.

IkeWiki is one of the representative Semantic Wiki [5]. It uses annotated relations among pages. The page names will be class names and the relations will be class relations. Therefore, each wiki page can be formalized and reused for semantic searching and navigation. It provides not only searching results but also relational information between the searching keyword and the results.

Another related Semantic Wiki is COW [6]. It provides explicit ontology editor in the outside of text Wiki. In the ontology editor, users can use ontological functions by using form based web such as class management, property management, instance management, and ontology version management.

Almost of the existing researches consider ontology engineers as main participants who are in charge of ontology construction and evolution except Semantic Wiki approaches. They provide the collaborative ontology construction environments which are not familiar to the domain experts. Therefore, domain experts need to learn about background knowledge of ontology and ontology representation language or cooperate with ontology engineers to construct domain ontology for semantic web applications. In the preceding case, domain experts may have many obstacles to participate collaborative ontology construction such as; how to create classes, what is the concept and etc. In the other case, ontology engineers have to extract formalized information from knowledge elements provided by domain experts. However, it is hard work because ontology engineer also doesn't have enough domain knowledge.

Wiki has been already widely used in various domains to accumulate knowledge by any users. The Wikipedia is a well known example. Therefore, wiki-based approach can be a solution for collaborative ontology construction that covers various users. However, existing wiki-based researches focus on knowledge formalization by using annotation [5,7] or explicitly editing of ontology representation language such as RDF/OWL [6]. The IkeWiki just represents relation between classes and the COW is almost same to other web-based collaborative ontology construction from the viewpoint of ontology engineer.

## IV. Template-based Wiki for Collaborative Ontology Construction

In this section, we describe the Template-based Semantic Wiki to satisfy collaborative ontology management requirements for semantic web applications. Domain experts can participate in domain knowledge population, evaluation, refinements, and ontology extraction through our approach. Figure 1 shows the whole cycle of the Template-based Wiki from the knowledge production phase to the knowledge consumption phase. We applied our approach to the u-health domain as the u-health Wiki. U-health ontology is essential feature of u-health applications. However, u-health experts cannot use conventional ontology construction tools and u-health knowledge cannot construct by a few experts. From the u-health Wiki, we could verify that collaborative ontology construction requirements for semantic web applications are satisfied in u-health domain.

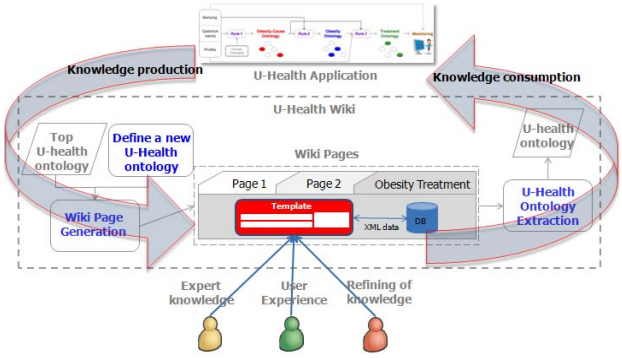


Figure 1. A cycle of Template-based Wiki for Collaborative Ontology Management.

We describe each phase of the cycle in the following subsections.

### A. The semantic web application requirements acquisition

The first phase is analysis of semantic web application requirements. In this phase, application developers, ontology engineers, and domain experts construct ontology model from target domain. The domain ontology model provides top-ontologies to build a wiki. In u-health wiki case, we can

get top-ontologies; obesity treatment and its properties such as effective treatment region of body.

### B. *Wiki pages & knowledge templates production*

The second phase is Wiki pages and knowledge template generation. As we mentioned above, existing Semantic Wiki approaches handle only wiki pages as ontology classes and their relations. In order to overcome the limitation, we use the knowledge template as the means to construct ontology from knowledge. The Figure 2 shows the Wiki page and template generation process.

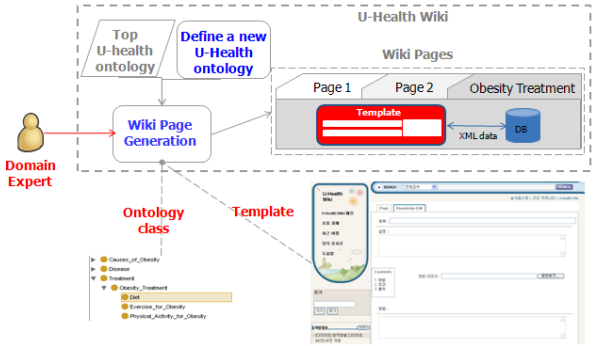


Figure 2. Wiki page and template generation.

When domain experts generate a new Wiki page and templates for knowledge contained in the page, ontology class is created by the page name and its properties are also generated according to the template. Each template is organized by sections for knowledge.

### C. *Knowledge accumulation by predefined template*

In the third phase is knowledge accumulation by predefined template. Figure 3 shows knowledge accumulation process.

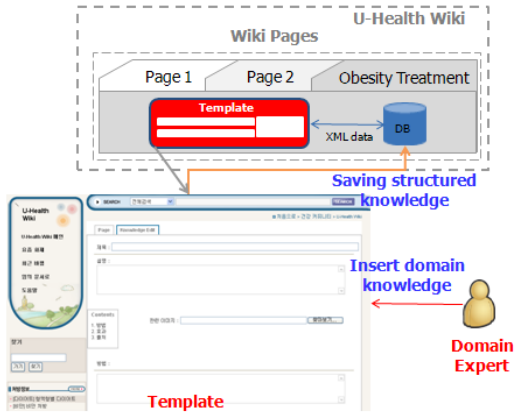


Figure 3. Knowledge accumulation process.

Domain experts can insert relevant knowledge to the Wiki page through the template. The accumulated knowledge becomes a candidate of the ontology class instance. The domain experts can also extend sections of the template if the predefined template is not enough to represent their knowledge.

### D. *Knowledge evaluation & refinement*

The fourth phase is knowledge evaluation and refinement. Accumulated knowledge needs to be evaluated and refined for its quality. Domain experts can participate in the knowledge evaluation by decide discuss point and rating point. The discuss point is used to decide whether the knowledge is appropriate to wiki page and it can be calculated by weighing up the pros and cons of the participants. If domain expert input agree comment then that knowledge discussion points increased. For the rating point, the domain experts can give certain value for the knowledge. The rating point represents the usefulness of the knowledge. Both points are used to decide that the knowledge is acceptable to be an instance of the ontology class. If the knowledge is not accepted, the domain experts can refer the discussion comments and modify the knowledge.

### E. *Ontology extraction*

The last phase is ontology extraction from the refined knowledge. The following equation explains that how to decide whether knowledge is enough to extract ontology.

$$\text{extract}_{\text{bool}}(\text{page}_{\text{know}}) = \\ True\ iff\ knowledge_{appr} \geq threshold_{appr}\ and \\ knowledge_{disc} \geq threshold_{appr}\ and \\ knowledge_{part} \geq threshold_{part}$$

The knowledge in the Wiki page will be extracted as an ontology class instance if it has more than three of threshold values such as; appropriate point, discussion point, and participation number. After ontology extracting, the formalized knowledge can be used for semantic web application.

### F. *Usage Example*

We give a usage example of knowledge generation in u-health Wiki. Assume that there is the u-health Wiki and a domain expert try to contribute his knowledge about exercises for obesity. First, the domain expert creates a Wiki page of exercise for obesity treatment and it is subordinate obesity treatment page. The exercise for obesity treatment inherits template sections and properties such as; method, effect, and effective region of body. The domain expert set threshold values for the knowledge refinements.

The domain expert, then, inserts knowledge about swimming in the page of exercise for obesity treatment. The knowledge will be an instance of the exercise for obesity treatment after the knowledge refinement phase.

## V. IMPLEMENTATION

The u-health Wiki has been implemented based on the Template-based Wiki framework to construct ontology collaboratively on the u-health domain as mentioned section 4. This framework consists of the interface layer to

implement, manage and provide ontology through the web to the user, and the management layer to create ontology from the user input, as well as the data storage layer to store the input data from user. Figure 4 illustrates the whole system architecture of the Template-based Wiki. In this section, we provide more detail explanations of the each layer and interoperations among the system components.

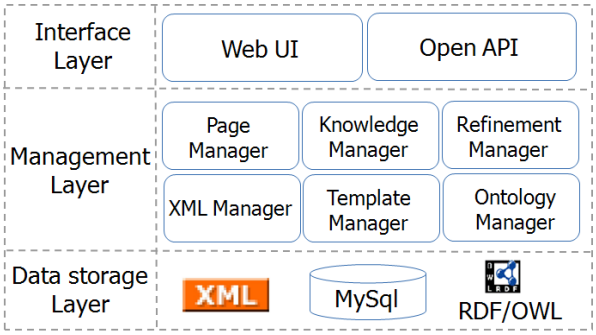


Figure 4. Template-based Wiki system architecture.

### A. *Interface Layer*

According to the Figure 4, the Interface Layer consists of Web UI which covers the user interaction and Open API which provides ontology for the Semantic Web application. The Web UI has developed using JSP as well as the Open API has developed by using JAVA. The u-health obesity application takes ontology data from the ontology manager on the management layer through the Open API.

### B. *Management Layer*

The System Management Layer consists of several managers to support the system management.

- Page Manager

  In this system, the Page Manager is in charge of to create wiki pages which consist of knowledge that users contribute.

- Knowledge Manager

  The Knowledge Manager is in charge of the knowledge management which includes creating and modifying knowledge in the wiki pages.

- Refinement Manager

  The Refinement Manager allows user to decide the rating point the knowledge from 1 to 5 point as well as provides the discussion manner. Each score of the knowledge is stored into the Data Storage Layer. The scores are used to decide the knowledge is converted to ontology class instance by the Ontology Manager.

- XML Manager

  The XML Manager is in charge of XML parsing. The Wiki pages and its knowledge are saved by using predefined XML. System can extract necessary part of information from the XML data by using this manager.

  The following table 1 shows the sample XML page which consist of the page name, description, super Wiki page, knowledge name, knowledge description, and contents.

TABLE I. WIKI PAGE XML EXAMPLE

```
<?xml version="1.0" encoding="EUC-KR"?>
<UWT>
<PAGE_NAME>Treatment </PAGE_NAME>
<PAGE_DESC>Disease Treatment page</PAGE_DESC>
<SUPER>none</SUPER>
<KNOWLEDGE_NAME></KNOWLEDGE_NAME>
<KNOWLEDGE_DESC></KNOWLEDGE_DESC>
<CONTENTS></CONTENTS>
</UWT>
```

- Template Manager

  The Template Manager is in charge of template construction and modification at the page creation and knowledge modification phase. The template provided by the Template Manager, supports domain experts to accumulate the knowledge and to construct ontology collaboratively without the ontology background knowledge.

- Ontology Manager

  The Ontology Manager is in charge of overall ontology management. It provides existing ontology class name list and creates the ontology class and instance from refined knowledge.

### C. *Data Storage Layer*

The collaborative Wiki System uses the three kinds of techniques to store data which are used in system. First technique is XML. The template is represented by using the XML and knowledge is inserted by using this template. User can also extend template dynamically by using the XML. The Wiki pages and its knowledge are also represented by using the XML. The system extracts relevant data from this knowledge XML to generate ontology. The RDF and OWL are used to save ontology from the system. The XML, RDF, and OWL data are saved in database by using MySql.

## VI. CONCLUSION

In this paper, we proposed an approach for allowing domain experts to effectively participate in collaboratively constructing and managing ontology. The core of this approach is the Template-based semantic Wiki, which enables the users to transparently populate and refine domain knowledge without having a background of ontology engineering. By using this Wiki-based environment, Wiki pages can be semi-automatically created based on the ontology structure in a domain. Specialized Wiki pages can be created from existing ones, and the ontology structure is updated accordingly.

We have adopted this Wiki-based knowledge management environment to the u-health domain and developed an obesity management application. In this application, doctors and nutritionists can easily manage the ontology of obesity treatments via the Wiki-based environment. We are also currently extending our approach to provide a Wiki-based collaboration environment for managing electronic program guides (EPGs) of IPTV contents.

We are currently conducting a user study to prove the effectiveness of the Template-based Semantic Wiki for constructing and managing domain ontologies. We believe that our approach will contribute to make domain experts, who are not ontology engineers, effectively and economically work together to manage domain knowledge that can be consumed by Semantic Web applications.

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