A Community-Driven Approach to Development of an Ontology-Based Application Management Framework

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Abstract. Although the semantic web standards are established, applications and uses of the data are relatively limited. This is partly due to high learning curve and efforts demanded in building semantic web and ontology-based applications. In this paper, we describe an ontology application management framework that aims to simplify creation and adoption of a semantic web application. The framework supports application development in ontology- database mapping, recommendation rule management and application templates focusing on semantic search and recommender system applications. We present some case studies that adopted our application framework in their projects. Evolution of the software tool significantly profited from the semantic web research community in Thailand who has contributed both in terms of the tool development and adoption support.

Keywords: semantic web application framework, ontology application development tool, software tool development model.

1 Introduction

With the Semantic Web data standards being established, some organizations and initiatives started creating and sharing their data in the RDF format, aka. Linked data initiative [1]. Further, domain knowledge in different areas has been increasingly captured in ontology form that can be shared as OWL data that can be linked with the RDF data. Although creation of the Semantic Web data rapidly grows, e.g. the Linked data cloud [1], applications and uses of the data are relatively limited. This is partly due to high learning curve and efforts demanded in building semantic web and ontology-based applications. To facilitate development of such applications, development tools should allow application developers to focus more on domain problems and knowledge rather than implementation details. Put another way, application development tools should not only be designed for technologists but also researchers or domain experts who are non-technology experts.

In this paper, we introduce the Ontology-based Application Management (OAM) framework, a development platform for simplifying creation and adoption of a seman-

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tic web application. The framework is primarily built on top of some existing tools and frameworks, including the Jena framework [2] and D2RQ [3]. OAM allows the user to interactively define mapping between an existing database schema with an OWL ontology to produce the RDF data based on the mapping. It also provides some application templates that support RDF data processing focusing on semantic search and recommender system applications. Our framework is different from existing semantic web application frameworks in that it does not require user's programming skill in building a semantic web application prototype. Thus, researchers spend less time and effort in adopting the semantic web technologies and can focus more on higher-level application logics. The framework also provides application-level APIs and Web service interface to support a more advanced application development.

A community-driven approach was applied to the development of our software tool. In this approach, research community can contribute to evolution of a software tool. We have organized several activities for a semantic web research community in Thailand, which consists of interested users, developers, students, teachers, domain experts, and researchers, to support deployment of our tools. The activities include both adoption and development supporting activities. The adoption supporting activities include trainings and workshops where the research community can learn about ontology development and application development using the tool. The development supporting activities include student projects and theses and coding marathon event. The community-driven development approach has contributed to the tool evolution by means of user feedbacks, requirement gathering, and collaborative design, coding and testing.

The paper is organized as follows. Section 2 introduces a community-driven software tool development model which has been used in the development of our software tool. Section 3 focuses on some unique approaches and functions of our application framework. Section 4 present two case studies that adopted our application framework as a research tool in their projects. Section 5 discusses current status of the tool and some future development directions.

2 A Community-Driven Software Tool Development Model

A community-driven approach was applied to the development of our software tool. The approach can be illustrated as a software development cycle as shown in Fig. 1. In this model, contributions from research community are significant to the

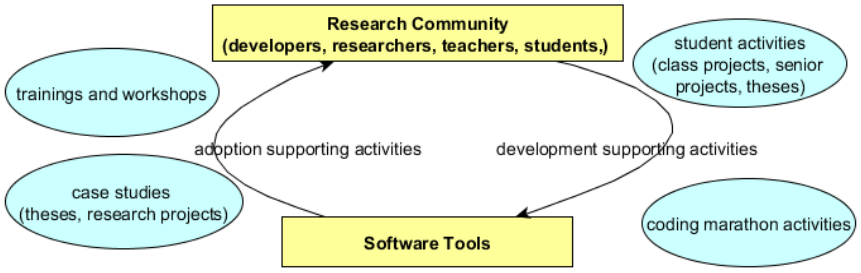

Fig. 1. A community-driven software tool development cycle

development and adoption of a software tool. In supporting tool adoption, training and workshop activities can be organized to introduce the tool to the research community. In addition, some case studies are needed to demonstrate application potentials of the tool. Related student theses or research projects should be set up and adopt the tool as a research tool. The community users who adopted the tool can help to provide feedbacks, testing and evaluation results, which can contribute to gathering additional requirements for improving the tool. In supporting tool development, university teachers can integrate some parts of the tool development as student assignments for class projects, senior projects or theses. In addition, coding marathon activity, which is popularly adopted in opensource software development, can be organized to promote collaborative efforts between researchers and developers in improving design and implementation of the tool.

Since the initial release of our software tool in 2010, we have conducted user training sessions to introduce the tool to the research community. Each session comprises of two hand-on trainings: ontology development[1] and ontology application development. Feedbacks from the participated users, who were developers, researchers, university teachers and students, were gathered as user requirements to guide the tool improvement. In addition, some university teachers have taken these requirements and assigned them as class and senior projects for their students. In addition, we organized a two-nights coding marathon activity which involved nearly 60 students, professional developers and researchers. These supporting activities have collectively contributed to improving the tool both in terms of functionalities and user interface designs. Further, several student projects and theses were set up and adopted the tool, which helped to demonstrate applications of the tool.

3 Ontology-Based Application Management Framework

The Ontology-based Application Management (OAM) framework[2] is an application development platform aims to simplify creation and adoption of a semantic web application. Our application framework differs from the existing tools in two main aspects. First, the framework provides common application templates that can process

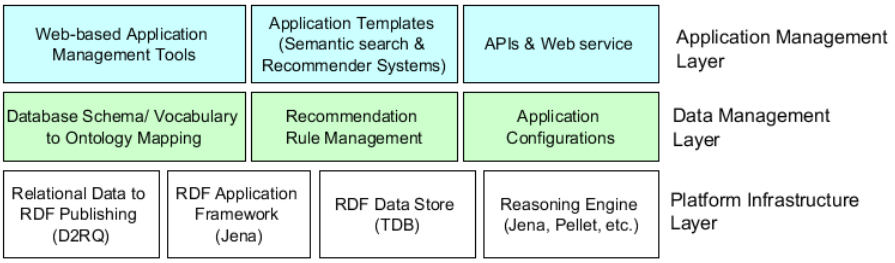

Fig. 2. A layered architecture of the OAM framework

[1] Hozo ontology editor (`http://www.hozo.jp/`) was used in the ontology development trainings.

[2] OAM Homepage – `http://text.hlt.nectec.or.th/ontology/`

the user's published RDF data. Thus, it does not require user's programming skill in building an application. Second, it is an integrated platform that supports both RDF data publishing from databases and processing of the published data in ontology-based applications, i.e. semantic search, recommender system applications.

Fig. 2 shows a layered architecture of the OAM framework. The framework was implemented on top of existing semantic web data and application platforms, i.e., Jena, D2RQ, RDF data storage and a reasoning engine. OAM added some data and application management functions, including database schema and vocabulary to ontology mapping, recommendation rule and application configuration management. The user can create and manage ontology-based applications using web-based application templates and management tools. OAM also provides APIs and Web service interfaces to support a more advanced application development.

3.1 Database Schema and Vocabulary to Ontology Mapping Management

There are typically two methods in creating instances for ontology classes. The first method is to manually construct an instance and define its attribute values based on a class. This is typically done using instance editor provided in ontology development tool. The second method is to create instances from some existing information sources, such as database records. This normally requires mapping process between the existing database schema and ontology structure [4]. After the mapping process, a database record can be transformed into a class instance. This method is most suitable when an organization already stored the data in some databases. Our framework focuses on the latter approach in creating instance data from existing databases.

OAM's data mapping management tool supports both schema mapping and vocabulary mapping between OWL ontology and a relational database source. In schema mapping, the user can define mapping between ontology classes and database tables. For each class, the user can define mapping between each property, i.e. either datatype property or object property, with a database column of any table with an optional join condition. The property mapping supports one-to-one, one-to-many and many-to-many relationship types in databases. Based on the mapping configuration, the tool can generate instances of the ontology classes as an RDF/XML file. In vocabulary mapping, the user can choose a table column and assign each attribute value as label of an ontology class. This will allow synonymous terms to be mapped with a class in ontology that would allow semantic-based processing in applications.

3.2 Recommendation Rule Management

OAM also focuses on simplifying creation and management of recommendation rules. It provides a recommendation rule management tool that supports two processes: create recommendation and link recommendation. Creating recommendation will create a recommendation class instance where the user can define conditions of class instances to be associated with the recommendation. For example, user can create a car recommendation instance and associate it with car model instances that match a condition of "a Japanese brand and priced under $20,000". Linking recommendation

allows the user to define conditions of class instances to which the recommendation is assigned, e.g., customer instances that match a condition of "young adults with Asian nationality". Fig. 3 shows an example of the resulted recommendation rules created in the Jena rule syntax. The tool facilitates the user to create such business logics using a form-based user interface and hides complexity of the rule syntax to be processed by reasoning engine.

```
[Create_car_rec_1: (?x rdf:type ns:CarModel) (?x ns:has_brand ?y) (?y rdf:type ns:JapaneseBrand)
                (?x ns:has_price ?z) lessThan(?z, 20000) -> (comp1:car_rec_1 rdf:type ns:CarRecommend)
                (comp1:car_rec_1 ns:has_rec_id '1') (comp1:car_rec_1 ns:has_car_model ?x)]

[Link_car_rec_1:  (?x rdf:type ns:Customer) (?x ns:has_nation ?y) (?y rdf:type ns:Asian)
                  (?x ns:has_age_group ?z) (?z rdf:type ns:YoungAdult) (?a rdf:type ns:CarRecommend)
                  (?a ns:has_rec_id '1') -> (?x ns:has_car_model_recommendation ?a)]
```

Fig. 3. An example of the resulted recommendation rules in the Jena rule syntax

3.3 Application Templates and Management

OAM allows the user to create a semantic web application using a provided application template. Using application template, the user only needs to define application configuration and does not need programming skill in building an application. This is suitable for researchers who want to experiment on research ideas that can be realized by means of the semantic web technology. Application template is typically ideal for rapid prototyping and hypotheses testing.

Currently, the framework provides two application templates: semantic search and recommender system applications. The semantic search application template provides a faceted search [5] interface. Using the provided form-based interface, the end-user can select a class in the ontology to search for its instance data and define some search property conditions. A search allows value comparison using both string and number comparators and semantic-based comparators, i.e. IS-A. It also allows the user to customize properties in displayed search results. The user's faceted search condition is automatically transformed to a SPARQL query for retrieving the instance data from an RDF database. The recommender system application template extends the semantic search template to support viewing of recommendation rules and results.

4 Case Studies

This section discusses some projects that adopted our framework in their research. One project was development of a food recommendation system [6] based on user's health status and nutrition goals. In another project, OAM was used to support human activity recognition task in smart home domain [7]. The ontology-database mapping tool helped to simplify mapping process between the domain ontology and the database storing the sensor-based data and to produce the RDF data. The recommendation rule management component helped to facilitate defining rules for the human activity recognition task. Finally, the semantic search application template allows for rapid prototyping and evaluating the recommendation results. Fig. 4 shows an example use of the application framework for activity recognition task in smart home domain.

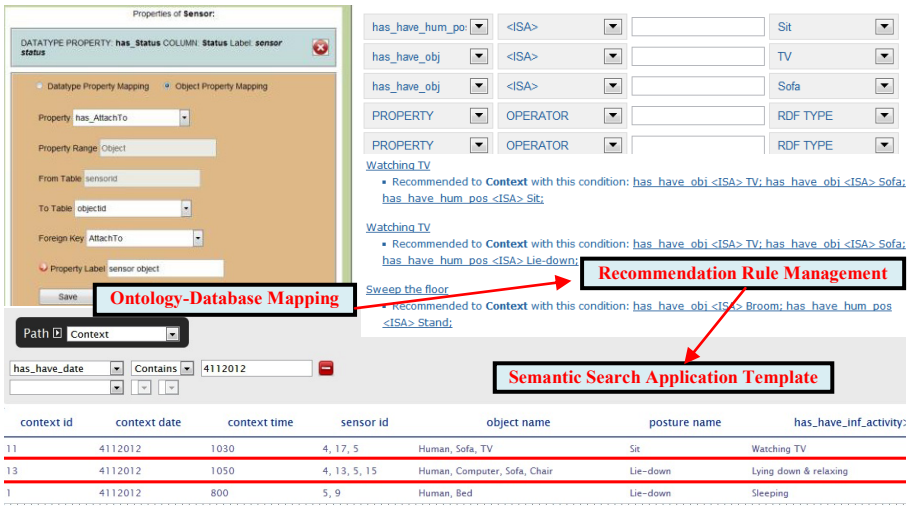

Fig. 4. Example use of the application framework for activity recognition in smart home domain

5 Discussion

In this paper, we describe OAM, an application framework aimed to simplify development of ontology-based applications that use the semantic web technology. Our tool development approach relied significantly on contributions from the research community. Adoption supporting activities, such as trainings and workshops, have contributed to promoting deployment of the software tool among the community. In addition, development supporting activities, i.e. student projects and coding marathon activity, have allowed the research community to contribute to improving design and implementation of the tools.

Based on download statistics in 2012, OAM has approximately 45 downloads monthly. Approximately 200 users have completed the user trainings. Some future development includes adding support for more application templates such as decision support system and NLP applications. We also aim to improve compatibility with various ontology tools and to add support for Linked data interoperability.

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